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Wetland Alteration and Conservation: Planning Implications and Strategies

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WETLAND ALTERATION AND CONSERVATION:
PLANNING IMPLICATIONS AND STRATEGIES

BY

KATHERINE LEE WEBER

A Research Project Paper Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER

IN

COMMUNITY PLANNING

University of Rhode Island

1988

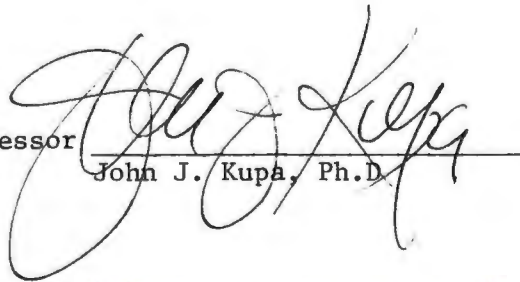
There are some who can live without wild things, and some who cannot. Like winds and sunsets, wild things were taken for granted until progress began to do away with them.

Now we face the question whether a still higher 'standard of living' is worth its cost in things natural, wild and free. For us of the minority, the opportunity to see geese is more important than television, and the chance to find a pasque-flower is a right as inalienable as free speech.

--A Sand County Almanac,
by Aldo Leopold

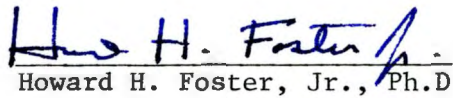
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Howard H. Foster, Jr., Ph.D.

DEDICATION

This report is dedicated to the memory of
Aldo Leopold who raised our national conscience
about 'things wild and free' and to my parents
who gave me a life to appreciate them.

TABLE OF CONTENTS

CONTENT	PAGE
APPROVAL PAGE	i
DEDICATION	ii
LIST OF TABLES	vii
LIST OF FIGURES	x
LIST OF APPENDICES	xi
CHAPTER I - INTRODUCTION	1
Growing Concern for Wetlands	1
Loss of the Resource Base	3
Project Background	4
Project Purpose and Scope	5
Synopsis of Chapters	6
Footnotes	7
CHAPTER II - WETLAND ECOLOGY	9
Definition	9
Wetland Classification Systems	11
Wetland Values	17
Hydrologic and Hydraulic Values	18
Flood Storage and Conveyance of Flood Flows ..	18
Barriers to Waves and Erosion	19
Sediment Traps	19
Water Quality Values	20
Water Supply	21
Pollution Control	21
Food Chain Values	22
Source of Nutrients for Fish and Shellfish ...	23
Food Production	23
Habitat Values	24
Habitat for Rare and Endangered Species	26
Critical Wetland Size for Wildlife	26
Harvest and Heritage Values	27
Timber and Crop Production	28
Recreation	28
Historic and Archeological Values	29
Education and Research	29
Open Space and Aesthetic Values	30
Endangered Species	30
Wetland Dynamics	31
Natural Processes at Work	31
Wetland Dynamics	35
Management Implications	36
Footnotes	38

TABLE OF CONTENT (continued)

CONTENT	PAGE
CHAPTER III - CONSTRUCTION ACTIVITIES THAT IMPACT WETLANDS ..	43
Overview	43
Construction Activities Associated with Floodplains, Banks and Shores	45
Pre-Construction Activities	45
Line Construction Activities	46
Building Construction	47
Construction of Open Air Industrial Plants	48
Construction of Drainage Structures	49
Tunnel Construction	50
Mineral Extraction on Land	51
Construction Activities Associated with Wetlands and Water Bottoms	52
Masonry Dam Construction	52
Construction of Fills in Wetlands	53
Construction of Drainage Ditches	54
River and Channel Modifications	54
Bridging in Wetlands	55
Dredging and Placement of Dredge Spoils	55
Construction Activities Associated with Waterway Margins	56
Construction of Breakwaters, Sea Walls and Shore Protection Systems	56
Breakwaters	56
Sea Walls	57
Shore Protection Systems	58
Construction of Ports	59
Off-Shore Construction Activities	60
Mineral Extraction from the Continental Shelf	60
Pipeline Construction	60
Footnotes	62
CHAPTER IV - WETLAND ALTERATION IMPACTS	64
Overview	64
Physical and Chemical Impacts of Construction Activities on Wetlands	66
Impacts Associated with Floodplains, Banks and Shores	66
Pre-Construction Activities	66
Impacts of Impervious Surfacing and Earth Work	67
Impacts of Line Construction Activities	71
Impacts of Building Construction Activities ..	72
Impacts of Open Air Industrial Plant Con- struction	73
Impacts of Bridge Construction	75
Impacts of Tunnel Construction	75

TABLE OF CONTENT (continued)

CONTENT	PAGE
Impacts of Mineral Extraction on Land	76
Topographic Impacts	77
Physical Impacts	78
Chemical Impacts	79
Impacts Associated with Wetlands and Water	
Bottoms	81
Impacts of Dam Construction	81
On-Site Impacts	82
Upstream Impacts	82
Downstream Impacts	84
Impacts of Fill Construction	90
Impacts of Dredging	91
General and Immediate Impacts of	
Dredging	91
Impacts of Stream Channelization	92
Impacts of Floodplain and Swamp Chan-	
nelization	93
Impacts of Dredging in Marshes	94
Impacts of Dredging in Bays and	
Estuaries	97
Impacts of Dredging and Spoil Dumping	
on the Continental Shelf	98
Impacts Associated with Waterway Margins	99
Impacts of Construction of Breakwaters, Sea	
Walls and Shore Protection Systems	99
Impacts of Piers, Wharves and Bulkheads	100
Impacts of Deepwater Structures	101
Impacts of Offshore Mineral Extraction and	
Pipeline Construction	101
Biological Impacts of Construction Activities on	
Wetlands	102
Biological Responses to Environmental Stress	
Factors	103
Overview of Biological Impacts of Construction	
Activities on Wetlands	104
Footnotes	111
CHAPTER V - WETLAND CONSERVATION	116
Causes of Wetland Deterioration	116
Patterns of Wetland Response	117
Planning Assumptions	119
Ecological Assumptions	119
Resource Management Assumptions	121
Wetland Conservation Recommendations	124
Planning Strategies	125
Policy Issues	130
Research Directives	132

TABLE OF CONTENT (continued)

CONTENT	PAGE
Strengthening Wetland Conservation Programs at the Local Level	134
Local Initiatives	135
Wetland Conservation Policy	137
Wetland Regulations	138
Wetland Zoning	138
Subdivision Controls	139
Building Codes	141
Sanitary Codes	141
Special Codes	146
Performance Standards	146
Non-Regulatory Programs	149
Wetland Use Principles	155
Conclusions	156
Footnotes	164
APPENDICES	166
BIBLIOGRAPHY	189

LIST OF TABLES

TABLE		PAGE
II-1	"National Wetlands Classification System" wetland systems	11
II-2	"National Wetlands Classification System" wetland classes	12
II-3	"National Wetlands Classification System" water regime modifiers for tidal and nontidal wetlands	13
II-4	"National Wetlands Classification System" wetland classes based on vegetative life form	14
II-5	Freshwater wetland classes and subclasses in the Northeast	16
II-6	Natural factors that determine a wetland's value as wildlife habitat	25
III-1	Impervious surfacing and earth work construction activities and facilities	46
III-2	Line construction activities and facilities	47
III-3	Building construction activities and facilities ...	48
III-4	Open air industrial plant construction activities and facilities	49
III-5	Drainage structure construction activities and facilities	50
III-6	Tunnel construction activities and facilities	50
III-7	Mineral extraction activities on land	52
III-8	Masonry dam construction activities and facilities	53
III-9	Sea wall construction operations	57
III-10	Shoreline stabilization operations employing fill .	59
IV-1	Major construction impacts on wetland environments	65
IV-2	Construction variables that influence wetland impacts	65

LIST OF TABLES (continued)

TABLE		PAGE
IV-3	Impacts of impervious surfacing and earth work on wetlands	70
IV-4	Impacts of impervious surfacing and earth work on wetlands	70
IV-5	Impacts of line construction on wetlands	72
IV-6	Impacts of building construction on wetlands	73
IV-7	Impacts of open air industrial plant construction on wetlands	74
IV-8	Topographic impacts of mineral extraction operations on wetlands	78
IV-9	Physical impacts of mineral extraction on wetlands	79
IV-10	Chemical impacts of mineral extraction on wetlands	80
IV-11	Upstream impacts of dam construction on the physical and chemical characteristics of wetlands	83
IV-12	Downstream impacts of dam construction on the physical and chemical characteristics of wetlands	88
IV-13	Impacts of fill construction in wetlands	90
IV-14	General and immediate impacts of dredging on wetlands	92
IV-15	General impacts of stream channelization on wetlands	93
IV-16	Impacts of channelization of floodplain and swamps	94
IV-17	Impacts of dredging and spoil placement in coastal marshes	96
IV-18	Impacts of dredging and spoil placement in estuaries and bays	98
IV-19	Impacts of breakwater, sea wall and shore protec- tion system construction on coastal wetlands	100

LIST OF TABLES (continued)

TABLE		PAGE
IV-20	Impacts of pier, wharf and bulkhead construction on coastal wetlands	101
IV-21	Generalized biological response patterns to increased levels of environmental stress	105
IV-22	Cumulative impacts of construction activities on wetland environments	110
V-1	Ecological assumptions of wetland alteration	121
V-2	Resource management assumptions of wetland alteration	123
V-3	Construction problems for which impact criteria are needed	126
V-4	Wetlands needing special protection	127
V-5	Remedial measures for restoring degraded wetlands	128
V-6	Wetland conservation policy goals	131
V-7	Wetland conservation issues requiring additional research	134
V-8	Examples of community initiatives to strengthen wetland conservation efforts	136
V-9	Activities involved in establishing and implementing a community wetland conservation program	137
V-10	Conditions for allowing wetland alteration	137
V-11	Overview of wetland zoning	140
V-12	Overview of wetland subdivision regulations	142
V-13	Steps in local wetland regulation	143
V-14	A comparison of common regulatory tools	147
V-15	Examples of wetland impacts prohibited by per- formance standards	148

LIST OF TABLES (continued)

TABLE		PAGE
V-16	Performance standards for protecting freshwater wetland functions	150
V-17	Selected public wetland protection techniques	153
V-18	Wetland use principles	155
V-19	Impacts of steps of construction in wetland habitats	158
V-20	Alternatives for wetland protection	163

LIST OF FIGURES

FIGURE		PAGE
1	"National Wetlands Classification" hierarchy of wetlands and deepwater habitats showing systems, subsystems and classes	15

LIST OF APPENDICES

APPENDIX		PAGE
A	Examples of Representative Vegetation for "National Wetlands Classification" Wetland Types.	166
B	Freshwater Wetland Classes and Subclasses in the Glaciated Northeast	167
C	Rhode Island Freshwater Wetlands Act	172
D	Potential Environmental Impacts of Hydroelectric Power Projects	175
E	Factor Train Analyses for Construction Activities .	185
F	Summary of Wetland Values and Hazards	188

One notion that owners of land have an inalienable right to the benefits of maximum potential development is an idea whose time has gone.

--Conservation Foundation Letter,
June 1973

CHAPTER I

INTRODUCTION

Growing Concern for Wetlands

Wetlands and saturated soils are not only unremunerative, but if the area is considerable, they prove a source of enervation and disease to the section in which they exist. Although individuals may neglect swamp lands, or find their reclamation and drainage too expensive, the State cannot afford to be indifferent to their continuance, because they check production, limit population, and reduce the standard of vigor and health. Their value, too, when reclaimed, in an economic view will be greatly enhanced.

President of the American Public Health Association, 1876. ¹

Wetlands are areas of great natural productivity, hydrological utility, and environmental diversity, providing natural flood control, improved water quality, recharge of aquifers, flow stabilization of streams and rivers, and habitat for fish and wildlife resources. Wetlands contribute to the productivity of agricultural resources of national interest. This piecemeal alteration and destruction of wetlands through draining, dredging, filling and other means has had an adverse cumulative impact on our natural resources and on the quality of human life.

President Carter, 1977 ²

The contrasting views expressed in these passages reflect the profound change in attitude towards wetlands and the growing appreciation of the importance of wetlands to the ecological balance of the environment. Wetlands have traditionally been considered wastelands, sources of mosquitoes and impediments to development and travel. Alteration of these natural systems through filling and draining to create solid ground has long been accepted construction practice. ³

The long-term physical and ecological relationships between water, land and man's activities are now better understood. The value of wetlands and the hazards that accompany wetland alteration are now being recognized. Wetlands in their natural state serve important functions, including purification of water bodies, flood storage and conveyance, fish and wildlife habitat and aquifer recharge.⁴ Coastal wetlands and those adjacent to major streams are often subject to serious flood and erosion hazard which may persist after draining and filling.⁵ Today, the protection of wetlands is more widely recognized as essential to restoring and maintaining water quality, preserving natural hydrologic cycles, providing wildlife habitat and enriching man's communities in general.

There is now a heightened awareness of the need to make conscious, informed choices about future modifications of the natural environment. The crucial trade-offs involved in altering wetland systems are now being weighed more heavily in the decision-making process in many communities. The wetland setting provides a framework within which important land use decisions must be made so as to optimize conservation and development opportunities while minimizing adverse environmental impacts.

The growing recognition of the ecological and economic importance of wetlands in the last decade, combined with accelerated flood losses and water pollution from wetland alteration, has prompted nearly one half of the states to adopt regulatory programs at the state and/or local levels to control coastal and inland wetland use

or to guide wetland use as a component of broader flood plain, coastal, scenic and wild river, shoreland and critical environmental area programs. ⁶

Loss of the Resource Base

Over one half of the nation's original two hundred and fifteen (215) million acres of wetlands have been lost through various forms of direct habitat destruction, and over half the remaining wetlands have been severely modified. ⁷ Construction activities continue to destroy wetland environments at an alarming rate. The primary types of construction activity that severely impact wetland systems include floodplain surfacing and draining, mining, impoundment, channelization, dredging, bank/shoreline construction and canalization. ⁸ Each type of construction activity produces an identifiable set of physical and chemical alterations of the wetland environment that may extend for many miles from the construction site, and which may persist for many years. In turn, each physical and chemical modification induces a predictable set of biological effects. ⁹

The most important ecologically damaging effects of construction activities on wetlands, in order of importance, are direct habitat loss, addition of suspended solids and modification of water levels and flow regimes. ¹⁰ Major construction-related impacts also derive from altered water temperature, pH, nutrient levels, oxygen, carbon dioxide, hydrogen sulfide and certain pollutants such as heavy metals, radioactive isotopes and pesticides. ¹¹

Many aquatic species have been lost or severely restricted as a result of wetland alterations. Other species are currently in jeopardy. Every aquatic system consists of a vast array of physical and biological elements that interact in subtle ways. In order to reverse the destructive trend and provide a rational basis for environmental management, it is necessary to minimize these activities. As one astute observer noted "Today there may be higher political priorities, but tomorrow may be too late".¹²

Project Background

The basis for this study is a personal conviction that wetlands are valuable ecological systems and significant features of the landscape. Wetlands are valuable natural assets that simply cannot be discarded through ignorance, indifference, accident or design. Environmental planning at the national and state level has focused on chemical water pollution and water quality standards. These regulations address only one aspect of wetland protection. In the absence of comprehensive wetland regulations that take into account the causes of wetland deterioration and patterns of response, construction activities will continue to eliminate and degrade our nation's wetlands.

My appreciation of wetlands led me to the realization that there is a general lack of awareness of the magnitude of wetland losses in this country and the immediate need for improved regulations to deal

with incremental wetland losses at the community level. As a planner and a citizen, I cannot stand idly by and accept the loss of these valuable national assets.

Project Purpose and Scope

The purpose of this project is identify those construction activities that are impacting wetlands on a large scale and consider their planning implications. Recognition of the values of wetlands has prompted many states to enact wetland protection regulations. Some of these regulations go so far as to require restoration of altered wetlands.¹³ In addition to the multitude of legal ramifications, significant ecological questions remain unanswered as to the environmental impacts and success of these restoration efforts. Yet, even with these regulations "on the books", incremental losses of wetland habitat continues in every community.

The goals of the project are, therefore, to:

1. Assess the impacts of wetland alteration; and
2. Offer strategies for wetland conservation.

The objectives of this project are to:

1. Highlight wetland values;
2. Identify construction activities that impact wetlands;
3. Review wetland alteration impacts and patterns of response; and
4. Discuss planning implications and recommendations for wetland conservation at the local level.

Synopsis of Chapters

Chapter I serves to introduce the topic and scope of the project. This chapter also highlights the changing attitudes toward wetlands and the need for comprehensive resource planning at the local level. Chapter II provides a discussion of wetland ecology with an emphasis on definition, classification, values and dynamics. The management implications for regulating wetlands in light of these dynamic natural processes are also discussed briefly in this chapter. Chapter III describes common construction activities that impact wetland environments throughout the United States. The physical, chemical and biological impacts of these construction activities on wetlands are discussed in Chapter IV. Chapter V synthesizes the preceding information on wetland alteration impacts and provides some recommendations for wetland conservation strategies.

FOOTNOTES

Chapter I

1. Toner, "A View of Some of the Leading Public Questions in the United States", Public Health Reports 1,22 (1876) in "Federal Protection of Wetlands through Legal Process", Christopher B. Myhrym, Boston College Environmental Affairs Law Review, vol. 7, no. 4 (Newton Centre, Massachusetts: Environmental Affairs, Inc., Boston College Law School, 1979), 567.
2. "Presidential Statement accompanying Executive Order No. 11990", 13 Weekly Comp. of Pres. Doc. 808, 809 (May 24, 1977) in "Federal Protection of Wetlands through Legal Process", Christopher B. Myhrum, Boston College Environmental Affairs Law Review, vol. 7, no. 4 (Newton Centre, Massachusetts: Environmental Affairs, Inc., Boston College Law School, 1979), 567.
3. Jon A. Kusler, Wetland Protection: A Guidebook for Local Governments, in collaboration with Corbin C. Harwood (Washington, D.C.: The Environmental Law Institute, 1977), 16.
4. Ibid.
5. Ibid.
6. Jon A. Kusler, Strengthening State Wetland Regulation (Washington, D.C.: The Environmental Law Institute, 1977), Preface.
7. U.S. Department of Agriculture, U.S. Department of the Army, U.S. Department of Commerce, U.S. Environmental Protection Agency, and U.S. Department of the Interior, Our Nation's Wetlands: An Interagency Task Force Report (Washington, D.C.: Government Printing Office, 1978), 1 and 49.
8. Reznat M. Darnell, Impacts of Construction Activities in Wetlands of the United States, in collaboration with Willis E. Pequengnat, Bela M. James, Fred J. Benson and Richard A. Defenbaugh, U.S. Environmental Protection Agency, Ecological Research Service, EPA-60013-26-045 (Springfield, Virginia: National Technical Information Service, 1976), Abstract.
9. Ibid.
10. Ibid.
11. Ibid.
12. Robert Leo Smith, Ecology and Field Biology (New York: Harper and Row, 1966), 686.

FOOTNOTES

Chapter I (continued)

13. Recognition of the values of inland wetlands prompted the Rhode Island Legislature to enact legislation (RIGL SS 2-1-18 to 2-1-25) entitled "An Act Relating to Freshwater Wetlands" (1971) declaring:

2-1-19: It is the public policy of the State of Rhode Island and Providence Plantations to preserve the purity and integrity of the swamps, marshes and other freshwater wetlands of this State... The health, welfare and general well-being of the populace and the protection of life and property require that the State restrict the use of wetlands and, therefore, in the exercise of the police powers such wetlands are to be regulated hereunder...

2-1-24: Whenever any person, firm, industry... shall commence any activity set forth in Section 2-1-21 without first having obtained the approval of the director, the director may serve said person with written notice to cease said operation and/or order the removal of any such fill placed illegally on such wetlands and the wetlands restored to their original state insofar as possible...

2-1-23: In the event of a violation of Section 2-1-21 of the General Laws, the director shall have the power to order complete restoration.

We abuse land because we see it as a commodity belonging to us.
When we see land as a community to which we belong, we may begin
to use it with love and respect.

--A Sand County Almanac
by Aldo Leopold

CHAPTER II

WETLAND ECOLOGY

Definition

The concept of wetlands represents the intergrading of terrestrial and aquatic ecosystems. Wetlands are areas where water is the primary factor influencing the environment and the associated plant and animal life.¹ Wetlands embrace a number of characteristics, including:

1. Elevation of the water table with respect to the ground;
2. Duration of surface water;
3. Soil types that form under permanently or temporarily saturated conditions; and
4. Various types of plants and animals that have become adapted to life in a "wet" environment.²

For purposes of the "National Wetlands Classification System" adopted by the U.S. Fish and Wildlife Service in 1977, wetlands are defined as "lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water".³ Wetlands are characterized by one or more of the following attributes:

1. At least periodically, the land supports predominantly hydrophytes*;
2. The substrate is predominantly undrained hydric soil**;
3. The substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season each year.⁴

In wetlands, the water table is at, near or above the land surface long enough each year to promote the formation of hydric (water-logged) soils and to support the growth of hydrophytes (plants capable of surviving in aquatic or water-logged soil conditions) as long as other environmental conditions are favorable. Wetlands span a continuum of environments where terrestrial and aquatic intergrade. The single feature that all wetlands share is the presence of more soil moisture than is necessary to support the growth of most plants. This excess of water creates severe physiological problems for all plants except hydrophytes which are adapted to life in water or in saturated soil. ⁵

The upland limit of a wetland is designated by the following:

1. A change from predominantly hydrophytes to upland vegetation;
2. A change from predominantly hydric to nonhydric soils; and
3. A change from land that is flooded at some time to land that is never flooded.

The lower limit of a coastal wetland coincides with the elevation of extreme low spring tide. At inland sites, a depth of two (2) meters below low water level or the deep water boundary of emergent aquatic vegetation, shrubs or trees that may grow beyond this depth is considered the lower limit of the wetland. ⁶

* Hydrophyte - Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

** Hydric soil - Soil that is wet long enough to periodically produce anaerobic conditions (oxygen deficient), thereby influencing plant growth.

Wetlands are known by common names such as swamps, marshes, bogs, flats, sloughs, beaches and rock shores. Because these common names have different meanings in different parts of the country, the term "wetlands" is used to cover all transitional habitats that occur between upland and aquatic environments where the water table is at or near the surface of the land, or where the land is covered by shallow water up to six (6) feet deep.

Wetlands Classification Systems

The "National Wetlands Classification System" recognizes five (5) major wetland systems. These major systems are outlined in Table II-1.

Table II-1. "National Wetlands Classification System" wetland systems

MAJOR WETLAND SYSTEMS

Marine

Estuarine

Riverine

Lacustrine

Palustrine

5 MAJOR WETLAND SYSTEMS

Marine and Estuarine Systems are each divided into two (2) sub-systems - Subtidal and Intertidal. The Riverine System has four (4) subsystems - Tidal, Lower Perennial, Upper Perennial and Intermittent. The Lacustrine System has two (2) subsystems - Littoral and Limnetic. The Palustrine system has no subsystem. ⁷

For planning purposes, Marine and Estuarine habitats include coastal wetlands, such as tidal marshes and mangrove swamps. The other three (3) major wetland categories describe freshwater systems, which account for ninety percent (90%) of the nation's wetlands.⁸ Lacustrine wetlands are associated with lakes while Riverine wetlands are found along rivers and streams. The word Palustrine means marshy and includes wetlands commonly known as marshes, swamps and bogs.

The hierarchial system developed by the U.S. Fish and Wildlife Service further divides the major wetland subsystems with reference to general structure, vegetation, flooding pattern, water chemistry and soils. Within the subsystems, six (6) classes are based on substrate material and flooding regime, and five (5) classes are defined by dominant vegetative life form.⁹ The dominance type, which is named for the dominant plant or animal forms, is the lowest level of the classification hierarchy.¹⁰ The six (6) classes based on substrate and flooding regime are listed in Table II-2.¹¹

Table II-2. "National Wetland Classification Systems" wetland classes based on substrate and flooding regime

WETLAND CLASSES

- Rock Bottom with a substrate of bedrock, boulders or stones
- Unconsolidated Bottom with a substrate of cobbles, gravel, mud or organic material
- Rocky Shore with a substrate of bedrock, boulders or stones
- Unconsolidated Shore with a substrate of cobbles, gravel, mud or organic material
- Streambed with any type of substrate
- Reef with substrate composed of the living and dead remains of invertebrates (i.e., corals, mollusks or worms)

6 WETLAND CLASSES

The Rock and Unconsolidated Bottom classes are flooded all or most of the time while the Rocky and Unconsolidated Shore classes are exposed most of the time. The class Streambed is restricted to channels and intermittent streams, and tidal channels that are dewatered at low tide.¹²

The type and duration of flooding in tidal wetlands are further described by four (4) water regime modifiers.¹³ In nontidal areas, eight (8) water regimes are used.¹⁴ These modifying terms are summarized in Table II-3.

Table II-3. "National Wetlands Classification System" water regime modifiers for tidal and nontidal wetlands

WATER REGIME MODIFIERS

TIDAL (4)

Subtidal

Irregularly exposed

Regularly exposed

Irregularly flooded

NONTIDAL (8)

Permanently flooded

Intermittently exposed

Semi-permanently flooded

Seasonally flooded

Saturated

Temporarily flooded

Intermittently flooded

Artificially flooded

12 WATER REGIME MODIFIERS

The "life form" of the dominant vegetation defines the five (5) classes based on vegetation forms.¹⁵ These five 'life form classes' are described in Table II-4.

Table II-4. "National Wetlands Classification System" wetland classes based on vegetative life form

WETLAND CLASSES

Aquatic Bed dominated by plants that grow principally on or below the surface of the water

Moss-Lichen Wetland dominated by mosses or lichens

Emergent Wetland dominated by emergent herbaceous angio-sperms

Scrub-Shrub Wetland dominated by shrubs or small trees

Forested Wetlands dominated by large trees

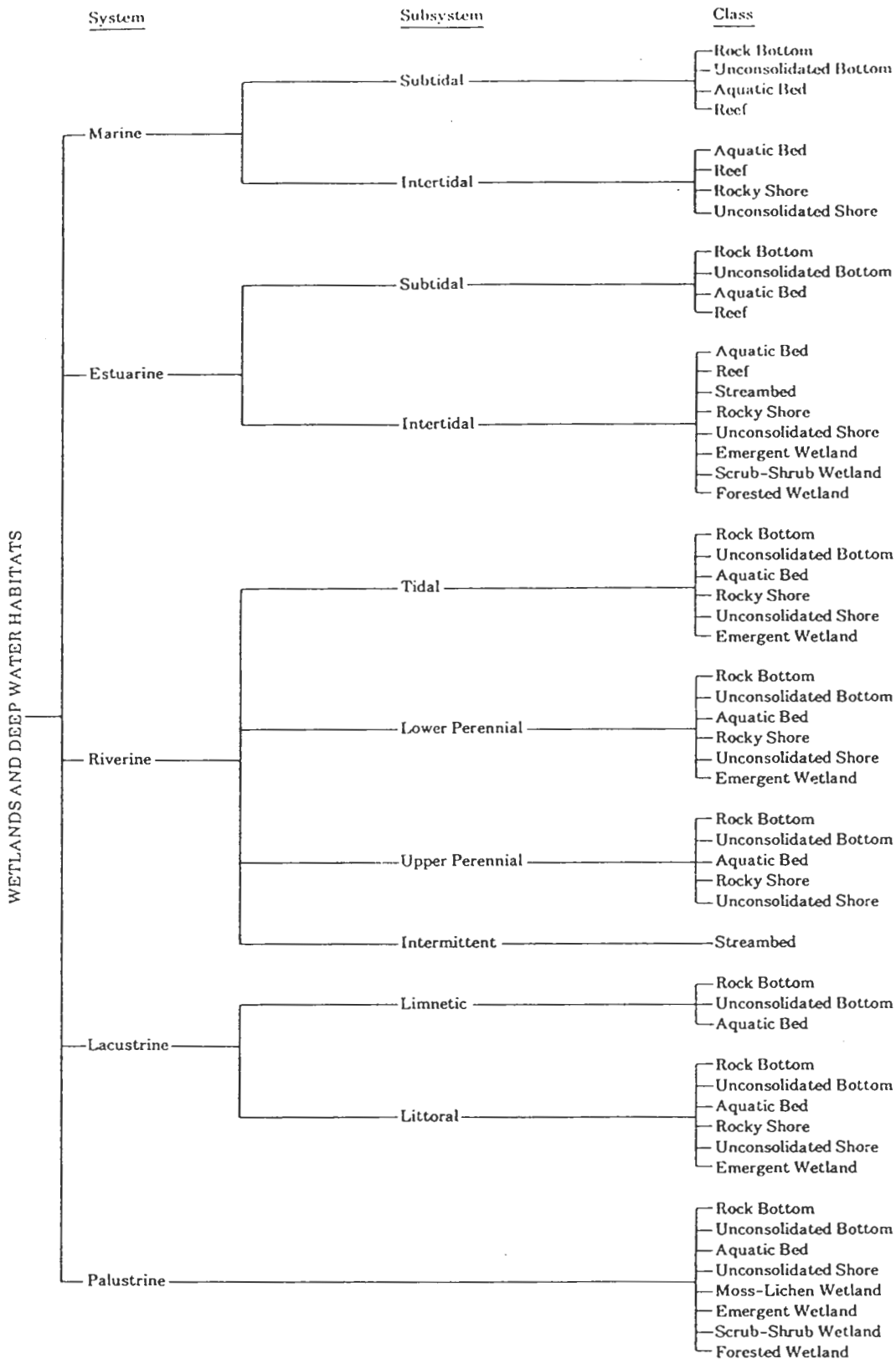
5 WETLAND CLASSES BASED ON VEGETATIVE LIFE FORM

A hierarchical system of water chemistry modifiers is used in the "National Wetlands Classification System" to describe the salinity of the water in wetlands. Fresh water wetlands are further divided on the basis of pH. A system of soil modifiers based on U.S. soil taxonomy is also incorporated into the Classification System.¹⁶

The Classification hierarchy of wetlands and deepwater habitats showing systems, sub-systems and classes is presented in Figure 1. Wetland categories are further described in Appendix A.

In the glaciated Northeast, the most common freshwater wetland types are deep marshes, shallow marshes, meadows, shrub swamps, wooded swamps, fens, bogs and open water.¹⁷ These freshwater wetland classes and subclasses are listed in Table II-5 and described in Appendix B.

Figure 1. "National Wetlands Classification" hierarchy of wetlands and deepwater habitats showing systems, subsystems and classes



Source: Lewis M. Cowardin, Virginia Carter and Francic C. Golet. Classification of Wetlands and Deepwater Habitats of the United States. (Washington, D.C.: Biological Services Program, FWS/OBS 79/31. 1979), 5.

Table II-5. Freshwater wetland classes and subclasses in the Northeast

WETLAND CLASS	WETLAND SUBCLASS
Open Water	(OW-1) Vegetated
	(OW-2) Nonvegetated
	(OW-3) Shallow Vegetated*
Deep Marsh	(DM-1) Dead Woody
	(DM-2) Shrub
	(DM-3) Sub-Shrub
	(DM-4) Robust
	(DM-5) Narrow-Leaved
	(DM-6) Broad-Leaved
Shallow Marsh	(SM-1) Robust
	(SM-2) Narrow-Leaved
	(SM-3) Broad-Leaved
Meadow	(M-1) Ungrazed
	(M-2) Grazed
Shrub Swamp	(SS-1) Deciduous Sapling*
	(SS-2) Bushy
	(SS-3) Compact
	(SS-4) Aquatic
	(SS-5) Evergreen Sapling*
Wooded Swamp	(WS-1) Deciduous
	(WS-2) Evergreen
Fen*	(F-1) Emergent*
	(F-2) Low Shrub*
Bog	(B-1) Emergent*
	(B-2) Shrub
	(B-3) Forested
8	26

* These classes and subclasses represent additions to or modifications of the system as published in Golet and Larson (1974). The class seasonally flooded flats and its subclasses have been deleted entirely.

With the advent of legislation restricting alteration of wetlands, it became necessary to construct a formal definition of wetlands to ease application of the law. For example, the Rhode Island "Freshwater Wetlands Act of 1974" defines freshwater wetlands

to include marshes, swamps, bogs, ponds, rivers, river and stream flood plains and banks, areas subject to flooding or storm flowage, emergent and submergent plant communities in water bodies, and that area of land within 50 feet of the edge of any bog, marsh, swamp or pond. Appendix C provides a description of each freshwater wetland classes delineated in the Rhode Island Wetlands Act.

It is important to realize that whatever wetland classification system is used, the actual physical features of the wetland, not its label, are the most critical from a wetlands management perspective. Wetland values and hazards, and management needs are determined by size, shape, depth, water quality, relationship to ground and surface water flow systems, vegetation, wildlife, flood hazards and soils.

Wetland Values

Wetlands vary significantly in terms of dominant vegetation, size, distribution, density, water quality, hazards, development pressures and other parameters. Despite these differences, wetlands share important characteristics and provide valuable natural functions. Wetland values can be grouped into five (5) broad categories; namely:

1. Hydrologic and hydraulic values;
2. Water quality maintenance values;
3. Food chain values;
4. Habitat values; and
5. Harvest and heritage values.

These values are discussed in more detail the following subsections.

Hydrologic and Hydraulic Values

All natural wetland functions are closely linked to wetland hydrology. Wetland primary productivity, nutrient cycling, wildlife habitat, harvest and aesthetic values are tied to the presence, movement, quality and quantity of water in the wetland. Water enters the wetland as precipitation, surface flow (run-off or tidal flow), or ground water discharge, and leaves the wetland as evapotranspiration, surface flow, or groundwater recharge. The existence and pattern of water movement through wetlands -- the pathways by which water moves, and the amount and timing of water moving along each pathway -- are basic to the functioning of wetlands in terms of producing organic materials, cycling nutrients, altering water quality and providing distinctive habitat. Hydrologic functions have their own values, including flood control, shoreline stabilization, absorption of storm wave energy, and some groundwater recharge capabilities. ¹⁸ These wetland functions are highlighted below.

Flood Storage and Conveyance of Flood Flows

Wetlands associated with rivers and streams store and slow flood waters, thereby reducing flood peaks and increasing the duration of flow. Wetlands act as flood control reservoirs, spreading the release of a given volume of flood water over a longer time and thus reducing the peak flow rate that the downstream channel must handle. Since wetlands and flood plains are generally located in flat areas, they permit flood waters to spread out, thus providing

temporary storage. In addition, natural vegetation and meandering stream courses slow the passage of flood waters through physical resistance. ¹⁹

The flood-control effectiveness of any wetland depends on its size, hydrologic character and location in the drainage basin, as well as the size, hydrologic character, flooding characteristics and distribution of streams and rivers in the drainage basin. Flood control effectiveness is generally greatest during high-intensity, short-duration storm events which generate the largest floods. ²⁰

The importance of wetlands in flood storage can be appreciated when it is recognized that a wetland one (1) acre in size will hold 330,000 gallons of water if flooded to a depth of one foot. ²¹

Filling a wetland or channelizing an associated water course will negate the function of flood storage, causing increased flood heights on adjacent and upstream lands and increased velocities downstream.

Barriers to Waves and Erosion

Coastal and inland wetlands along lakes and streams reduce the impact of storm tides and waves by dissipating much of their energy before they reach upland areas. Wetland vegetation, with their complicated root systems, form dense mats which bind and protect the soil from eroding. ²²

Sediment Traps

Wetlands support a lush vegetative cover and are natural sediment traps in their unaltered condition. Surface runoff flowing through wetlands from adjacent uplands will be slowed by both the

flat slopes and the dense vegetation, permitting much of the sediment load to settle out. By acting as flood storage reservoirs, wetlands reduce the amount and velocity of flood waters, thereby, reducing erosion and causing flood waters to release their sediments. Wetland vegetation filters and holds the sediment which would otherwise be transported downstream.²³ Overloading wetlands with sediments will, however, decrease their ability to perform this valuable control function.

Water Quality Values

Water passing through a wetland undergoes a number of changes. Surface flow is slowed, allowing sedimentation and absorption of some materials. Larger particles suspended in the water are filtered out by aquatic vegetation. Some dissolved materials are precipitated when inflowing water comes in contact with water of a different quality.²⁴

Other water quality changes occur as a result of biological activities in the wetland. Oxygen is added to the water as a result of photosynthesis. The production of oxygen by wetlands is important in maintaining the global oxygen/carbon ratio and in purifying the air in urban areas. Nutrients, metals, hydrocarbon pollutants and other chemicals are taken up by plants during the growing season. Some of these materials may later be released through plant decay. Organic materials are decomposed by microbiota in wetland sediments.²⁵

Water Supply

Wetlands have a valuable influence on the quantity of surface water that supplies large portions of the population with clean water for recreational, domestic and industrial uses. The low, flat surfaces of wetlands gather runoff from adjacent uplands and allow the water level to build up as they slowly release water to streams, thus reducing peak flood flows. After wetlands are flooded, they may recharge ground water aquifers for several weeks. In addition, wetland water storage augments the low flows of streams for an even longer period. ²⁶

Hydrologic studies indicate that some wetlands are a valuable potential source of ground water. Wetlands can be underlain by productive ground water supplies called aquifers. ²⁷ The importance of these wetlands as a source of ground and surface water will increase with the growth of urban centers and dwindling water supplies. Particular care must be taken not to over-develop or pollute these valuable natural resources.

Pollution Control

Inland wetlands serve major pollution control functions by protecting lakes and streams from sediments, nutrients and other natural and man-made pollutants. Coastal wetlands also assimilate large quantities of nutrients, sediments and other pollutants that would otherwise reach recreational beaches. Wetland vegetation filters sediment, organic matter and chemicals. Microorganisms utilize dissolved nutrients and break down organic matter. ²⁸

Natural and man-made wetlands are now being used as tertiary

treatment facilities for domestic, industrial and storm water wastes.

Food Chain Values

Wetlands are among the most productive biological systems on earth. In wetlands, as in all ecosystems, plants convert solar energy to chemical energy, producing organic material as plant tissue. Some of this plant tissue is consumed by herbivores during the growing season while some is consumed as detritus. The energy trapped by wetland plants may be passed on to either herbivore-based or detrital food chains. ²⁹

Wetlands -- part water and part land -- may supply either an aquatic or terrestrial food chain, or both. The food chain value of a wetland depends on how effective the environment is in trapping energy and passing it on to these food chains, and on how effective the wetland is in biochemical cycling (i.e., tapping reservoirs of elements available in the biosphere and making those elements available to the biota). Because nutrients, such as nitrate, can be exported from a wetland via water outflow, the wetland can contribute to food chains downstream as well as within the wetland. ³⁰

Wetland systems are subject to cyclical changes, such as annual or biannual flooding and drydown. Not only do productivity and food chain values change with these environmental cycles, but the maintenance of these values over the long-term seem to depend on the maintenance of such periodic pulsing. ³¹

Without wetlands, there would be a very rapid downstream transport of nutrients to the sea. Therefore, wetlands tend to retard the

biochemical cycles and retain nutrients for local production and partial recycling. Marshes, swamps, estuaries and lakes tend to retain nutrients and recycle them for long periods of time. Those nutrients which do eventually leave the wetland system via streams constitute an energy-rich output which has a positive effect on downstream production. ³²

Source of Nutrients for Fish and Shellfish

Coastal wetlands are important sources of nutrients for commercial fisheries and shellfish industries. The net primary productivity (net plant growth) of salt marshes exceeds that of all but the most intensely cultivated agricultural areas. These plants provide a rich source of nutrients for aquatic life as they decay and are washed into tidal creeks, bays and offshore waters. Salt marshes and inland wetlands also provide protected nursery grounds for the young of important commercial fish species. ³³

Food Production

Due to their high productivity, tidal and inland wetlands in their natural state have food production potential for the harvesting of marsh vegetation and aquaculture. This capability will become increasingly important in the future.

The drainage of coastal and inland wetlands for upland agriculture is a common but ecologically-unacceptable practice. Drained land poses severe limitations due to periodic flooding and wetness, high acidity, subsidence, lack of nutrient balance, poor air-soil moisture relationships and problems with workability. Aquaculture

holds the promise of being a more profitable and less destructive method of food production in wetlands. ³⁴

Habitat Values

Wetlands provide essential breeding, nesting, feeding, resting and predator escape habitat for numerous waterfowl, mammal and reptile species. Some animals depend on wetlands in order to carry out all their life functions; others use wetlands for only one or two functions. Some species are resident in a particular wetland throughout their life, while some are residents only during a particular life-cycle stage or season of the year. Other animals use the wetland throughout their life for feeding but reside primarily in deeper water or in upland habitats. ³⁵

The wetland "land-water interface", including upland buffer areas, is among the richest wildlife habitat in the world due to the presence of the following characteristics:

1. Abundant water needed for all life forms;
2. Rich and diverse vegetation which serves as the basis for food chains; and
3. Cover provided by both wetland and shoreland vegetation. ³⁶

The value of a particular wetland as wildlife habitat depends on a number of natural factors. ³⁷ Some of these factors are listed in Table II-6.

Table II-6. Natural factors that determine a wetland's value as wildlife habitat

HABITAT FACTORS

Diversity of wetland types present in the wetland, including size and spatial arrangement of habitats

Diversity of life forms and subforms of vegetation and their arrangement in relation to one another

Amount of open water and water regime (especially, fluctuation in water level)

Relation of wetland to topographic features, lakes and streams, surrounding habitat and other wetlands

Water chemistry

Energy flow between systems

6 HABITAT FACTORS

Wetlands constitute the principal habitat for ducks, geese, swans, herons, marsh hawks, egrets, and fur-bearing animals such as muskrats, minks, otter and beaver, and for some fish species. Other game species, including deer, moose, rabbits and hares, grouse, quail, woodcock, pheasant and turkey, although not generally associated with wetlands, also use wetlands, as do marsh birds, song birds, eagles, owls, woodpeckers and osprey. ³⁸

Diversity and abundance of most wetland animal groups, particularly birds and invertebrates, increase with increasing structural diversity of habitat. The greater the habitat zonation (vertical and horizontal) and amount of edge between zones (ecotone effect), the greater the species diversity in a wetland. The location of the wetland is also important. Isolation tends to reduce the habitat value while proximity to other wetlands increases habitat value. The diversity of nearby habitat and the presence of adequate buffer areas

is also important in maintaining the habitat value of a wetland.³⁹ Diverse adjacent habitats provide nest sites for herons, terns, certain waterfowl and other birds, denning sites for raccoons, otters and other mammals, travel lanes between wetlands for frogs, turtles, salamanders and other vertebrates, food, such as willows for beaver, and protection from weather or predators.⁴⁰

Habitat for Rare and Endangered Species

Almost thirty-five percent (35%) of all rare and endangered wildlife species are either located in wetlands or are dependent on them for their survival.⁴¹ Preservation of wetland habitat in a relatively undeveloped state is essential for continued survival of these species, and their protection as a gene pool and source of scientific research.

Critical Wetland Size for Wildlife

There is no minimum size of wetland below which the habitat has no value for wildlife. The space required by various wetland species ranges from minute (a crayfish hole for a mosquito) to hundreds of acres for geese and swans. Depending on their location, wetlands of less than one (1) acre in size may have extremely high habitat value for certain animals, such as small ephemeral prairie potholes have for nesting ducks.⁴²

If stressed, small wetlands in urban areas may not have diverse or abundant animal populations, but the aesthetic and educational values of such wetlands probably outweigh any shortcomings in fish and wildlife diversity and production.⁴³ The small marsh in a city

that attracts a pair of mallards or redwings, or the salmon stream running through a town may bring pleasure and natural beauty to a large number of people.

Harvest and Heritage Values

Harvested resources include the broad categories of food, fiber, fuels and water; or more specifically, fish and shellfish production, waterfowl production, timber and crop production, fur-bearing animals, and peat or above-ground biomass that can be harvested to produce energy.⁴⁴ The harvest value of a wetland depends on the contribution of the wetland to the production of something harvested or harvestable by man. Heritage values include a whole array of "intangible" wetland values, including historical, anthropological, educational, recreational, aesthetic and symbolic values. In addition, some wetland resources or functions are valued primarily on ethical or aesthetic grounds; for example, wetland-dependent endangered species and climate modification or amelioration functions of wetlands.⁴⁵

Harvest and heritage values differ from habitat, water quality maintenance, and other functional values of wetlands in that they address direct human use of or benefit from wetland resources. Use values of wetlands are more difficult to define than functional values because of the significance of human interaction with the wetland as a factor in determining value.⁴⁶ Educational, recreational, aesthetic and other heritage values of wetlands are intertwined in human experience with wetlands.

Socio-cultural values or functions of wetlands are human perceptions of the forms, processes and productions of wetlands over time. These functions are multi-dimensional with spatial, temporal, psychological, and socio-economic components of human experience with wetlands. Socio-cultural functions of wetlands have played a vital role in the evolution of human relations to the environment.⁴⁷

The size of a wetland does not determine its heritage value. There is no minimum size for heritage value. Location and accessibility are more important than size in determining the cultural value of a particular wetland.⁴⁸ Small wetlands that are easily accessible to urban populations often have high cultural value.

Timber and Crop Production

Forested wetlands are an important source of timber in many sections of the country despite the physical problems of timber removal. Wild rice, cranberries, cattails and salt marsh hay have traditionally been harvested from wetlands.⁴⁹

Recreation

Water bodies and related wetlands are not only essential to a community's environmental well-being, but they also provide valuable recreational and cultural amenities in the form of both water and non-water based leisure activities. There are many different recreation values associated with wetlands. Many of which are passive and inexpensive recreation activities that require little or no organization, equipment or development, and are spread out over a

large area rather than concentrated in a small area. ⁵⁰

Historic and Archeological Values

Archeological sites are often found in or adjacent to wetland areas. Indian settlements were often located near the rich supplies of fish and shellfish found in wetland areas. Historic sites such as early manufacturing mills were frequently situated on water courses and add considerably to a wetland's aesthetic value. Wetlands also bear important historic associations as battlegrounds, sites of early settlements and scenes of inspiration for writers and artists. These natural features often influenced early patterns of community growth and communication, lending to their historical significance today. ⁵¹

Education and Research

Wetlands are living museums where the dynamics of ecological systems can be taught and observed. Wetlands provide unique opportunities for nature observation and scientific study by scientists, students and the general public. Wetlands are ideal areas for natural outdoor recreational and scientific research laboratories because of the intimate association of plant and animal life and life support cycles that these habitats exhibit. A wetland is a superb self-contained, living laboratory for studying ecosystem dynamics, including energy flow, the stability of diversity, recycling, carrying capacities, etc. ⁵² Education is probably the least recognized value of wetlands, but appreciation of this aspect is increasing.

Open Space and Aesthetic Values

Coastal and inland wetlands are natural areas of great diversity and beauty, providing open space for recreation, meditation and visual enjoyment. Wetland aesthetic values depend on the wetland type, size, land form contrast and diversity, associated water body size and type, surrounding land uses and other factors.⁵³ Some wetlands, such as bogs, are appealing in their uniqueness as natural habitats. Others, such as urban wetlands, have particular value as quiet, natural places in a largely unnatural environment. Protecting the integrity of these wetlands is essential to the environmental and social well-being of the individual community and the nation at large.

Endangered Species

Endangered species are an important part of the heritage value of wetlands because they are identifiable concrete reminders of the importance of ecological diversity and temporal change. Among those endangered species which are widely distributed but low in numbers, some are located at the top of wetland food chains or play other important roles in wetland ecosystems.⁵⁴ Because of their sensitivity to environmental change, endangered species can often be used as indicators of the health of wetland systems. All endangered species have value as gene banks for future evolutionary change or possible human use.⁵⁵

Endangered species have special value in stimulating interest in the environment and history. Many people initially find it easier

to relate to an endangered species than to an ecosystem. The concept of "endangered landscapes" -- rare and disappearing wetland systems -- may have similar value.⁵⁶ Endangered species may thus serve as a tool for bringing wetland values to public attention.

Wetland Dynamics

Natural Processes At Work

Wetlands are dynamic ecosystems, subject to natural and man-induced directional changes over time. Vegetation is one component of wetlands that is involved in many wetland functions. Energy flows and wildlife values are greatly influenced by vegetation. Flood control and water quality functions also vary according to the dominant vegetation community on the site. Changes from one vegetational class to another affect these functions. Proper management of dynamic ecosystems is enhanced by knowledge of the directions and rates of change that affect the functions and values that management seeks to either protect or enhance.⁵⁷

Change is inherent in wetland systems. Temporary stages are essential to maintaining the integrity of the ecosystem. There is a limit, however, to the amount of change that a wetland system can undergo and still remain in a particular condition. Many natural processes have been operating to both increase and decrease the diversity of freshwater habitats in New England since their glacial origins 10,000 to 12,000 years ago.⁵⁸

Plant succession is responsible for the majority of changes that occur in wetlands. In temperate regions, freshwater wetlands

normally follow the pattern of hydrarch succession from hydric conditions (open water) to more mesic conditions (wooded swamps) unless natural disturbance factors or man intervenes. The rate of succession and the seral stages represented vary considerably depending on the plant species that assume dominance, the rates of sedimentation and the hydrology of the wetland basin. 59

The process of wetland succession is a continuous one. As succession proceeds, surface water generally decreases in depth and eventually becomes seasonal. The dominant life forms of vegetation change from submergents and floating-leaved plants in the open water stage to emergents in the marsh and meadow stages, then to shrubs and finally to trees in the swamp stages. Throughout this process, organic, and possibly mineral, deposits thicken. The end point of hydrarch succession is not the dry forest of "old field" succession but a site with wet, usually organic, soils (histosols) with a closed cover of trees. 60

Bog development in the northern latitudes exhibits a different route of hydrarch succession. If the original lake basin has steep sides, if drainage is congested and if the supply of nutrients within the basin or from the surrounding land is meager, the lake may give rise to a marginal mat of sedges or other emergents leading toward bog development. With time, the floating bog mat will thicken and become dominated by sphagnum moss (Sphagnum spp.) and low shrubs such as leatherleaf (Chamaedaphne calyculata), then taller shrubs and finally evergreen trees. When the basin has filled in entirely and peat deposits have consolidated, deciduous trees may assume dominance. 61

In the absence of outside disturbances, the abundance of wetland classes intermediate between open water and forested wetlands is reduced, creating a polarity between the initial and climax stages of succession. Deep water, including vegetated open water, and forested wetlands are the most stable classes in southern New England; open water because soils in this region have low rates of erosion and lakes tend to be oligotrophic; wooded swamps because these habitats represent the end point of succession in the region. ⁶²

Changes from open water to deep marsh represent a major change in water regime, such as permanently or semi-permanently flooded conditions to seasonally or temporarily flooded conditions. Shallow marsh, meadow and shrub swamp are the wetland classes undergoing the greatest successional changes. These classes all have a seasonally flooded water regime similar to forested wetlands; the end point of succession. Thus succession from shallow marsh, meadow and shrub swamp to forested wetland is merely a case of replacement of one dominant life form by another. ⁶³

Under certain conditions, however, disturbance factors interrupt or temporarily reverse the classical pattern of hydrarch succession. Man, fire, floods, beavers and the deposition of soil may alter environmental conditions and set succession back to an earlier stage or maintain wetlands in the intermediate classes. Beavers play an important role as agents of disturbance in creating habitat diversity by flooding forested wetlands and encouraging the reestablishment of marsh vegetation. Wildfires help to maintain wetland diversity as well, by periodically killing trees, shrubs and herbaceous plants, thus changing wetlands back to an earlier

successional stage. In recent years, the control of wildfires and beavers has reduced the impact of these important natural disturbance factors which tended to create diversity in wetlands. ⁶⁴

Wetland succession in New England has also been set back, modified or arrested by man as native peoples and later European settlers cleared the forests for agriculture. Human activities resulted in the reestablishment of marshes and meadows in place of wooded swamps. With the decline in agriculture in the Northeast during the 1800's, the passive changes in vegetation brought about by natural succession again overshadowed the active impact that man had on vegetation communities during the settlement era. Abandoned fields quickly reverted back to forests which continue to dominant the present landscape of the region. ⁶⁵

As a result of succession, wooded swamps now occupy more acreage in Rhode Island than all other wetland types combined. ⁶⁶ Changes from wooded wetlands to other wetland types are almost entirely due to man's intervension. ⁶⁷ In many cases, man is responsible for creating wetlands. Flood control and hydroelectric dams, reservoirs, impoundments for irrigation, farm ponds, and pits, ponds and depressions associated with mining, quarrying and road construction are examples of human activities that create wetlands. ⁶⁸

Development in rural and suburban areas is the principal factor affecting the abundance and diversity of wetlands and the path of succession. Intensive land development impacts not only the nature of existing wetlands but results in the complete or partial destruction of valuable wetland functions. Current growth trends in

the Northeast are expected to continue, thus jeopardizing those remaining unaltered wetlands.

Wildlife Dynamics

As wetlands change from one successional stage to another, wildlife populations within these wetland communities change as well, for each species has particular habitat requirements that only specific wetland types can satisfy.⁶⁹ During the last 10,000 years, the composition of wetland wildlife populations has fluctuated between primarily marsh species such as muskrats and waterfowl, and forest species such as deer and grouse. The current trend toward decreasing wetland diversity in the region suggests that wildlife diversity is also decreasing.⁷⁰

In a region where prime habitat for waterfowl and other marsh wildlife is already scarce, further reductions in such habitat is likely to occur. The abundance of waterfowl, marsh birds, muskrats and many other species of wetland wildlife will gradually but steadily continue to decline in Rhode Island unless natural or man-made disturbances act to set wetland succession back to an earlier stage.⁷¹

As society continues to enjoy more leisure time, outdoor activities will remain popular forms of recreation. Wildlife is becoming an important source of enjoyment for non-consumptive uses, including bird watching, photography, hiking, canoeing, camping and education. Viewing a diversity of wildlife in their natural habitat is a meaningful experience for many people. As development in the

region continues, and the opportunity to hunt declines, emphasis on the management of non-game species will likely increase to reflect societal needs and desires. ⁷²

Management Implications

The relative abundance of wetland types and diversity of wetland plant and wildlife communities has undoubtedly fluctuated considerably since the formation of most of the region's wetlands. Many of the wetland changes that have occurred in the past will continue to occur in the future. Wooded swamps will grow in acreage as a result of natural succession, and non-wooded wetlands will decline. Shallow marshes and meadows are easily altered and will likely suffer the greatest damage and destruction. Other wetlands will be altered unintentionally during construction activities. ⁷³

It is neither prudent nor possible to halt successional trends on a regional level. On the other hand, the value of heterogeneity in wetland ecosystems is important. Resource management decisions are often made without regard for the dynamics of natural habitats. A knowledge of wetland dynamics should be an integral part of wetland management. ⁷⁴

Public agencies charged with the regulation of wetlands should examine the implications of wetland vegetation changes and trends over time. Statistics on the abundance of individual wetland types from year to year do not constitute a sound basis for wise resource management and comprehensive decision-making policy. Resource agencies need to adjust their programs from static protection to

management that is comparable and compatible to the resource itself. This will necessitate a planned dynamic program of protection and management to insure that the public values being protected today will continue to be provided in the future. ⁷⁵

Methods for evaluating wetlands for a variety of values are available. These resource planning tools should be employed so that management decisions on the fate of our nation's wetlands may be more objective. In situations where the value of wetlands is declining because of natural or man-induced changes, resource agencies should consider active management of public lands. In addition, the long-term effects of such changes should receive more consideration in efforts to manage wetlands wisely for all natural values. ⁷⁶

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75. Larson and Golet, Models of Freshwater Wetland Change in Southeastern New England, 185.

76. Joseph S. Larson (Editor). Models for Assessment of Freshwater Wetlands, University of Massachusetts, Water Resources Center, Publication No. 32 (Amherst, Massachusetts, 1976), 5.

Much of the urban growth experience in the United States over the past quarter century has consisted of people running away--from other people in the older cities, now even from the suburbs to the mountains and the seas. Now it is dawning on us that there is not really any place to run to . . . There is no hiding on two-acre lots.

--The Use of Land,
William Reilly, Editor

CHAPTER III

CONSTRUCTION ACTIVITIES THAT IMPACT

WETLANDS

Overview

This chapter provides an overview of common construction activities that affect wetlands and have the potential for generating physical, chemical and biological impacts on wetland environments. Wetland impacts vary with locale and from site to site. The "house-keeping" practices employed at the construction site will also significantly affect the magnitude of the alteration impacts. Sloppy engineering practices will tend to magnify environmental impacts. ¹

Wetlands may be impacted directly by construction that takes place within or at the margins of the wetland, or indirectly by construction activities on adjacent floodplains, banks and shores. Numerous construction activities are associated with large development projects. For purposes of this report, these activities are grouped into ten (10) classes of activities as follows:

1. On-site activities prior to construction;
2. Construction of access roads;
3. Establishment of construction camp;
4. Storage of materials;
5. Clearing of the site;
6. Earth excavation and filling;
7. Preparation and construction of the foundation;
8. Disposal of excess excavated materials;

9. Major construction activities; and
10. Site restoration and clean-up.²

All ten classes of activities may not be required for all construction projects, particularly for small projects in existing built-up areas. In addition, the long-term impacts of the construction project will depend on the nature, use and operation of the structure(s), and by other activities and developments which occur as a result of the initial construction project.³

Construction activities can be grouped according to the types of wetland environments generally impacted by these activities. Construction activities associated with floodplains, banks and shores include:

1. Pre-construction activities;
2. Construction involving impervious surfacing and earthwork;
3. Line construction activities;
4. Building construction;
5. Construction of open air industrial plants;
6. Construction of drainage structures;
7. Tunnel construction; and
8. Mineral extraction on land.⁴

Construction activities associated with wetlands and water bottoms include:

1. Masonry dam construction;
2. Construction of fills in wetlands;
3. Drainage ditches;
4. River channel modifications;
5. Bridging in wetlands; and
6. Dredging and placement of dredge spoils.⁵

Construction activities associated with waterway margins include:

1. Construction of breakwaters, sea walls and shore property;
and
2. Port development. ⁶

Off-shore construction activities that affect marine environments include:

1. Mineral extraction from the continental shelf; and
2. Pipeline construction. ⁷

In order to evaluate the actual and potential impacts of construction activities on wetlands, it is essential to outline the engineering aspects of various types of construction activities. A brief overview of the major construction activities and facilities associated with wetland environments is presented below.

Construction Activities Associated with
Floodplains, Banks and Shores

Pre-Construction Activities

The activities required prior to construction are similar for most projects. These activities involve the design and initial on-site lay-outs accomplished by surveying and preliminary engineering work. Surveying generally requires minor clearing of vegetation and the placement of stakes, flags and pins. The preliminary engineering work involves borings to establish the nature and extent of subsurface formations. Seismograph surveys may be employed that require the movement of men and machines over the construction site. ⁸

Construction Involving Impervious Surfacing and Earth Work

Activities that involve impervious surfacing and earth work include the construction of highways, roads, streets, driveways, airports, parking lots, playing fields, dikes, levees and earthen dams. The activities and facilities that characterize impervious surfacing and earth work construction are listed in Table III-1. ⁹

Table III-1. Impervious surfacing and earth work construction activities and facilities

ACTIVITIES AND FACILITIES

Clearing and grubbing

Earthwork

Rock excavation

Subgrade stabilization

Base course construction

Aggregate production

Portland cement concrete pavements

Bituminous pavements

Equipment parking, maintenance and service areas

Paving plants

Site restoration

Riprap

Borrow pits and landfill areas

13 ACTIVITIES AND FACILITIES

Line Construction Activities

Line construction activities include pipelines of various types, water and sewer lines, oil and gas pipelines, storm sewers, land and

building drains, drainage canals, power lines, pole lines, and underground electrical and communication lines. The activities and facilities associated with line construction are summarized in Table III-2. ¹⁰

Table III-2. Line construction activities and facilities

ACTIVITIES AND FACILITIES

Clearing and grubbing

Ditch excavation

Storage and/or disposal of excavated materials

Preparation and delivery of pipe, cable or rickwell

Pipe laying

Lining of ditch and canal

Backfilling of the ditch

Installation of pipeline appurtenances such as manholes, valves, fire hydrants and pumping stations and electrical power poles

Disposal of surplus excavated materials

9 ACTIVITIES AND FACILITIES

Building Construction

Similar types of activities are involved in the construction of all buildings regardless of the size or use of the structure. The characteristics of the site, and the design of the building will dictate the extent of construction activities required. The activities and facilities associated with building construction are listed in Table III-3. ¹¹

Table III-3. Building construction activities and facilities

ACTIVITIES AND FACILITIES

Site preparation

Demolition

Excavation

Foundation construction

Storage yard for materials

Construction of building/structure, parking lots and access roads

Installation of mechanical and electrical equipment

7 ACTIVITIES AND FACILITIES

Construction of Open Air Industrial Plants

Industrial plants such as oil refineries, chemical plants, cement plants, power plants, and steel fabricating yards are generally built and operated in the open. Construction operations for such facilities differ somewhat from conventional building construction. Some elements of these open air industrial plants, such as control systems, specialized equipment, laboratories and offices, are housed in buildings. Therefore, the development of these industrial plants combine aspects of open air construction with standard building construction. The activities and facilities typically associated with open air industrial plant construction are summarized in Table III-4. ¹²

Table III-4. Open air industrial plant construction activities and facilities

ACTIVITIES AND FACILITIES

Site preparation

Excavation

Foundation construction

Plant construction

Construction of plant access roads

5 ACTIVITIES AND FACILITIES

Construction of Drainage Structures

Drainage devices include a wide spectrum of structures ranging from small, corrugated metal culverts which discharge the drainage from a few acres, to large suspension bridges over major rivers. In general, most drainage structures can be divided into these two (2) classes -- culverts and bridges.

Culverts are employed primarily to permit drainage through normally dry channels and streams with small flows. Culverts generally span less than fifty feet (50'). Bridges, on the other hand, are used to cross major waterways requiring spans of over fifty feet. Bridge piers may be constructed using wet or dry construction techniques. The activities and facilities associated with the construction of these two classes of drainage structures are presented in

Table III-5. ¹³

Table III-5. Drainage structure construction activities and facilities

ACTIVITIES AND FACILITIES

Culvert construction
 Channel changes
 Bridge piers - wet or dry construction
 Construction of bridge abutments
 Construction of bridge superstructure

5 ACTIVITIES AND FACILITIES

Tunnel Construction

Tunneling is necessary when highways, railways, subways, canals, large sewers and other grade-restricted installations must traverse major topographic features, such as mountains, or when it is desirable to place such facilities underground beneath surface structures and rivers. Tunnels may be constructed through rock and earth, or under water. In all situations, tunneling operations require the storage of large amounts of materials as well as access to a concrete plant for construction of the tunnel liner. The activities and facilities associated with tunnel construction include those listed in Table III-6. ¹⁴

Table III-6. Tunnel construction activities and facilities

ACTIVITIES AND FACILITIES

Tunnels in rock
 Tunnels in earth
 Tunnels under water
 Cut-and-cover tunnels
 Construction plant and yard

5 ACTIVITIES AND FACILITIES

Mineral Extraction on Land

Mineral extraction on land includes strip mining, shaft and tunnel (drift) mining, and mineral extraction from wells. Strip mining includes open-pit mining and is used to recover minerals from surface or shallow deposits. The most common minerals extracted by this method are coal, rock, sand and gravel, copper, iron and other ores. The mining process involves the use of large excavating machines that create strips extending twenty to forty feet (20-40') wide longitudinally for the length of the deposit.

Shaft and tunnel mining is used to extract mineral from deep deposits. These minerals are mined by sinking a vertical shaft to the mineral layer, tunneling into the deposit and transporting the ore horizontally then vertically to processing plants at the surface. Tunneling operations utilize heavy equipment and require blasting and shoring to prevent cave-ins. The general methods employed in strip and drift mining are the same as those used in impervious surfacing and earthwork described earlier.

Petroleum, natural gas, sulfur, mineral brines and water are recovered from wells drilled into the formations containing these minerals. The construction operations involved include drilling the bore hole, securing the pipe casing, cementing the casing to prevent the movement of liquid and gases between the casing and the bore hole, and installation of production equipment. These operations usually involve a limited land area. The activities associated with mineral extraction on land are summarized in Table III-7. ¹⁵

Table III-7. Mineral extraction activities on land

ACTIVITIES

Strip mining

Shaft and tunnel (drift) mining

Mineral extraction from wells

3 CATEGORIES OF ACTIVITIES

Construction Activities Associated
with Wetlands and Water Bottoms

Masonry Dam Construction

Dams are constructed on flowing waterways for the production of hydro-electric power, storage of water for irrigation, urban or industrial use, flood control, or for a combination of these purposes. Dams may be constructed of concrete (i.e., masonry), rock-fill or earthfill.

Masonry dams are built in narrow, deep canyons, normally with rock walls and foundations which permit the rapid impoundment of water. Rockfill and earthfill dams are usually constructed in areas where the flow rate is relatively slow, the valley walls are of earth, and the floodplain is relatively broad.

The operations involved in the construction of earthfill and rockfill dams are essentially the same as those discussed under earthwork construction. The activities and facilities associated with the construction of masonry dams are presented in Table III-8. ¹⁶

Table III-8. Masonry dam construction activities and facilities

ACTIVITIES AND FACILITIES

River diversion

Foundation and abutment excavation

Grouting

Concrete for dam structure

Cement/aggregate production

Construction plant

Construction camp

Appurtenances for masonry, earth and rockfill dams (including overflow spillways, dam gates, penstocks, power plants, and irrigation water diversion structures)

8+ ACTIVITIES AND FACILITIES

Construction of Fills in Wetlands

Fills for highways, airports, railways and other similar types of construction in wetlands involve building over unstable substrates of organic or inorganic origin. The methods employed in filling activities are dependent on the depth and characteristics of the unstable material and the nature of the underlying stable substrate.

Specific methods of ditch and fill construction include the following:

1. Excavation and replacement of stable fill method is used where the depths of unstable material do not exceed ten feet (10');
2. Displacement method is used where deeper deposits (10 to 25 feet) are encountered; and

3. Preconsolidation method is used where materials can be stabilized by overloading which essentially squeezes out the water and compacts the underlying materials. ¹⁷

Construction of Drainage Ditches

Drainage ditches are constructed in low-lying areas and wetlands to enhance surface run-off, to lower the water table level, and to remove water from wetlands. Drainage ditches may be excavated by the following methods:

1. Dry land excavation; and
2. Floating dragline. ¹⁸

In the floating dragline method, materials are excavated using a steam-shovel or grab operating from a barge. The excavated material is deposited as a spoil bank on one or both sides of the excavation.

River and Channel Modifications

River and channel modifications are carried out to stabilize the channel or to shorten the length of the river by cutting off meanders. In the latter case, the dry land excavation method is usually employed to create a broad, deep trench which almost connects with the river at either end. The end sections between the river and the trench are then blasted open to admit the river into the new channel. The old channel or oxbow may be filled or allow the remain as a man-made or remnant oxbow. ¹⁹

Bridging in Wetlands

In wetland areas where the unstable material is quite deep or extensive, the most economical solution for linear construction such as highways or railways is to bridge the wetland. This bridging is accomplished by placing the bridge super-structure on pile bents and bent caps. The operation proceeds from the bank outward with pile driving, pile caps and bridge super-structure placed consecutively. ²⁰

Dredging and Placement of Dredge Spoils

Dredging refers to excavation in water. Dredging is employed to deepen channels, ports and harbors, and to provide fill materials for the construction of piers, docks, wharves, dams and underwater foundations. The excavated material may also be used for dikes, levees and other terrestrial structures. Dredging is also used to maintain open channels, canals and other waterways, for the desiltation of dam reservoirs, for the excavation of construction materials such as sand, gravel and shells, and for the recovery of bottom minerals such as gold, tin and diamonds.

The two (2) major methods of dredging are those that employ the following:

1. Bucket or mechanical dredges classified as grab (orange peel or clam shell) dredge, dipper dredges and ladder dredges; and
2. Hydraulic dredges including the plain suction, draghead and cutterhead types. ²¹

Bucket dredges are used in areas where hydraulic dredges are not

practical such as around docks, piers and in corners. The most commonly used dredge today is the pipeline cutterhead dredge. The prime function of the pipeline cutterhead dredge is to excavate and move material hydraulically to its ultimate location without rehandling.

Bucket dredges must discharge the excavated materials alongside the place of excavation, or into barges or scows adjacent to the dredge which tow the dredge material to a disposal site. Hydraulic dredges discharge the dredge spoil ashore or in water areas adjacent to the dredging site. Land disposal areas must be adequate for settling and must have levees strong and high enough to confine the material permanently. ²²

Construction Activities Associated
with Waterway Margins

Construction of Breakwaters, Sea Walls and Shore
Protection Systems

These waterway margin construction activities are undertaken to provide protection against wave action and/or high water and fast currents. The characteristics and functions of the individual structures are highlighted below.

Breakwaters

Breakwaters are used to form protected, artificial harbors which provide safe docking from the impact of waves. The most common

breakwaters are made of natural rock or concrete, and are constructed in water up to sixty feet (60') deep. Massive weight gives most breakwaters their stability against wave action. Breakwaters are of two (2) types; namely:

1. Mound type; and
2. A second classification of breakwaters consisting of concrete block gravity walls, concrete caissons filled after placement, rock-filled sheet-pile cells, rock-filled timber cribs and braced concrete or steel sheet pile walls. ²³

Sea Walls

Seawalls are massive concrete structures used to protect shorelines subject to wave erosion from storms. The construction of seawalls is normally undertaken near the water's edge. The construction operations involved in sea wall construction include those listed in Table III-9. ²⁴

Table III-9. Sea wall construction operations

OPERATIONS

Foundation excavation

Foundation dewatering if necessary

Placement of forms

Placement of reinforced steel

Pouring of concrete

Removal of forms

Backfilling behind the sea wall

7 OPERATIONS

Shoreline Protection Systems

A shoreline protection system is used where there is a permanent change in the shoreline due to wave and current-generated beach erosion. There are two (2) methods of arresting beach erosion, specifically:

1. The along-shore drift of materials may be reduced until a sufficient supply of new material is accumulated; or
2. The eroded length of beach may be artificially refilled. ²⁵

The first method may employ the use of groynes which are wave and current-assisting installations placed perpendicular to the shoreline and extending both inshore and offshore. Groynes may be composed of short pilings, large quarry rocks or precast concrete blocks placed in a line. The length and spacing of groynes is a function of the rate and limit of littoral drift and the maximize size of shore waves. ²⁶

Intermediate barriers consist of revetments (retaining walls) placed parallel to the shoreline in a position half-way between high and low water. These structures reduce the beach slope shoreward and seaward. Off-shore barriers are commonly composed of rock mounds placed parallel to shore that resemble breakwaters. ²⁷

Imported materials may also be used to stabilize shorelines from erosion. This material may come from borrow on uplands or from dredging operations. Table III-10 summarizes the construction operations employed in this method of shoreline stabilization. ²⁸

Table III-10. Shoreline stabilization operations employing fill

OPERATIONS

Driving of piles

Placement of fill materials

Spreading of materials along the shoreline

3 OPERATIONS

Construction of Ports

Port development includes the construction of docks, piers, wharves, bulkheads and dolphins, and placement of moorings. The bottom topography along the shore dictates whether a wharf or pier is built. Piers are generally preferred for flat sloping shores while wharves are preferred for steep sloping shores.

Two general types of construction methods are used for piers, wharves and bulkheads; namely:

1. Closed construction consisting of steel sheet pile cells, sheet pile bulkheads, concrete caissons, or precast concrete blocks; or
2. Open construction consisting of transverse rows of piling made of wood, precast concrete, or steel driven into the harbor floor. ²⁹

Dolphins are clusters of pilings, steel sheet pile cells capped with heavy concrete slabs, or concrete platform slabs supported by vertical and batter piles of steel or precast concrete. These structures are used for anchoring moorings and breasting ships in the

harbor. Moorings consist of a single buoy or a series of buoys. Buoys are usually steel drums up to eighteen feet (18') in diameter and nine feet (9') deep with a mooring hook to which the ship is anchored. ³⁰

Off-Shore Construction Activities

A number of construction activities are undertaken in marine waters that have the potential for impacting marine environments. These activities are mentioned briefly below.

Mineral Extraction from the Continental Shelf

Sand, gravel, shells and certain minerals are extracted by dredging in marine waters. These materials are either loaded onto barges or pumped ashore. Magnesium and other minerals are extracted by direct processing of seawater pumped to the plant through pipes or canals. Within the processing plant, the seawater is subjected to electrolytic, evaporative or other extractive processes, and the spent seawater is then returned to the sea through an open canal. Petroleum and natural gas are recovered from wells drilled in wetlands and marine waters. Drilling platforms may be fixed on piles driven into the wetland floor, or may be on movable platforms. ³¹

Pipeline Construction

Pipelines are constructed in coastal wetlands and marine waters to a depth of approximately six hundred feet (600'). In shallow waters, estuaries and rivers where bottom sediments are cohesive, the marine plow, clamshell or dragline dredge is used to excavate a

steep-sloped trench to a depth of six feet (6'). The pipe is laid in the excavated trench and the trench is back-filled.

In deeper waters (15 to 125 feet), stationary suction, cutter, or trailing suction hopper dredges are used to produce a very wide trench with flat-sided slopes. In low- and non-cohesive bottom materials, the shell fluidization method is used. This method consists of towing along the pipeline a train of carriages equipped with powerful jets which scour away the bottom under the pipeline and the materials in suspension. As the train passes, the pipe is immediately buried by settling and solidification of the sand. ³²

The alteration impacts of the ten classes of construction activities highlighted in this chapter are discussed in Chapter IV.

FOOTNOTES

Chapter III

1. Rezneat M. Darnell, Impacts of Construction Activities in Wetlands of the United States. U.S. Environmental Protection Agency, Ecological Research Service, EPA-600/3-76-045 (Springfield, Virginia: National Technical Information Service, 1976).

2. Ibid., 75A.
3. Ibid., 76.
4. Ibid., 77.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid., 76.
9. Ibid., 79.
10. Ibid., 85.
11. Ibid., 89.
12. Ibid., 91.
13. Ibid., 93.
14. Ibid., 97.
15. Ibid., 99.
16. Ibid., 103.
17. Ibid., 91, 106-107.
18. Ibid., 110.
19. Ibid.
20. Ibid.
21. Ibid., 110-113.
22. Ibid., 111 and 113.
23. Ibid., 115-118.

FOOTNOTES

Chapter III (continued)

24. Ibid., 118.
25. Ibid.
26. Ibid., 118-119.
27. Ibid., 119.
28. Ibid.
29. Ibid., 120.
30. Ibid., 121.
31. Ibid., 122.
32. Ibid., 123-124.

Small and unrelated decisions systematically foul the water, pollute the air, dam the rivers, subdivide the farms, fell the forests, fill the marshes, occupy the floodplains, and make accidental and whimsical growth emerge as the physical image of our state.

--"The Vacation Home Projects,"
J. Jackson Walter

CHAPTER IV

WETLAND ALTERATION IMPACTS

Overview

This chapter describes the physical, chemical and biological impacts of construction activities on wetland environments. In Chapter III, four (4) main classes of construction activity were identified that have the potential for significantly impacting wetlands. These activities are:

1. General lowland construction;
2. Mineral extraction;
3. Dam construction; and
4. Dredge and spoil placement.

Lowland construction activities may involve draining or filling of wetlands, and various types of building construction. Mineral extraction on land is especially damaging in mountainous regions, but open pit and strip mining in lowland areas may also produce major impacts on wetlands. Dam construction adversely affects wetland environments upstream, immediately downstream, far downstream, in estuaries and other coastal wetlands, and even on the marine beaches. Dredging and spoil placement causes widespread environmental damage to wetlands, particularly when the spoil material is chemically polluted.

Many construction projects are individually small, yet, the cumulative effect of these activities on wetland systems in an area is great. Each type of construction activity is accompanied by a distinct set of environmental impacts. Some of the major impacts of

construction activities in wetlands are presented in Table IV-1. ¹

Table VI-1. Major construction impacts on wetland environments

CONSTRUCTION IMPACTS

Loss of natural vegetation

Loss of topsoil

Increased surface runoff

Increased soil erosion

Modification in patterns of stream flow

Modification in flooding regimes

Increased turbidity

Increased sedimentation

Modification of water chemistry through the addition of sediments,
nutrients and pollution

9 MAJOR IMPACTS

It is important to recognize that the effects of any construction project will vary according to certain site and engineering variables. These variables include those listed in Table IV-2. ²

Table IV-2. Construction variables that influence wetland impacts

CONSTRUCTION VARIABLES

Location

Topography

Season of the year (especially in relation to rainfall)

Method of construction activities

Care taken during construction to avoid unnecessary environmental
damage

Extent of area involved

Duration of construction

7 VARIABLES

The specific impacts of any construction activity fall in three (3) general time-related categories; namely:

1. Direct and immediate impacts that taken place during the construction process;
2. Impacts that occur during the period of stabilization following completion of the construction project; and
3. Long-term impacts and permanent changes brought about by the construction itself or by subsequent human use and environmental management resulting from the constructed facility. ³

Physical and Chemical Impacts of
Construction Activities on Wetlands

The physical and chemical impacts of construction activities on wetlands will be discussed in the same order that these activities were presented in Chapter III. The biological and ecological impacts will be discussed in a separate section later in this chapter.

Impacts Associated with
Floodplains, Banks and Shores

Pre-Construction Activities

Pre-construction activities, such as surveying and initial on-site lay-outs, involve the removal of some vegetation cover. This removal of vegetation may cause some increase in erosion and surface runoff. These impacts tend to be temporary and highly localized, except in areas of steep terrain. In mountainous regions, even limited removal of vegetation during pre-construction activities can have significant impacts. ⁴

Impacts of Impervious Surfacing and Earth Work

Impervious surfacing and earth work involves a number of different construction activities as described in Chapter III. The initial clearing of land removes the vegetative cover, allowing the rainfall to strike the bare soil surface. Subsequent earth work removes the topsoil layer, exposing the deeper soil layers. Excavated material is often mounded adjacent to the construction site.

Increased surface runoff and erosion are likely to result from these activities. These impacts will be accentuated in steep terrain, and in rainy weather or dry conditions. Runoff and soil erosion export great quantities of solids into lowland drainage areas. These solids eventually end up in wetlands in the form of increased water turbidity and sedimentation. The dust clouds raised in dry weather will be transported at a later date when the rain falls.⁵

Denuded areas also lose large quantities of dissolved minerals, particularly calcium, magnesium, phosphates, nitrates, sodium and potassium. Increased loss of ground water and spring flow may result from the removal of floodplain trees which pump water up through the roots for transpiration. In other instances, spring flow may diminish as the water table is lowered through lack of discharge.⁶

Surface runoff from devegetated forest lands may increase by as much as four hundred percent (400%).⁷ The wetland receiving the sediment will undergo a number of ecological changes. The violent fluctuation in water level will result in greater flow rates during

wet weather. Flood peaks may be doubled. The stream bed may be cut deeper. The banks will be undercut resulting in a widening of the stream section. Riffles may disappear and pool areas fill with inorganic silt. Vegetation and other debris are washed downstream. Bottom habitat diversity is greatly reduced or eliminated. ⁸

The increased flow rates increase water turbidity. This situation, in turn, lowers the light penetration of the water, increases the chemical and biological oxygen demand, and modifies the chemical characteristics of the water in other ways. This increase in turbidity, compounded by a loss of stream bank vegetation, serves to elevate the temperature of the water as much as ten degrees (10°F).⁹ These impacts may persist far downstream of the construction site.

During dry weather, stream flows are reduced, or cease entirely, due to reduced ground water inflow. Land clearing may alter the local hydrological regime so drastically that formerly perennial streams may become intermittent. Since deep pools are reduced or eliminated, the aquatic habitat may become severely restricted or lost during dry spells. The water that remains in the stream bed is now subject to more rapid and extreme temperature fluctuations. ¹⁰

The burning of trees and brush in the floodplain can seriously impact the adjacent wetland through the introduction of ash which is highly alkaline. Ash can cause an immediate increase in the pH of water. In addition, the heat from the fire can elevate the stream temperature. The water temperature may remain elevated for some time due to the heat exchange between soil and water. ¹¹

Direct loss of stream bottom habitat results from the excavation

of stream bed gravel for use in the construction project. Washing gravel in the stream generates large quantities of highly turbid water which will directly or indirectly impact the wetland environments downstream. Projects requiring relatively straight routes, such as highways and railroads, are often accompanied by extensive straightening or bridging of streams. Stream habitat is highly modified or lost by these activities. Borrow pits and landfill sites will destroy additional semi-aquatic environments. ¹²

Once the impervious surfaces are laid down, all rainfall runs off as surface flow. Drainage structures and ditches are constructed to channel runoff directly into streams. Chemical substances are leached from the concrete or bituminous surfaces of the drainage structures and enter the stream with the runoff water. In the case of concrete structures, the leached chemicals are mostly carbonates and hydroxides of calcium and magnesium. Bituminous structures leach organic coal-tar derivatives, many of which are carcinogenic. The greatest leaching occurs during and immediately after construction, but low-level, long-term leaching occurs as well. ¹³

Petroleum products can enter water courses as spills from construction and/or maintenance equipment, and as runoff from highways. Large quantities of heavy metals, hydrocarbons, oil, grease, asbestos fibers from brake linings, and other materials can enter wetlands from adjacent highways. ¹⁴ The major impacts of impervious surfacing and earth work on wetlands are summarized in Table IV-3. ¹⁵

Table IV-3. Impacts of impervious surfacing and earth work on wetlands

IMPACTS

Loss of habitat from devegetation of the construction area, stream straightening and realignment, mining of stream gravel, borrow pit mining and dump site filling;

Loss of land fertility from surface erosion and subsurface flow

Increased erosion from construction site activities

Lowered ground water level from devegetation

Greatly increased fluctuation in stream level due to faster runoff following rains and decreased flow during dry periods because of loss of ground water

Greatly increased stream sediment load due to erosion and runoff

Greatly increased stream turbidity due to erosion and runoff

Modified chemical composition of the water due to increased sedimentation, runoff, turbidity, leaching of soil nutrients, leaching of concrete and bituminous materials, cement plant operation, use and maintenance of construction activities, and road use following construction

8 MAJOR IMPACTS

The long-term impacts of these construction activities on wetlands will depend greatly on local circumstances. In general, however, the long-term impacts listed in Table IV-4 may result from the construction activity. ¹⁶

Table IV-4. Impacts of impervious surfacing and earth work on wetlands

IMPACTS

Permanent loss of natural habitat and topsoil

Increased surface runoff and reduced ground water flow

"Ditchification" of stream (i.e., the replacement of normal stream habitat with man-altered habitat)

Persistent chemical modifications associated with high levels of sedimentation, turbidity, pavement leaching and highway runoff

4 IMPACTS

Impacts of Line Construction Activities

Small line construction projects, such as power and pole lines, small pipelines and underground electrical and communication lines, create little physical damage. Large pipeline construction projects may cause significant increases in stream sediment loads if the digging or earth piling activities are located in the vicinity of a wetland or storm ditch.

The primary physical impacts associated with line construction activities derive from drainage ditching and canal lining. Under natural conditions, surface water from rainfall flows downhill until it reaches a low area or a gully. The water will then flow through the gully until it is either absorbed by the vegetation or the soil, or it reaches a small stream. Drainage ditches are constructed to facilitate surface water runoff. ¹⁷

Under artificial drainage conditions, the vegetation is removed and meanders are straightened. The drainage ditch is often lined with concrete, and may be covered over as a pipe. These man-made drainage systems tend to remove the native soil and vegetation, lower the water table, create greater flow velocities and increase soilbank erosion. The water entering streams from drainage ditches usually carries a heavy sediment load. Significant erosion may occur where the drainage ditch enters the stream. Spoil banks located adjacent to these drainage ditches will accentuate these erosional tendencies and magnify the impacts on the receiving wetlands. ¹⁸

Secondary impacts of line construction activities result from the development that frequently follows major drainage ditching projects. Additional drainage ditches are often constructed to carry

urban or agricultural runoff after the main ditch becomes available. Floodplain drainage ditching encourages further land clearing and intensive development in flood-prone areas. The direct long-term effects of line construction activities resulting in ditching and canalization are summarized in Table IV-5.¹⁹

Table IV-5. Impacts of line construction activities on wetlands

IMPACTS

Loss of gully land

Lowered water table levels in the soil

Faster run off times

Increased erosion and stream sedimentation

Rapid and extreme fluctuation in stream height and flow volume

Increased downstream flooding

Loss of stream and riparian habitats

7 IMPACTS

Impacts of Building Construction Activities

Building construction involves many of the impacts associated with impervious surfacing and earthwork concentrated in one location. The construction of large buildings are generally accompanied by the construction of drainage ditches, storm sewers and parking lots. Rapid surface runoff from these impervious surfaces will carry soil sediments, concrete leachings and oily compounds from the site to neighboring wetlands. The water level, turbidity, sediment load and chemical composition of the receiving water will be affected by this runoff.²⁰ The long-term impacts of building construction activities are indicated in Table IV-6.²¹

Table IV-6. Impacts of building construction on wetlands

IMPACTS

Rapid surface runoff

Increased turbidity and sedimentation of local waterways

Loss of natural vegetation

Loss of topsoil

Loss of habitat

Changes in chemical composition

6 IMPACTS

Impacts of Open Air Industrial Plant Construction

The impacts of open air industrial plant construction include those that result from the construction activities themselves; namely, loss of natural vegetation and topsoil and increased turbidity and sedimentation of local waterways. The potential also exists for significant wetland pollution from heavy metals, concrete and bituminous materials, salt and coal tars employed in the construction processes. These materials are derived from a variety of sources on the construction site including rusty building supplies, welding chemicals, paint, and galvanizing, water-proofing and chemical-proofing materials. ²²

Once the open air industrial plant is in operation, there is the potential for additional wetland impacts. Raw materials supplied to the plant potentially enter surface runoff. Materials from leakages, accidents, wastes and by-products may also be carried off-site in ditches to the nearest waterway. The transportation elements of the operation produce associated chemical contamination. Some

industrial plants have ponding areas where solid residues settle out before the water is discharged to the waterway. The dissolved chemical contaminants, however, remain in the discharge. ²³

Steel and paper mills, and power plants require large quantities of water for cooling or other processes. If this water is returned to the stream, it may be at an elevated temperature or have chemical contaminants. If the water is consumed in the plant for steam or product production, the water course suffers reduced flow. Refineries and smelters introduce noxious chemicals into the atmosphere which may settle in water courses far downwind of the plant. ²⁴

The long-range impacts of open air industrial plants depend on the nature of the plant. However, major impacts associated with these industrial operations generally include those listed in Table IV-7. ²⁵

Table IV-7. Impacts of open air industrial plant construction on wetlands

IMPACTS

Increased surface run off of chemically-contaminated water

Increased sedimentation

Increased turbidity

Changes in chemical composition

Loss of natural cover

Loss of topsoil

Loss of wetland habitat

7 IMPACTS

Impacts of Bridge Construction

Bridge construction, whether carried out completely on land or partially in the water, will cause temporary erosion, stream turbidity and sedimentation as well as some vegetation and topsoil removal. If bridge and overpass construction precedes roadway paving, the prepared roadbed may be subject to severe and continual erosion.

The long-term impacts of bridge construction are generally negligible, but vehicular traffic over the bridge contributes heavy metals, asbestos fiber and unoxidized hydrocarbons to the water course and bottom sediments continuously. ²⁶

Impacts of Tunnel Construction

The primary impacts of tunnel construction on wetlands derive from the disposal of excavated materials. Wetlands have often been the dipository for the large volumes of excavated rock and earth associated with tunneling operations. This filling permanently destroys wetland habitat. Stream sedimentation may also result from the transport of disposal materials (which are not placed directly in the wetland) as well as from pumping, washing and drainage activities associated with the construction.

The construction plant and yard itself will eliminate habitat either temporarily or permanently. Furthermore, some chemical contamination from the large volume of cement used in the construction process is inevitable. In general, the magnitude of the long-term impacts of tunnel construction on wetlands depends on the

quantity of habitat destroyed or modified by dump or fill operations.²⁷

Impacts of Mineral Extraction on Land

Mining operations vary in the types of minerals extracted, the methods employed, and the topographic characteristics of the site. The environmental modifications associated with mining operations relate, in part, to these variables. Regardless of these variables, all mining activities produce enormous quantities of extracted materials that must be placed somewhere. Mining operations can be divided into three (3) general categories, each with its own specific impacts, in addition to the general and cumulative impacts associated with any mining operation.²⁸ For purposes of this report, these general impacts will be discussed in terms of their topographic, physical and chemical impacts on wetlands.

The three major types of mining operations are: (1) Surface mining which includes placer, open pit and strip mining operations; (2) Drift mining; and (3) Drilling operations. Placer mining is carried out in stream beds and banks, and on floodplains to recover gold and other minerals. Open pit mining varies from shallow quarries for limestone, granite and other building stone, gravel, sand and clay to the deep quarries for iron, copper, coal and uranium. Strip mining is employed in the extraction of coal, sand, gravel, stone, clay, gypsum, phosphate, and certain minerals such as iron and copper. Drift mining or tunneling operations are undertaken where the veins and seams of coal and various metals are too deep for overburden removal. Drilling operations produce water, natural gas,

petroleum and other liquid substances. ²⁹

Topographic Impacts

Mining activities often take place in hilly and mountainous terrain. Survey trails and access roads into the mining site are subject to severe erosion if poorly constructed. The removal of soil and overburden during the mining operation involves the destruction of valuable topsoil. Additional topsoil may be buried by stock piles, waste disposal sites and tailings. In other operations, mine spoil is bulldozed over the edge of the mine shaft where it falls down-slope into the valleys and streams below. Hillside vegetation is destroyed in the process. The loose material that remains on the slopes is subject to erosion and landslides. When erosion and landslides occur, more sediment is added to the streams and floodplains. Streams may be dammed up entirely. ³⁰

Many mining operations create extensive vertical exposed cliff faces or highwalls which disrupt animal movements and allow seepage of groundwater. Water tables in the land above mining operations may be drastically lowered as a result of this leaching. Some types of mining require enormous quantities of water for digging and processing which further deplete groundwater supplies. Abandoned operations often leave quarries and open pits which eventually become filled with seepage water. Exposed bedrock surfaces accelerate runoff, either to surface drainage or through fractures and tunnels to groundwater and deep mines. The topographic impacts of mineral extraction operations on wetlands are summarized in Table IV-8. ³¹

Table IV-8. Topographics impacts of mineral extraction operations on wetlands

TOPOGRAPHIC IMPACTS

Removal of natural cover

Removal of topsoil/burial of topsoil

Exposure of vast bare rock surfaces

Creation of linear miles of steep vertical highwalls

Creation of open pits, quarries and spoil depressions which may fill by seepage

Creation of vast areas of spoil piles which seep and erode, and are physically unstable

Coverage of hillsides and valleys with spoil and tailings which are unstable and subject to landslides, erosion and seepage

Acceleration of surface runoff

Greatly increased erosion

Watercourse modification by spoil and tailing impoundment

Lowering of groundwater

II IMPACTS

Physical Impacts

Mining operations may result in the direct destruction of wetlands through filling. Wetlands have frequently been used as receptacles for spoil and mine tailings resulting in increased turbidity, sedimentation and lowered water depth, if not complete destruction. As streams are filled with sediments, the bottoms become compacted and the streambeds widen across the floodplain. Habitat diversity is greatly reduced or eliminated.

The impacts associated with habitat destruction continue downstream many miles from the mining site. Many miles of streambeds

and extensive estuarine areas may be affected. The physical impacts of mineral extraction on wetlands are presented in Table IV-9. ³²

Table IV-9. Physical impacts of mineral extraction on wetlands

IMPACTS

Drainage of wetlands

Filling of wetlands with spoil and tailings

Alteration of stream courses through channelization, diversion and impoundments

Widening of stream beds

Covering of wetland bottoms with spoil and tailings

Increased silt load

Increased turbidity

Decreased light penetration

Reduction in wetland habitat diversity

9 IMPACTS

Chemical Impacts

Some of the by-products of mining operations are inert while others are chemically active. Inert materials are most soils, silts, sands, gravels, rocks and stone residues. These materials may, however, indirectly influence water chemistry by covering the bottom, reducing light penetration, and influencing biological processes. ³³

Mine tailings and spoil dumps, on the other hand, contain a variety of active chemicals including aluminum, arsenic, calcium, chloride, copper, lead, magnesium, silicon, sodium, sulfur, zinc and radioactive materials. Metallic sulfides (pyrites) are the most abundant by-products of mining operations. When these sulfides come

in contact with moisture, a set of chemical reactions occur which produce metallic oxides and hydroxides, as well as large quantities of sulfuric acid. Sulfuric acid upsets the natural buffer system of wetlands by converting carbonates to bicarbonates and carbon dioxide which escapes as a gas. This results in a lowering of the pH value of the receiving wetlands. ³⁴

Lead, zinc and certain other heavy metals are soluble in acid water. Iron and aluminum remain in suspension and solution, or are precipitated as complex oxides and hydroxides covering the wetland bottom. Increased chemical oxygen demand may lower the free oxygen in the affected waters.

Polluted surface water in mining areas may also contaminate underground aquifers. Surface water often enters deep mines by pumping or seepage through fractures and drill holes eventually coming in contact with groundwater. Thus the chemical impacts of mining can extend for downstream of the activity as well as far into the earth. The chemical impacts of mineral extraction are summarized in Table IV-10. ³⁵

Table IV-10. Chemical impacts of mineral extraction on wetlands

IMPACTS

Addition of large quantities of chemical elements to wetland habitats

Increase in salt content of wetland waters and bottoms

Addition of large quantities of chemically-reduced materials
(especially sulfides)

Addition of metallic oxides and hydroxides

Addition of large quantities of sulfuric acid

Lowering of pH

(CONTINUED)

Table IV-10. Chemical impacts of mineral extraction on wetlands
(continued)

<u>IMPACTS</u>
Reduction and elimination of carbonates (and, hence, the natural buffering system)
Placing of heavy metals into solution
Reduction of free oxygen
Contamination of groundwater aquifers

10 IMPACTS

Impacts Associated with
Wetlands and Water Bottoms

Impacts of Dam Construction

Dams differ greatly in size, structural composition, design and intended use. Dams have a finite life expectancy. Thus the environmental impacts will vary with time in relation to the dam's life phase (i.e., construction, impoundment filling, basin leaching, sedimentation and senescence). Four (4) variables must be considered in a discussion of the impacts that dams may have on local wetlands. These variables are the following:

1. Nature of the dam and its impoundment;
2. Time-phased sequence of events;
3. Water management practices after the dam is operational; and
4. Downstream series of impacts. ³⁶

In general, dams have far-reaching impacts on wetlands located both upstream and downstream. Upstream impacts extend to the upper reaches of the impoundment and beyond. Downstream impacts may be evident throughout the lower reaches of the river system as well as

in the estuary and on the nearby continental shelf. These impacts, along with those generated during dam construction, are discussed in the following subsections.

On-Site Impacts

The most significant impact during the dam construction phase is the blocking of stream flow by cofferdams. Lateral tunnels at the construction site may allow some water to pass downstream, but the volume and timing of such flow will differ from the normal flow pattern. Sediments are added to the stream as a result of rock blasting, excavation and road work. Some chemical leaching from the concrete dam will also occur. ³⁷

Upstream Impacts

As the water level in the impoundment rises, wetlands and tributaries in the basin above the dam are inundated and destroyed. Eventually the reservoir becomes a long, multi-branched body of water subject to considerable water loss through surface evaporation. Streams entering the reservoir deposit large quantities of sediment as deltas near the stream mouths. Stream and reservoir banks are eroded contributing great quantities of soluble minerals to the basin. In addition to sulfate, calcium, sodium, potassium and chloride, concentrations of nitrogen and phosphorous tend to increase as a result of soil leaching and decomposition of inundated vegetation. ³⁸

Operation of the dam greatly influences conditions in the reservoir and thus upstream impacts. Riparian habitat is lost along the margin of the reservoir as a result of water level fluctuations

which restrict the development of vegetative cover. When the water level is reduced, the exposed bottom is subject to severe erosion that moves the mudbanks further downstream in the reservoir. 39

With the passage of time, these sedimentation deltas build up and coalesce. Heavy calcium carbonate (marl) deposits may build up on the reservoir bottom. After the first few years, the quantity of dissolved minerals in the reservoir tends to decline due to decreased leaching and downstream passage of water. Stratification of the reservoir during the summer months also affects the physical and chemical properties to the water. The bottom water layers may become anaerobic and develop toxic concentrations of methane, hydrogen sulfide, and other unoxidized chemicals resulting in a lowering of pH and an increase in metallic ions. 40

Eventually the reservoir becomes silted up and its storage capacity greatly reduced. Water masses often remain somewhat distinct within the reservoir. Seasonal river flows may be delayed in passage. Efforts to prolong the life of the reservoir include dredging and the release of silt-laden waters through low-level conduits in the dam. These activities, in turn, produce impacts on downstream wetlands. Table IV-11 summarizes the upstream impacts of dam construction on the physical and chemical characteristics of wetlands. 41

Table IV-11. Upstream impacts of dam construction on the physical and chemical characteristics of wetlands

UPSTREAM IMPACTS

Habitat loss through inundation of floodplains, rivers, lakes, ponds, marshes and swamps

Loss of water through surface evaporation
(CONTINUED)

Table IV-11. Upstream impacts of dam construction on the physical and chemical characteristics of wetlands (continued)

UPSTREAM IMPACTS

Water erosion of banks and submerged hills

Formation of sedimentary deltas around mouths of entering streams
(which enlarge throughout the life of the reservoir)

Leaching of soluble materials from bottom and banks of basin

Initial increase in dissolved salts and nutrients

Precipitation of bottom marl deposits

Delayed water passage through reservoir

Temperature and chemical stratification of reservoir waters

Devegetation of broad band around water's edge due to water level
fluctuation

Long-term reduction in dissolved salts and nutrients

Long-term sedimentation of basin

12 IMPACTS

Downstream Impacts

The magnitude of the downstream impacts of dam projects on wetlands is dependent, in large part, on the pattern of water release. The release pattern is, in turn, determined by the specific type of dam involved. The release pattern of a hydro-electric power generating dam, for example, ranges from that of a large river to that of a small headwater within a short period of time. The release pattern of a flood control dam, on the other hand, eliminates natural flood-flow rates and water level heights. Dams built for irrigation purposes release significantly reduced quantities of water downstream altogether. These dams are used to supply water to irrigation

ditches during dry weather. Due to evaporation in the reservoir and irrigation ditches, the overall volume of water is reduced and is high in salts. ⁴²

Downstream floodplains are severely impacted by dam projects in a number of ways. Since these floodplains and associated wetlands are no longer inundated at regular (natural) intervals, they do not receive annual or seasonal replenishment of water and nutrients. Floodplain groundwater levels recede. Lower water tables and flood protection encourages utilization of these floodplains for agriculture and permanent development. These activities, in turn, lead to channelization, erosion and other environmental problems. ⁴³

The water that is released downstream varies not only in quantity but also quality from that of an undammed river. During routine operation, the discharge water is clear since much of the suspended matter has been deposited in the reservoir. During flushing periods, however, the water contains large quantities of suspended materials. Epilimnic waters released from the upper levels of the dam during the spring and summer months are often rich in oxygen and plankton but low in other nutrients. High levels of dissolved atmospheric nitrogen may be present below large impoundments and create super-saturated conditions for many miles downstream. Hypolimnic waters released from below the thermocline, on the other hand, have large quantities of nutrients and decomposing organic matter but also a reduced pH value. These lower-level waters may also contain hydrogen sulfide, ferrous and manganous compounds as well as other heavy metals. ⁴⁴

Irrigation projects pose additional problems for downstream wetlands. Irrigation water that is reintroduced to the river or stream is higher in salt and nutrient content than the natural flowage, and reduced in volume as a result of evaporation. This reduction in total flow, in combination with overall reduced peak flows, leads to the accumulation of sediments in the streambed. In the absence of natural floods, these accumulated sediments tend to elevate the stream bottom and reduce the cross-sectional area of the stream. This situation of clogging channels, in turn, creates increased flood hazards downstream of the dam project. Thus, the dam eventually recreates the problem that it may have been built to correct in the first place. Extensive dredging above and below the dam is now required to prolong reservoir life and maintain downstream channels for navigation. ⁴⁵

Dam construction affects not only those river stretches below the project, but also the estuaries and adjacent continental shelves many miles from the dam itself. Estuaries are greatly impacted by the reduced quantities of fresh water and altered peak flows following upstream impoundment. The entire pattern and seasonality of flow are affected which, in turn, greatly reduces incoming sediment load. Reduced flushing leads to sediment accumulation and altered patterns of scouring, shoaling and bottom contouring due to wind disturbance of the shallow waters. Estuarine flushing is also important to reduce the build up of pollutants, especially pesticides and heavy metals. These pollutants would be flushed out with the excess sediment load at high flood stages under normal flow conditions. The altered circulation patterns also affect the

salinity gradient in the estuary. Salinity levels generally increase in response to reduced freshwater inflow and recontouring of the bottom.⁴⁶ As is the case upstream, these environmental changes ultimately lead to wetland habitat alteration and possible destruction.

The impacts of dam construction on the estuarine environment are likewise felt on the adjacent continental shelf. Since the estuary receives less freshwater, it, in turn, delivers less to the adjoining marine environment. The diminished annual flow volume (hence, reduced nutrient loads) and reduction in peak flow rate (hence, reduced flushing) greatly impact coastal areas. Coastal beaches are subject to severe erosion because the balance between the deposition of river-borne materials and the erosional forces of wind, waves and longshore currents has been disturbed. Artificial stabilization structures have been built along much of the Nation's coastline in an effort to combat erosion resulting from upstream construction activities.⁴⁷

The downstream impacts of dam construction on the physical and chemical characteristics of wetlands are presented in Table IV-12. The biological impacts of impoundments as they relate to habitat alteration are discussed under "Biological Impacts of Construction Activities on Wetlands" in this chapter. An overview of the impacts of hydropower projects on the environment which I wrote in 1981 while employed at the Rhode Island Governor's Energy Office is provided as Appendix D.

Table IV-12. Downstream impacts of dam construction on the physical and chemical characteristics of wetlands

DOWNSTREAM IMPACTS

GENERAL IMPACTS

Reduction in total volume of flow

Deviation from normal seasonal flow patterns

Severe reduction in wetland habitat diversity

Jeopardization of certain wetland habitat types; generally those associated with fast flows (i.e., riffles, rapids, and areas between bluffs and cliffs which are amenable to damming and impoundment)

IMPACTS NEAR THE DAM AND SHORT DISTANCE DOWNSTREAM

Elimination of peak flows

Sudden and drastic changes in flow rates

Reduction in sediment flushing

Sediment accumulation

Elimination of floodplain flooding by:

- a. Elimination of annual replenishment of floodplain wetlands with water and nutrients;
- b. Reduction in ground water levels; and
- c. Reduction of litter wash into streams.

Sudden elimination of large volumes of sediments into streams ("river mud" from reservoir bottom flushing)

Modification of water temperature (by release of water from epi-or-hypolimnion of reservoir)

Modification of stream nutrient loads (by release of water from epi-or-hypolimnion of reservoir)

Reduction of pH (by release of hypolimnic waters)

Release of hydrogen sulfide and other reducing compounds (by hypolimnic release)

Reduction of oxygen content (by hypolimnic release)

Super-saturation with nitrogen gas

(CONTINUED)

Table IV-12. Downstream impacts of dam construction on the physical and chemical characteristics of wetlands (continued)

DOWNSTREAM IMPACTS

IMPACTS FURTHER DOWNSTREAM

Increase in salt content (from irrigation water return)

Reduced flushing due to:

- a. Increased sediment accumulation;
- b. Clogging of channels; and
- c. Shallowing of streams.

Creation of flood hazards

IMPACT ON DOWNSTREAM ESTUARIES

Reduction of freshwater input

Reduction of peak flows

Reduction of flushing

Abnormal seasonality of flow

Reduction of sediment and nutrient input by stream

Sediment accumulation

Altered patterns of shoaling and bottom contouring

Build-up of sediment-associated pollutants

Modified water circulation patterns

Increased saltwater penetration

Increased estuarine salinity

Sharpened salinity gradients

IMPACTS ON ADJACENT MARINE ENVIRONMENTS

Reduction of estuarine water outflow

Reduction of nutrient transport to continental shelf

Reduction of sediment transport for beach nourishment

34 IMPACTS

Impacts of Fill Construction

Many construction projects involve the filling of all or part of the local wetlands. Since wetlands are areas of surface and subsurface water movement, projects that involve filling retard or prevent normal water movements. During the process of constructing linear projects, such as highways and railways, side canals are often excavated parallel to the right-of-way. Such canals accelerate runoff, drain the submerged lands, reduce water table levels, and lead to saltwater intrusion in coastal areas. Spoil banks give rise to erosion problems. Substantial amounts of adjacent upland may be cleared for rights-of-way and structures. These activities result in direct and indirect loss of wetland habitat.⁴⁸ The general impacts of fill construction in wetlands are listed in Table IV-13 and discussed in more detail under "Impacts of Dredging".

Table IV-13. Impacts of fill construction in wetlands

<u>IMPACTS</u>
Interference with surface flows through wetland
Creation of spoil banks
Creation of canals through wetlands
Creation of spoil and canal erosional problems
Loss of wetland habitat (especially freshwater marsh habitat in coastal areas)
Creation of marshland salinity problems

6 IMPACTS

Impacts of Dredging

Dredging and the subsequent disposal of dredge spoils have significant impacts on our nation's wetlands. These impacts can be divided into two (2) inter-related categories; namely (1) those associated with the removal of bottom sediments, and (2) those associated with the extracted materials either during the removal process or after they have been dumped as spoil.

General and Immediate Impacts of Dredging

Regardless of the dredging methods used, the immediate impacts are the creation of deep holes or linear channels and the temporary suspension of large amounts of sedimentary materials. Dredging operations remove the thin oxidized layers of chemically-reduced particles. These materials have high chemical and biological oxygen demands. They may also contain toxic materials such as hydrogen sulfide, methane, organic acids, ketones, aldehydes, heavy metals and pesticides. ⁴⁹

The turbidity created by the dredging activity reduces light penetration, thus interfering with the photosynthetic production of oxygen. Water temperature become elevated. The sediments, along with whatever nutrients and pollutants they contain, are redistributed either near the dredge site or far downstream. This redistribution of materials modifies bottom topography and alters patterns of water circulation downstream of the project.

The dredge holes act as new sedimentary basins and the cycle begins again. The problems associated with dredging are accentuated if the dredge spoil is deposited back into the water. Table IV-14

highlights the general and immediate impacts of dredging on wetlands.

Table IV-14. General and immediate impacts of dredging on wetlands

IMPACTS

Modification of wetland bottom topography through the creation of:

- a. Persistent dredge holes;
- b. Channels; and
- c. Canals.

Modification of water circulation patterns

Increased turbidity of water due to:

- a. Increased oxygen demand;
- b. Reduced light penetration;
- c. Reduced photosynthetic oxygen production;
- d. Release of toxic organic compounds;
- e. Release of pesticides, heavy metals and hydrogen sulfide; and
- f. Increased temperature.

Bottom siltation with very fine sediments

4 IMPACTS

Impacts of Stream Channelization

Stream channelization is undertaken primarily to (1) reduce flood hazards, or (2) maintain deep-water navigation channels. Both types of projects straighten streambeds and cut-off meanders, which, in turn, produce a steeper stream gradient and faster flow rate. This faster flow rate increases the erosive power of the water and its ability to transport sediments. Erosive streambank cutting eliminates protective vegetation and broadens the stream channel. Deepening of the channel causes a drop in the water table along the banks, and leads to erosion of tributary streambeds. Increased flow rates in the main tributary stream lead to reduced habitat diversity throughout the stream system. The elimination of littoral areas,

riffles and rapids, and eddy and pool habitats results in uniform and relatively unproductive habitat conditions along the length of the stream. 50

When the stream returns to a shallower gradient downstream of the channelization project, the flow diminishes and the sediment load is dropped. This, in turn, creates a shallower streambed and a heightened downstream flooding hazard. The general impacts of stream channelization on wetlands are presented in Table IV-15. 51

Table IV-15. General impacts of stream channelization on wetlands

IMPACTS

Stream straightening due to:

- a. Cutting off of meanders; and
- b. Shortening of stream length.

Deepening channel

Lowering of water table

Increase in stream gradient due to:

- a. Increase in flow rate;
- b. Increase in channel and bank erosion; and
- c. Widening of channel.

Reduction in stream habitat diversity

Increase in downstream sedimentation

Increase in downstream flood hazard

7 IMPACTS

Impacts of Floodplain and Swamp Channelization

The floodplains and swamps associated with a major stream system are often channelized as part of the mainstream channelization project. Draining of these wetlands lowers the water table of the

land. This situation, in turn, reduces or eliminates annual flooding and thus replenishment of the remaining wetlands. Peak flows are now sent downstream as flood surges. Large quantities of nutrients and freshwater are lost to the system. Aquifer and groundwater recharge is also reduced. Saltwater penetration may occur in low coastal plains. The harvesting of timber in the now dry lowlands is often a prelude to other land uses. Erosion may become a problem as a result of these new activities. The impacts of channelizing floodplains and swamps are summarized in Table IV-16. ⁵²

Table IV-16. Impacts of channelization of floodplains and swamps

IMPACTS

Drainage of surface waters

Lowering of water table

Elimination of periodic flooding and fertilization

Reduction of groundwater recharge

Increase in erosion

Peak streamflow sent downstream as a surge

Increased saltwater penetration (in coastal areas)

Exposure to deforestation, agriculture, construction and other land uses

8 IMPACTS

Impacts of Dredging in Marshes

The impacts of dredging in marshes are similar to those of channelizing floodplains and alluvial swamps. Dredging in marshes accelerates drainage, reduces groundwater levels, and destroys wetland habitat. Additional habitat is lost if the dredge spoils are

placed directly in the marsh.

Since coastal wetlands tend to be large and complex drainage systems in their natural state, dredging and channelization of coastal marshes may have severe and far-reaching ecological impacts. Their proximity to saltwater and the natural process of coastal subsidence create a delicate balance at this interface between the land and sea.

In an undisturbed state, freshwater from streams and rivers enters the coastal wetland producing a salinity gradient in the marsh from freshwater to the more brackish waters of the estuary. The balance between compaction and subsidence of river deposits and the build-up of organic matter is maintained through a network of dendritic tidal creeks. ⁵³

Dredging and channelization of marshes produce artificial canals. These canals tend to erode and widen as a result of tidal action and increased boat traffic. Channelization may also accelerate the rate of freshwater runoff in the marsh. This, in turn, may lower the water table and dry out the higher areas of the marsh. ⁵⁴

Artificial canals not only drain away freshwater but offer paths for saltwater penetration of the marsh. This saltwater penetration, in combination with increased compaction and subsidence resulting from reduced sediment loading in the upper marsh, significantly alters the ecology of the coastal wetland. The effects of saltwater are felt further inland. Vehicular traffic over the marsh associated with the construction activities further accentuates the environmental problems created by dredging and channelization. ⁵⁵

Disposal of dredge materials on the marsh itself creates another set of ecological impacts that threaten the delicate coastal environmental. Under normal conditions, marsh sediments are in a chemically-reduced state. Spoil materials mounded adjacent to the canals create surface dams which impound water on both sides and seriously interfere with normal surface drainage patterns. Large acreages of marshland are destroyed when the natural vegetation is covered by dredge spoils. Furthermore, spoil banks are highly subject to erosion. As the chemically-reduced spoil materials fall back into the canals, the oxygen concentration in the canal waters is further reduced. Erosion of spoil banks also tends to fill in the canals, thus requiring redredging. The impacts of this never-ending cycle are compounded by the build-up of very potent biotoxins.⁵⁶ The impacts of dredging and spoil placement in coastal marshes are summarized in Table IV-17.

Table IV-17. Impacts of dredging and spoil placement in coastal marshes

IMPACTS

Interference with surface drainage patterns

Acceleration of surface drainage by canals

Damming of surface drainage by spoil banks

General acceleration of freshwater runoff

Loss of marshland habitat due to:

- a. Canalization;
- b. Water table lowering;
- c. Erosion and widening of canals;
- d. Spoil coverage; and
- e. Acceleration of marsh subsidence.

(CONTINUED)

Table IV-17. Impacts of dredging and spoil placement in coastal marshes (continued)

IMPACTS

Acceleration of saltwater penetration

Conversion of sulfates (of saltwater) to sulfides in the canals and precipitation of iron sulfide in the canals

Erosion of spoil banks and distribution of chemically-reduced sediment into canals and open marsh

8 IMPACTS

Impacts of Dredging in Bays and Estuaries

Dredging in bays and estuaries affects the topography, circulation patterns and water quality of these wetland environments. The bottom topography is modified through the deposition of spoil materials. Water circulation is impacted by the altered patterns of tidal exchange and mixing which result from siltation, shoaling and the channels themselves. The directions, velocities and seasonal patterns of currents may be severely modified. Extensive shoaling may reduce flushing and eventually lead to closure of passages to the sea. 57

Channels may accelerate the flow of freshwater through the estuary. This, in turn, accelerates the penetration of saline bottom waters into the estuary or bay. The result is an increased salt concentration and sharpening of the salinity gradient. 58

Hydraulic dredging creates siltation and turbidity problems on-site as well as downstream. The clay and silt sediments that are stirred up by dredging operations eventually settle out in the estuary or bay. These fine sediments form a thin surface ooze which inhibits oxygen circulation. This situation may lead to oxygen

reduction through the estuarine environment, particularly in the areas protected from wind action and general water circulation. The impacts of dredging in estuaries and bays are presented in Table IV-18.

Table IV-18. Impacts of dredging and spoil placement in estuaries and bays

IMPACTS

Modification of bottom topography due to:

- a. Creation of bottom holes and channels; and
- b. Segmentation and shoaling.

Modification of current directions, velocities and patterns due to:

- a. Modification of flushing patterns;
- b. Altered patterns of tidal mixing and exchange;
- c. Acceleration of passage of freshwater through the estuary;
- d. Increased penetration of saline water into the estuary; and
- e. Sharpening of estuarine salinity gradients.

Increase in turbidity

Reduction in particle size of surface sediments

Reduction in oxygen concentration of near-bottom water

5 IMPACTS

Impacts of Dredging and Spoil Dumping on the Continental Shelf

The impacts of dredging and spoil dumping in the ocean vary with the site and nature of the bottom sediments. The most severe environmental hazards are created when the dredge spoils are freshwater-derived and polluted.⁵⁹ Contaminated spoils pose a major threat to spawning areas on the continental shelf. Depending on the nature of the pollutants and the quantities involved, significant fisheries resources may be affected. The environmental and economic impacts can be far-reaching and long-term.

Impacts Associated with Waterway Margins

Impacts of Construction of Breakwaters, Sea Walls and Shore Protection Systems

The beach zone is a dynamic environment influenced by complex natural forces. Construction projects that do not take these dynamic forces into account create impacts which require further construction or continual maintenance. Breakwaters and sea walls that project perpendicular to the beach interrupt the longshore currents and lateral transport of sand. The result is the accumulation of sand on the upstream side, beach erosion on the downstream side, and overall loss of beach habitat. ⁶⁰

This "artificial" beach situation creates other problems as well. Sand is removed from the nearshore continental shelf creating a steeper slope where waves impact the shore with greater force. The removal of sand from the beach dunes eliminates valuable "high beach" habitat and reduces protection of the back lagoons. Removal of material from behind the dunes eliminates the lagoon habitat altogether. The addition of sand to the forebeach, in turn, alters this habitat and the cycle is repeated. In short, repeated habitat destruction is generally the price of artificial shoreline stability. ⁶¹

Attempts to stabilize the beach dunes with sandbags and other methods ususally fail because this activity creates a narrower forebeach and steepened beach profile. This occurs as a result of the erosion of the finer sands from the surf zone and the subsequent creation of reflection waves which further accelerate beach erosion. The loss of fine sand also means that new dunes cannot form to

replace those lost by the construction activity.⁶² The impacts of construction of breakwaters, sea walls and other shore protection systems are highlighted in Table IV-19.

Table IV-19. Impacts of breakwater, sea wall and shore protection system construction on coastal wetlands

IMPACTS

Interruption of long-shore currents and lateral transport of sand

Accelerated beach erosion due to removal of sand from the nearshore continental shelf creating greater wave forces

Alteration or destruction of "high beach" (dune) habitat due to removal of sand

Alteration or destruction of lagoon habitat due to dune erosion

4 IMPACTS

Impacts of Piers, Wharves and Bulkheads

The construction of piers, wharves and bulkheads permanently eliminates productive inter-tidal and sub-tidal "water-edge" habitat. Dredging to obtain fill for such structures destroys additional shallow or deepwater habitat. These structures tend to be vertical walls which extend into relatively deep water. The hard vertical surfaces of these structures create reflection waves which cause further habitat disruption. When groups of piers, wharves and bulkheads are built in close proximity (as is often the case), blind channels are created. Poor circulation in these channels leads to anaerobic conditions and reduced environmental quality.⁶³ The impacts of pier, wharf and bulkhead construction are listed in Table IV-20.

Table IV-20. Impacts of pier, wharf and bulkhead construction on coastal wetlands

IMPACTS

Elimination of inter-tidal and sub-tidal "water-edge" habitat
Destruction of shallow or deepwater habitat through dredging
Creation of reflection waves causing habitat disruption
Creation of anaerobic conditions due to poor circulation in blind channels

4 IMPACTS

Impacts of Deepwater Structures

Deepwater structures such as moorings and dolphins do not generally produce environmental impacts themselves. Port facilities however, often generate water pollution problems from spillage and from flushing of domestic wastes. Submarine pipelines may constitute barriers for bottom-dwelling species which normally move long-shore or offshore. Pollution from pipeline leaks and breaks can cause serious local problems. ⁶⁴

Impacts of Offshore Mineral Extraction and Pipeline Construction

Offshore dredging for sand, gravel and shell destroys bottom habitat and eliminates protective cover. Dredging near shore removes protective barriers and accelerates beach erosion.

The problems of offshore drilling for petroleum and natural gas stem from water pollution hazards and the creation of "artificial" habitats. These hazards are particularly acute in extreme environments such as those in the Arctic Ocean. Construction under arctic conditions must, therefore, incorporate high construction

standards, advanced safety devices, attention to good "housekeeping", and provide for frequent inspection and monitoring. ⁶⁵

Biological Impacts of Construction Activities on Wetlands

Environmental modification seldom impacts only a single physical or chemical factor. These impacts generally fall into two (2) groups that are time-related. These two types of impacts are:

1. Primary impacts that occur immediately after the environmental modification; and
2. Secondary and tertiary impacts that occur later in time and often some distance from the site. ⁶⁶

It is important to recognize that a given environmental impact may result from more than one wetland alteration activity. For example, the total sediment load in a river system may be the result of multiple construction activities along its length. It is also important to note that two or more factors, working in combination, may produce impacts that may not have been predicted based on an examination of the factors taken separately. In some instances, one factor tends to partially cancel another, while in other instances, the combined effect may be more severe than the simple sum of the two acting separately. ⁶⁷

The set of secondary and tertiary impacts resulting from the primary disturbances are referred to as a "factor train". ⁶⁸ Factor train analysis is the first step in assessing environmental impacts on wetland systems. Factor train analyses for various types of construction activities are presented in Appendix E.

Biological Responses to Environmental Stress Factors

There are several potential categories of biological response. At the outset, the biological response may manifest itself at any of the four (4) levels of biological organization; namely:

1. Individual organism level;
2. Population level;
3. Species level; or
4. Community level. ⁶⁹

Any physical or chemical modification may be thought of as an actual or potential stress agent which is imposed on the already hostile environment of the organism or group. At the individual organism level, the response may be physiological, behavioral or reproductive. At the population level, the most sensitive individuals will exhibit the first effects of stress. As the level of stress is increased, even the most tolerant individuals show stress symptoms. ⁷⁰

At the species level, populations vary in their sensitivity to environmental stress agents. As the stress level increases, sensitive populations will disappear first, while hardier populations remain but undergo genetic simplification. Under high stress situations, even the hardiest populations may be eliminated. ⁷¹

At the community level, shifts occur in species composition and relative abundance as some species become reduced or eliminated and others find conditions favorable due to reduced composition or other factors. Environmental stress factors may cause a change in the rate or intensity of vital processes such as respiration and

photosynthesis. There may be a decrease in species diversity or in the number of individuals or certain species. Under extremely stressful conditions, the community may collapse. ⁷²

In short, physical and chemical modifications of the environment may act as stress agents. The biological response to these burdens on the system may be gradual and related to the intensity of the stress factor, or may result in an "all or nothing" relationship where a threshold defines the difference between success and failure of the biological system. Furthermore, the response may be manifested at several different levels of biological organization. Since species of a community share the same environment and their population levels are mutually interdependent within the community, complex patterns of biological response interactions are likely to result from wetland alteration. ⁷³

The generalized response patterns to increased levels of environmental stress at the different organizational levels discussed above are summarized in Table IV-21. ⁷⁴ Specific biological impacts on wetland and riparian environments resulting from construction activities are discussed below.

Overview of Biological Impacts of Construction

Activities on Wetlands

The cumulative impacts of construction activities on wetland environments are largely independent of the type of construction activity that produced the impacts. Every type of construction activity removes native vegetation and topsoil.

If only the vegetation is removed, secondary succession may

DEGREE OF STRESS	Response at indicated level of organization			
	Individual Organism	Population	Species	Community
Moderate	<ul style="list-style-type: none"> .Some metabolic and behavioral interference .Reduced competitive ability .Reduced resistance to parasites and predators .Reduced capacity for reproduction 	<ul style="list-style-type: none"> .Reduced competitive ability of most sensitive individuals .Some genetic selection for more tolerant individuals 	<ul style="list-style-type: none"> .Most sensitive populations undergoing selection for hardest individuals, hence losing genetic diversity .Most tolerant population little affected. 	<ul style="list-style-type: none"> .Noticeable shifts in relative species abundance as the most sensitive species suffer reduction in numbers while more tolerant competitor species remain the same or increase in abundance
Heavy	<ul style="list-style-type: none"> .Individual under heavy stress load .Survival not in jeopardy, but individual weakened and susceptible to parasites, disease, and predation .Reproduction greatly curtailed 	<ul style="list-style-type: none"> .Elimination of most sensitive individuals .Increase in more tolerant individuals .Population level may or may not be affected .Reduction in genetic diversity 	<ul style="list-style-type: none"> .Most sensitive populations eliminated .Most tolerant populations losing sensitive individuals, hence losing genetic diversity 	<ul style="list-style-type: none"> .Significant shifts in species composition as sensitive species are eliminated and hardy competitors remain and often increase .New hardy species may enter from elsewhere
Severe	<ul style="list-style-type: none"> .Severe metabolic and behavioral interference .Individual survival in question .Reproduction no longer possible 	<ul style="list-style-type: none"> .Survival of only the most tolerant individuals .Population level may or may not be reduced .Severe reduction in genetic diversity 	<ul style="list-style-type: none"> .Only the hardest individuals of the most tolerant population still survive 	<ul style="list-style-type: none"> .Great shifts in species composition .Most species reduced or eliminated .Hardy species may become very abundant .Total system greatly simplified .Community metabolism greatly modified .Stability severely reduced
TOTAL	DEATH	ELIMINATION	EXTINCTION	COLLAPSE

* Response is given for several different levels of biological organization. Entries within a given vertical column are meant to indicate trends of response pattern. Habitat elimination sends all columns to the bottom entry.

replace the original community over time. When the topsoil is removed, however, primary succession must take place. Topsoil development, and the subsequent successional development of plant communities, takes many centuries to complete. ⁷⁵

Lowered fertility and reduced environmental options also result from the removal of topsoil. Loss of fertility means a long-term reduction in the capacity of the ecosystem to recover. Nutrient loss, in turn, is accompanied by a significant increase in surface water runoff. ⁷⁶

The removal of vegetation temporarily deprives riparian species of food, cover, and nesting and denning sites. Natural vegetation helps retain soil moisture and helps prevent floods in certain areas. Removal of the vegetative cover reduces or eliminates the ecosystem's ability to perform these important natural functions. ⁷⁷

Partial or total habitat destruction can result directly from dumping and surfacing, digging, modification of water level, and indirectly, by erosion and loss of nutrients, chemical modifications by leaching and addition of wastes, and by the introduction of exotic plant species which out-compete natural vegetation. Dumping and filling activities are often associated with hard surfacing which permanently destroys the riparian habitat. If the spoil material used as fill is subject to erosion and leaching, the effects may be evident over broad areas of the floodplain as well as in the adjacent and downstream waters. These detrimental impacts are magnified if the spoil material is chemically active. ⁷⁸

Levee construction involves floodplain dumping intended to contain natural waterways and prevent the cyclic flooding of riparian

environments. Once the levee is constructed, swamps and other riparian wetlands along the landward-side of the levee fail to receive the annual replenishment of water, nutrients and aquatic stocks. Furthermore, these wetlands are often subsequently drained for agricultural use or industrial development. 79

Drainage ditching and mining are digging activities that severely impact wetland environments by removing surface water which, in turn, lowers the water table. Many marginal aquatic and riparian plant species are quite sensitive to even minor changes in water level. Lowering the water table, thereby, induces a shift from lowland moisture-requiring species to upland vegetation. The spawning grounds for many fish species, feeding and resting areas for migratory waterfowl, nesting sites for marsh birds, and habitat for many reptile populations are lost in the wake of floodplain destruction. 80

Major channelization projects often destroy not only the riparian environment, but also the complex of bottomland forests, swamps and permanent water bodies associated with the floodplain. In addition, valuable "edge" habitats are also lost in the process. The frequency and duration of flooding declines, soil moisture is reduced, and severe erosion frequently occurs.

Permanent flooding and periodic drawdown associated with channelization and dam construction have major impacts on riparian environments. Periodic drawdown of flooded areas desiccates and kills submerged and emergent vegetation, permitting the invasion of annual weeds. Alternating the water level inhibits the natural development of shoreline vegetation in general. Frequent or extreme fluctuations

in water level create a broad devegetated zone along the shore of reservoirs. ⁸¹

Flooding is also a major cause of nest failure for many species of ducks. Fluctuating water level damages nests, reduces hatching success, and leads to nest desertion and nesting failure. Many species of floodplain animals, such as opossums, cottontail rabbits, woodchucks, skunks and foxes, are particularly impacted by the mortality of timber and woody species caused by permanent flooding. ⁸²

The death of floodplain forests by inundation results in considerable nutrient loss as well. Decomposition of the dying forest releases organically-bound nutrients. Nutrient enrichment of downstream waters may lead to the extensive development of aquatic vegetation. Extensive siltation and eutrophic development will result in the rapid filling of shallow areas. ⁸³

Wetland alteration activities also impact animal species by imposing barriers to normal movement. Under natural conditions, the floodplain provides passage for daily or nightly foraging along rivers and stream banks. Many species over-winter in valleys and lowlands seeking food and shelter in the associated wetlands. Streamside highways and fences may prevent access to the water, thereby, restricting passage of animals to watering and foraging grounds. In addition to the direct impacts of the construction activity, the increased levels of noise, human activity and vehicular traffic undoubtedly have detrimental effects on local wildlife populations. ⁸⁴

It is important to recognize that the destruction of the natural

environment is often accompanied by significant financial losses from reduced wildlife production and subsequent harvests. When the monetary value of lost wildlife harvest is added to the "intangible costs" of the project, the impacts of even a small project can often be substantial. ⁸⁵

Much wetland habitat is lost each year as a result of chemical changes. Habitat destruction can result from the leaching of sulfuric acid and heavy metals from acid mine spoils and industrial wastes, from increased concentrations of sodium and calcium chloride used for winter road maintenance, from automobile exhausts and highway runoff, and from other pollution sources. ⁸⁶

The introduction of exotic vegetation is sometimes a secondary impact of wetland construction projects. Species such as Kentucky bluegrass, Bermuda grass and some species of rye grass are commonly used to restore and landscape the construction site. Ecologically, these hardy varieties can out-compete and eliminate many of the native plants. In other cases, exotic weeds are inadvertently introduced, frequently colonizing spoil heaps and disturbed areas. The floral and faunal mixing associated with construction activities is slowly crowding out many native species, thereby, reducing the size and genetic diversity of many local populations. ⁸⁷

The cumulative impacts of construction activities on wetland environments are summarized in Table IV-22. The implications of these construction impacts for wetland conservation and resource planning are discussed in Chapter V.

Table IV-22. Cumulative impacts of construction activities on wetland environments

IMPACTS

Direct removal of vegetation

Direct removal of topsoil

Habitat destruction by dumping and surfacing:

- a. Landfill from construction projects;
- b. Hard-topping for roads, factories, etc.;
- c. Grading and concreting for drainage ditches;
- d. Rip-rapping of banks;
- e. Dumping of mine overburden, spoil, tailings;
- f. Dumping of dredge spoil;
- g. Levee construction; and
- h. Construction of primitive access, logging, and mining roads (especially in steep or rough terrain).

Habitat destruction by digging:

- a. Ditching (main, as well as lateral ditches); and
- b. Mining (especially placer mining and sand and gravel excavation).

Habitat modification by water level manipulation:

- a. Permanent flooding;
- b. Alternate flooding;
- c. Protection from flooding;
- d. Drainage; and
- e. Lowering of soil water table.

Habitat modification by indirect methods:

- a. Erosion and loss of nutrients;
- b. Chemical modification by leaching of acids, metals and sulfides from spoils; leaching of chemicals from pavement; addition of salts (sodium and calcium chloride); motor vehicle wastes (petroleum products, heavy metals); other chemical wastes from factories; etc.; and
- c. Introduction of exotic vegetation.

6 MAJOR IMPACT CATERGORIES

FOOTNOTES

Chapter IV

1. Rezneat M. Darnell, Impacts of Construction Activities in Wetlands of the United States. U.S. Environmental Protection Agency, Ecological Research Service, EPA-600/3-76-045 (Springfield, Virginia: National Technical Information Service, 1976), 126.

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3. Ibid., 126-127.

4. Ibid., 128.

5. Ibid.

6. Ibid., 130.

7. J.E. Hobbie and G.E. Likens, "Output of phosphorus, dissolved organic carbon, and fine particulate carbon from Hubbard Brook Watersheds" Limnol. Oceanogr. 18 (5): 734-742 (1973) in Darnell, Impacts of Construction Activities in Wetlands of the United States, 131.

8. Ibid., 132.

9. D.W. Chapman, "Effects of logging upon fish resources of the west coast". J. Forestry 60:533-537 (1962) in Darnell, Impacts of Construction Activities in Wetlands in the United States, 132.

10. I.A.E. Bayly and W.D. Williams, "Inland waters and their ecology" Longman, Australia (1973) in Darnell, Impacts of Construction Activities on Wetlands in the United States, 132.

11. Ibid., 130.

12. Ibid.

13. Ibid.

14. Ibid., 131.

15. Ibid.

16. Ibid., 133.

17. Ibid, 133-134.

18. Ibid., 134.

19. Ibid., 135.

FOOTNOTES

Chapter IV (continued)

20. Ibid.
21. Ibid., 139.
22. Ibid., 137.
23. Ibid.
24. Ibid.
25. Ibid., 139.
26. Ibid., 138.
27. Ibid., 140.

28. Bayly and Williams (1973); J.A. Bocardy and W.M. Spaulding, Jr., Effects of Surface Mining on Fish and Wildlife in Appalachia. U.S. Fish and Wildlife Service, Resource Publication 65 (1968); R.M. Davis, "Limnology of a Strip Mine Pond in Western Mayland", Chesapeake Sci. 12 (2): 111-114 (1971) and "Benthic Macroinvertebrate and Fish Populations in Mayland Streams Influenced by Acid Mine Drainage" Univ. Md., Nat. Resources Inst., Contr. No. 528 (1973); H.B.N. Hynes The Biology of Polluted Waters. Liverpool University Press (1960); E.C. Kinney, Extent of Acid Mine Pollution in the United States Affecting Fish and Wildlife. U.S. Fish and Wildlife Service Circular 191 (1964); J.D. Parson, "The Effects of Acid Strip-Mine Effluents on the Ecology of a Stream". Arch. Hydrobiol. 65 (1):25-50 (1968); W.M. Spaulding, Jr. and R.D. Ogden, Effects of Surface Mining on the Fish and Wildlife Resources of the United States. U.S. Fish and Wildlife Service, Resource Publication 68 (1968); U.S. Department of the Interior, Handbook of Pollution Control Costs in Mine Drainage Management. Fed. Water Poll. Contr. Adm. (1966), Study of Strip and Surface Mining in Appalachia: An Interim Report to the Appalachian Regional Commission (1966) and Surface Mining and Our Environment: A Report to the Nation (1967) in Darnell, Impacts of Construction Activities in Wetlands of the United States (1976), 140.

29. Ibid., 140-142.
30. Ibid., 142-143.
31. Ibid., 144.
32. Ibid., 146.
33. Ibid., 145.

FOOTNOTES

Chapter IV (continued)

34. Ibid., 145-146.
35. Ibid., 148.
36. Ibid., 149.
37. Ibid., 150.
38. Ibid., 151.
39. Ibid., 152.
40. Ibid., 151-152.
41. Ibid., 153.
42. Ibid., 152.
43. Ibid., 154.
44. Ibid., 154.
45. Ibid., 155.
46. B.J. Copeland, "Effects of Industrial Waste on the Marine Environment", J. Wat. Poll. Contr. Fed. 38 (6):1000-1010 (1966), "Effects of Decreased River Flow on Estuarine Ecology", J. Wat. Poll. Contr. Fed. 38 (11):1831-1839 (1966) and "Estuarine Classification and Responses to Disturbances", Trans. Amer. Fish Soc. 99 (4):826-835; and C.R. Chapman, "The Texas Basin Project", A Symposium on Estuarine Fisheries, Amer. Fish Soc. Spec. Publ. 3 (1966) in Darnell, Impacts of Construction Activities in Wetlands of the United States, 155-156.
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48. Ibid., 157 and 162.
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50. Ibid., 164 and 166.
51. Ibid., 167.
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53. Ibid., 169 and 171.

FOOTNOTES

Chapter IV (continued)

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55. Ibid., 171-172.
56. Ibid., 172-173.
57. Ibid., 166-169.
58. Ibid., 169.
59. Ibid., 172 and 174.
60. Inman and Brush (1973) in Darnell, Impacts of Construction Activities in Wetlands of the United States, 174.
61. Ibid., 175.
62. Ibid.
63. Ibid., 176.
64. Ibid.
65. Ibid., 176-177.
66. Ibid., 182.
67. Ibid., 182 and 190.
68. Ibid., 182.
69. Ibid., 191-192.
70. Ibid., 191.
71. Ibid., 191-192.
72. Ibid., 192.
73. Ibid., 195.
74. Ibid., 193.
75. Ibid.
76. Ibid.
77. Ibid.

FOOTNOTES

Chapter IV (continued)

78. Ibid., 199.
79. Ibid.
80. Ibid., 199-200.
81. Ibid., 203.
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85. Ibid., 208
86. Ibid., 197.
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As soon as society recognizes that it cannot maximize everything for everyone, it must begin to make choices. Should there be more people or more wealth, more wilderness or more automobiles, more food for the poor or more services for the rich? Establishing the societal answers to questions like these and translating those answers into policy is the essence of the political process.

Yet few people in any society even realize that such choices are being made everyday, much less ask themselves what their own choices would be. The equilibrium society will have to weigh the trade-offs engendered by a finite earth not only with considerations of present human values but also with consideration of future generations.

--Limits to Growth, Donella Meadows,
Dennis Meadows, Jorgen Randers,
and William Behrens

CHAPTER V

WETLAND CONSERVATION

From the preceding discussion, it is clear that construction activities do indeed impact wetland environments. The magnitude of the impacts will dictate the future environmental health of the impacted wetland ecosystem. It is critical that planners and decision-makers consider the potential and magnitude of these impacts in reviewing construction proposals. Planning efforts at the local level must identify steps that can be taken to reverse the trend of wetland deterioration and provide a focus for protecting wetlands in the community setting.

In order to effectively conserve wetlands, it is essential to understand the causes of wetland deterioration and major patterns of response. The following sections highlight these "causes" and "effects".

Causes of Wetland Deterioration

The most devastating cause of wetland deterioration is direct loss of wetland habitat. Many of those construction activities discussed in Chapter IV alter or destroy the entire wetland habitat. Other activities eliminate portions of the habitat and many of its associated values. Large and small projects alike have destroyed or severely modified over half of our nation's wetlands. Those wetlands that have been modified often bear little resemblance to their original ecosystem types.

Perhaps as destructive as direct habitat loss as a cause of wetland deterioration is chronic "stress". This stress can take the form of modified flow rates and seasonal flow patterns, including elimination of peak flows and altered species composition. Pollution, saltwater encroachment and loss of nutrient and mineral enrichment are additional causes of environmental stress for wetland ecosystems. ¹

Short-term, locally-severe impacts associated with individual construction projects are another cause of wetland deterioration. ² Although incremental in nature, their cumulative effect on the nation's resource base is substantial. Some of these severely impacted wetlands do recover after completion of the project. But growth trends have shown that once one project is built, subsequent development often follows. The result is a massive erosion of wetlands in growing communities as well as nationwide.

Pollution is a fourth major cause of wetland deterioration in this country. ³ Most construction activities lead to some form of pollution. This pollution usually persists as a by-product of the construction project; e.g., surface runoff from urban, industrial and transportation activities. Some construction activities produce highly toxic pollutants or large quantities of suspended sediments that cause significant wetland deterioration.

Patterns of Wetland Response

Patterns of wetland response to disturbance may be discussed in terms of time (in relation to the construction activity) and space (in relation to distance from the construction site). Wetland impacts

upstream and downstream of the site must be considered in addition to "on-site" impacts to determine the full effect of the project on the local environment.

In the case of construction along rivers and streams, the original ecosystem at the site and directly upstream and downstream is eliminated by the project. Further downstream, the impact is diminished. In some cases, however, the activity may again have a major effect much further downstream. For example, by reducing water flow, a dam project may have a moderate impact on the stream ecology but a major impact on that of the downstream estuary. This "two-stage response" is characteristic of activities that modify flow patterns, flow volumes and nutrient loads.⁴

Time-related patterns of wetland ecosystem response to construction disturbance result in habitat elimination followed by complete or partial recovery, or chronic modification.⁵ A serious ramification of construction in wetlands is a long-range reduction in productivity or diversity. Following construction, the wetland may appear to have recovered when, in fact, it now exists at a low-equilibrium, chronically-stressed state. This situation is undoubtedly the case for many of our nation's wetlands that have been subjected to floodplain devegetation or heavy siltation.

Another response pattern that is probably more common than is generally recognized is that of "delayed response". This may result from life history peculiarities, environmental idiosyncrosies, multiple construction projects, or a combination of these factors.⁶ Pollution gradually added to wetland bottom sediments, for example, may suddenly be released by a dredging project or the impacts of a water diversion project may be magnified during a drought period.

Wetland response to alteration by construction activities may appear insignificant at first but have far-reaching ecological or economic impacts. This is the case when one species or set of species is substituted for another.⁷ For example, commercially important species of fish or shellfish may be replaced by non-commercial species as a result of shifts in salinity or water quality.

It is also prudent to keep in mind that ecosystem response patterns are not mutually exclusive but can grade into one another. Science provides us with a reasonable degree of predictability of cumulative biological response to human manipulation. We need to make use of this predictability in our resource management activities. But we must not lose sight of those elements of nature that, to-date, escape our sophisticated wetland management capability to understand.

Planning Assumptions

Although major gaps in our knowledge of wetland dynamics clearly exist, we do know a lot about the impacts of construction activities on these natural environments. We can use this information to actively pursue steps to reverse the nationwide trend of wetland deterioration and destruction through planning. We can summarize this knowledge in the form of "planning assumptions". I have divided these 'assumptions' into ecological assumptions and resource management assumptions.

Ecological Assumptions

Wetlands in their undisturbed state are ecologically-adapted to their prevailing habitat conditions.⁸ Wetland alteration disrupts this "steady-state equilibrium". This disruption may result in altered

genetic make-up of native populations and changes in the composition and functional aspects of the wetland ecosystem. Sensitive species are most affected by the alteration.

Wetlands in their natural state are "balanced" with respect to most environmental factors.⁹ Alteration of the aquatic system creates a deviation from some middle range to a deficiency or excess in one or more factors. The deviation may, for example, take the form of desiccation or inundation, starvation or over-enrichment, too-fresh or too-salty.

Wetland alteration creates ecological "stress" ranging from temporary pressure to complete habitat destruction.¹⁰ The characteristics and magnitude of the stress varies with the alteration activity. Chronic stress severely impairs the wetland's ability to function as a natural system with inherent values.

A given type of construction project generates a characteristic set of environmental impacts.¹¹ We can therefore expect to see these impacts each time a similar type of project is proposed. When a number of similar projects are undertaken, certain wetland types may be jeopardized on the local, regional or even national scale.

Certain wetland species and habitats are particularly vulnerable and require protection if they are to survive.¹² These include rare and endangered species, certain immobile and isolated species as well as highly vulnerable wetland types. Some wetland types are more vulnerable than others because of their location or as habitat for economically important or aesthetically valuable species. The most sensitive and "pressured" wetlands are not likely to survive intact without deliberate protective intervention.

These ecological assumptions are summarized in Table V-1 and used, along with my resource management assumptions, to develop some strategies and recommendations for wetland conservation.

Table V-1. Ecological assumptions of wetland alteration

<u>ASSUMPTIONS</u>
Undisturbed wetlands are ecologically-adapted to their habitat conditions
Undisturbed wetlands are balanced with respect to most environmental factors
Wetland alteration creates ecological stress ranging from moderate to severe
Each type of construction project generates a characteristic set of wetland impacts
Vulnerable wetland species and habitat types require special protection

5 ECOLOGICAL ASSUMPTIONS

Resource Management Assumptions

Human demands and pressures on our nation's wetlands will increase in the future. Wetlands will continue to be altered and destroyed by the construction activities that result from these socio-economic demands and growth pressures. Small wetlands in growing communities will remain those least appreciated and thus most affected by development.

The most important impacts of construction activities on wetland environments are loss of habitat, alteration of stream flow patterns and the addition of large quantities of suspended solids resulting in increased turbidity and widespread siltation. These impacts have already severely modified or destroyed numerous wetlands and threaten

many others. The on-site and downstream impacts of construction activities will continue to damage the natural ecosystems of our streams, riparian wetlands, coastal marshes, swamps, estuaries and ocean beaches.

Despite the predictability of wetland impacts for a given type of construction activity, every project is a "site-specific" ecological experiment. Local circumstances, in combination with the large number of physical, chemical and biological variables involved, make impact prediction somewhat uncertain at best. Planners need to recognize this potential for uncertainty and advocate that a significant margin of environmental safety be incorporated into the permitting process. Consideration should be given to requiring a built-in "control" for approved projects. This control should be a local wetland of comparable size and ecological type which can provide baseline data for comparison.

There is a need for ecological research on the response of wetlands to specific types of environmental manipulation. Systems analysis data on ecosystem structure and function will improve our ability to predict wetland impacts. There is also a need to develop a sophisticated technology for restoring degraded wetlands. Wetland restoration may help us regain those ecological values lost in the construction process and avoid destroying these values in future projects. In addition, further investigation of what constitutes an adequate "buffer" is needed to enhance wetland conservation.

The regional uniqueness of wetlands and their responses to human manipulation points to the need for sophisticated wetland ecosystem analysis on a regional basis throughout the nation. Integrated scientific information for the region where a project is proposed can be

used to make intelligent management decisions about the impacted wetland and the community at large.

To-date, wetland conservation has been "piece meal" and only marginally successful. Management of our nation's wetland resources has been hampered by a lack of public understanding of and appreciation for wetlands, as well as inadequate wetland inventories, maps, definitions, performance standards and other integrated scientific information. These management needs are particularly acute at the local level and in rural areas around the nation. Comprehensive planning for wetland conservation is not being undertaken by many communities and some states. This lack of resource planning offers planners a challenge in every region of the country. My resource management assumptions of wetland alteration are summarized in Table V-2.

Table V-2. Resource management assumptions of wetland alteration

ASSUMPTIONS

Wetland alteration and destruction will continue and intensify in the future

Small wetlands in growing communities will be most affected by development

The most important impacts of construction activities on wetlands are (and will continue to be):

- a. Loss of habitat;
- b. Alteration of stream flow patterns; and
- c. Addition of suspended solids causing increased turbidity and siltation.

Every wetland modification project is an ecological experiment

Present impact predictability is not adequate to fully assess site-specific variability and unique conditions

The predictability of alteration impacts can be enhanced through research on ecosystem structure and function, and on wetland responses to manipulation

(CONTINUED)

Table V-2. Resource management assumptions of wetland alteration
(continued)

ASSUMPTIONS

Regional ecosystem analysis information is needed to make intelligent wetland management decisions at the local level

Good wetland maps, definitions, performance standards and other planning "tools" are needed in every community

Lack of comprehensive resource planning is a threat to wetland conservation nation-wide

9 RESOURCE MANAGEMENT ASSUMPTIONS

Wetland Conservation Recommendations

Our concept of the value of wetlands has changed dramatically during the past three decades as the inherent worth of wetlands has been recognized. Despite increased appreciation, construction activities and pollution continue to threaten, alter and destroy our nation's wetlands. We can no longer accept incremental destruction of these valuable ecosystems, or ignore the problem altogether. Short-term and long-term steps can be taken to reduce wetland deterioration and preserve those wetlands most threatened by development and "progress".

Maintaining the quality of our nation's wetlands is one component of overall environmental protection. Wetland conservation cannot be separated from land use. Therefore, wetland conservation must be linked to a national program of environmental protection that extends from the uplands to the sea. We can work with the cycles of nature to preserve our environmental quality or be defeated by them. The following sections discuss some planning strategies, policy issues, research directives and specific recommendations for conserving wetlands at the community level.

Planning Strategies

The first step in conserving wetlands is to curtail the most environmentally destructive types of construction projects. "Growth management" is more than a popular planning term now. Many communities around the country recognize that 'growth and development' often brings with it reduced environmental quality. We are in an age when individual projects must be justified on their own merit in light of the social, economic and environmental costs.¹³ Communities and developers alike must consider alternative means of achieving desirable social goals and refrain from allowing those construction projects for which the environmental price is too high. The scarcer the wetland type (because of its biology or location), the more valuable it becomes to society as a means of preserving components of the living ecosystem for future generations. It is imperative that those projects that have the most serious environmental impacts be prohibited.

Balancing wetland conservation with appropriate development is the goal of resource planning. Some construction projects are necessary and desirable. For those projects that have been judged to be socially desirable, every effort should be made to ameliorate the impacts by requiring that the least-damaging construction methods be employed. Consideration should be given to seasonal ecological patterns to minimize habitat modification at "critical" times. "Good housekeeping" methods should be required and monitored. Permits and contracts should specify quality control of environmental damage during all phases of the construction project.¹⁴ Impact analysis efforts should address gaps in our technological capability to ameliorate the wetland impacts of future projects.

Wetland conservation has been accomplished largely as a result of broad pollution control standards adopted at the national and state levels. Enforcement of these standards has undoubtedly helped maintain the integrity of many aquatic systems in the United States. However, "water quality criteria" alone are not sufficient to prevent wetland deterioration and destruction. An additional set of criteria is necessary to reduce problems resulting from construction activities. 15 Some of the problems that need to be addressed by these criteria are outlined in Table V-3.

Table V-3. Construction problems for which impact criteria are needed.

PROBLEM AREAS

Habitat loss through dumping, filling, ditching, canalization, leveeing and spoil banking

Nutrient loss through floodplain devegetation

Provision of adequate peak flows

Maintenance of minimally-adequate flow rates

Provision of ecologically-appropriate seasonal flow regimes

Maintenance of adequate water levels and circulation patterns

Prevention of saltwater intrusion

Prevention of excess bottom sediments

Provision of adequate food, shelter and breeding areas for wetland species

9 PROBLEM AREAS

The above list implies that environmental protection involves broad ecosystem management as well as pollution control. Management must also incorporate adequate monitoring and enforcement. One way to ensure that

environmental precautions are taken during construction activities is to require a post-construction environmental impact statement. ¹⁶ Post-construction studies are useful not only to encourage "good house-keeping", but also as a means of assessing the accuracy of pre-construction impact prediction. The result of these studies can be used to make realistic predictions about the impacts of future projects on specific wetland types.

Some wetlands need special protection now. These are wetlands threatened because of their rarity or sensitivity to human activities, their size and location, or their desirability for incompatible uses. Subject to the twin pressures of construction and pollution, these wetlands need to be protected from certain destruction. The establishment of wetland sanctuaries may be required if these wetlands are to survive. Wetlands that are candidates for special protection include those listed in Table V-4.

Table V-4. Wetlands needing special protection

WETLAND TYPES

Habitat of rare and endangered species

Springs in arid regions (such small, isolated wetlands are highly sensitive and often habitat for rare species)

Small streams, shallow ponds and marshes near urban developments (because of their small size, they are sensitive to modification and highly vulnerable to filling)

Stream sections between bluffs (such areas may be the only stretches of swift water for miles and are especially amenable to damming)

Certain floodplain types that are easily destroyed by levees, canals and drainage ditches

Coastal marshes and swamps (especially those near expanding coastal communities)

Estuaries that may be damaged directly or indirectly by development and the impacts of development upstream

Remedial action is needed to restore some of our nation's degraded wetlands. Current technology provides the capability to partially restore some wetlands and fully restore others. There is considerable room for the application of creative engineering and additional research on remedial measures. The more effort that is made to restore degraded wetlands, the more knowledge we will gain and be able to apply to future restoration efforts. At present, a number of measures can be undertaken that have proven to be successful in restoring wetlands.¹⁷ Some of these measures are highlighted in Table V-5.

Table V-5. Remedial measures for restoring degraded wetlands

REMEDIAL MEASURES

IN THE WETLAND

Liming of acid waters to raise pH levels

Aeration of hypolimnic waters in reservoirs and anaerobic portions of streams, marshland canals and estuaries by means of pumps and perforated hoses

Creation of new riffles by bulldozing and desedimentation of degraded ones by use of hoses and water jets

Grating of coastal marshes and swamps to prevent saltwater intrusion and reduce erosion of canal banks

Reestablishment of marshes through plantings of marsh grasses (especially Spartina)

Reestablishment of submarine meadows through plantings of submerged grasses (especially Zostera and Thalassia)

Restoration of coastal marshes and swamps by increased freshwater release

Stabilization of wetland margins through revegetation projects

ADJACENT TO THE WETLAND

Creation of settling basins and other sediment traps near the stream entrance of drainage ditches, storm water outlets and other "point sources" of pollution

(CONTINUED)

Table V-5. Remedial measures for restoring wetlands (continued)

REMEDIAL MEASURES

Neutralization and revegetation of spoil banks and levees

Opening of levees to permit periodic floodplain flooding

Contouring, neutralization and revegetation of mine waste piles

12 EXAMPLES OF REMEDIAL MEASURES

In the short- and long-term, the cornerstone of wetland conservation is public education. This education must begin at the elementary school level and extend to every element of society in every region of the country. It is not enough for school children to be exposed to one unit of wetland ecology during the course of their education. Scientists, educators, planners, policy-makers, developers and concerned citizens must work together to heighten our national awareness of and appreciation for wetland values and habitats.

Researchers should continue to study wetland ecology, alteration impacts and mitigation methods and make their findings known. This information should serve as the basis for environmental protection and restoration policy that is technically sound and sensitive to regional and local environmental requirements. Failure to campaign for wetland conservation at the local, regional and national levels will lead to the further erosion of this important resource base and our overall environmental quality.

Public opinion influences public policy. As a nation, we are now more willing to accept the real costs of environmental protection. We can identify some important issues that need to be addressed by public policy and wetland research efforts. These policy issues and research directives are highlighted in the following sections.

Policy Issues

With increasing pressures on our nation's wetlands, the success of future conservation programs rests with improved scientific knowledge and public commitment to the long-range maintenance of environmental quality. Without such a commitment and adequate safeguards, human pressures will lead to further stress, genetic simplification, species extinction, habitat loss and ecosystem deterioration. The technology for environmental improvement is becoming more sophisticated daily. Technological capability allows us to make choices. It is time to ask ourselves some meaningful questions about the future of our society.

Comprehensive planning begins with a clear definition of the desired future state or condition; i.e., goals to be accomplished. We must establish environmental goals and integrate these goals into our public policies. Citizens, planners, governmental representatives and technical specialists need to work together to identify the desired environmental condition, and the social and institutional framework required to monitor and maintain the environment in the desired state. Such planning should be instituted now.

Maintaining environmental quality is an exercise in quality control. The pathway to our desired future is a narrow track balanced between society's demands, on the one hand, and ecological constraints on the other.¹⁸ In a political sense, maintaining environmental quality means retaining resource options for future generations. In a biological sense, it means perpetuating genetic diversity within functioning ecosystems. In an engineering sense, it is incorporating quality control into every construction project. In the absence of quality control, biology may reduce our political options. Extinct

species are non-renewable; they cannot be recycled, negotiated or compromised. We must, therefore, be concerned not only with the environmental quality balance, but also with environmental recovery. Our environmental policies must emphasize protection of healthy ecosystems and improvement of degraded ones.

Planning for our desired environmental future requires that we change our traditional approach to the environment. We must place environmental goals above societal goals for the latter cannot be accomplished in the absence of a quality environment. The emphasis of our planning efforts must be on protecting vital ecological and genetic processes. In the past, we have based our wetland protection programs on setting water quality standards; i.e., permissible levels of environmental stress. Ultimately, wetland protection must be based on genetic and ecological requirements, not simply allowable limits of ecosystem degradation.¹⁹

Table V-6 summarizes these policy issues in the form of goals. Planning efforts should focus on establishing specific goals and objectives for wetland conservation that address these issues.

Table V-6. Wetland conservation policy goals

POLICY GOALS

Establish national goals for the environment that include a wetlands' component

Incorporate the concept of "quality control" into public policies to protect ecosystems

Establish "permissible impact levels" based on ecological not social requirements

Incorporate "performance standards" for wetland conservation into the regulatory process

(CONTINUED)

Table V-6. Wetland conservation policy goals (continued)

POLICY GOALS

Require that "environmental impact statements" emphasize the critical biological issues and long-range ecosystem consequences

Establish a nationwide system of wetland reserves in and near urban areas

Establish wetland sanctuaries for rare and endangered species and habitats

7 GOALS

Research Directives

We must look to science to expand our knowledge of the requirements of the basic life support system and permissible impact levels that sustain healthy ecosystems. With this knowledge, we will be able to more accurately identify potential damage and acceptable environmental "boundary conditions" for individual construction projects.

The "environmental impact statement" (EIS) has proven to be a valuable mechanism for assessing potential environmental damage. At times, however, an EIS is more educated guesswork than scientific fact. With refinement, the EIS can be a more accurate tool for determining project impacts. The basis for more sophisticated impact statements rests with expanding our knowledge of wetland "systems" and the ecological effects of disturbance. In other words, we need to understand more about the composition and function of wetlands and how they respond to specific types of human perturbation.

Research is needed on the ecology of wetland systems and how such concepts as "succession", "climax", "stability" and "chronic stress" relate and are affected by construction activities. Research on impact mitigation should also be a wetland conservation priority. These

studies should be conducted on a regional basis and include adequate controls. Research findings should be integrated into ecosystem analysis capability systems that can be used at different decision-making levels.

"Systems analysis models" are available for the simulation of many physical, chemical and biological aspects of aquatic systems.²⁰ Modeling techniques are also available for treating many sociological phenomena and economic variables and for integrating scientific and socio-economic inputs into the same model. Systems analysis and mathematical models represent analytical tools for organizing and handling vast amounts of information. By necessity, all models are abstractions and simplifications of the "real world".²¹ Furthermore, models are more useful in dealing with certain classes of information (i.e., those that lend themselves to quantification and mathematical formulation) than with others. We do not yet have the scientific capability to include in our models all of the natural history and life-cycle information about all the biological species of a given environment. Yet, these natural history details are what often determines the success or failure of a given species when stressed by habitat manipulations.

Wetland conservation efforts will benefit greatly from improved ecosystem modeling capabilities. Models are, of course, no substitute for human input. Our public policies and research directives must be founded on the knowledge and judgement of experienced scientists and a concerned citizenry. Man alone can ask the relevant questions and interpret the data provided by the computer.

Some wetland conservation issues for which additional research is

needed are summarized in Table V-7. Such ambitious research efforts require manpower and resources. This will require a strengthening of governmental, private and university facilities already in existence as well as the establishment of new ones. This presupposes that we have adopted a public policy that "a healthy environment is an absolute prerequisite of a healthy society".²²

Table V-7. Wetland conservation issues requiring additional research

RESEARCH DIRECTIVES

"Boundary conditions" relative to impact levels

Wetland ecosystem composition, functions and interactions (for large and small wetland systems)

Wetland response to specific types of perturbations in a regional setting with adequate controls

"Impact mitigation" measures including adequate buffers

Improved wetland restoration techniques

Sophisticated ecosystem analysis capability systems

Improved ecosystem models that include natural history details for all species in the subject environment

Integrated ecological/socio-economic analysis capabilities for weighing the benefits and costs of a proposed project

"Performance standards" for wetland construction projects

9 DIRECTIVES

Strengthening Wetland Conservation Programs

at the Community Level

With many of our nation's wetlands facing great development pressure because of their prime waterfront locations and low cost in comparison to upland sites, it is time to strengthen both state and

local wetland conservation programs. Most coastal states now provide some measure of protection and control for coastal wetlands through coastal wetland regulation statutes or broader coastal zone or shoreland acts. Substantially less protection has been afforded inland wetlands which are more varied in their physical characteristics, vegetation and potential use. Some states have adopted inland wetland protection acts or provide for inland wetland protection as a component of broader regulatory programs. Non-regulatory wetland protection programs (e.g., public land management, flood control, public education, tax incentives, etc.) provide a valuable supplement to state regulatory programs.²³

Even with state mandates, much of the responsibility for conserving wetlands remains at the local level. Many municipalities have adopted wetland protection regulations on their own initiative or pursuant to state wetland regulation statutes. Others have adopted floodplain regulations in order to qualify for federally-subsidized flood insurance. Despite relatively widespread adoption of local regulatory programs and, to a lesser extent, non-regulatory programs, improvements in wetland conservation efforts are needed. The following sections suggest approaches for strengthening traditional regulatory techniques (e.g., zoning and subdivision controls) and initiating non-regulatory ones.

Local Initiatives

Strengthening efforts may involve a range of activities, and must be tailored to state requirements, the physical circumstances and preferences of the individual community. Integrating wetland management with comprehensive planning efforts that consider the environmental,

social and economic implications of land and water use is often the most successful way of conserving wetlands. Some examples of initiatives that a community can undertake to strengthen wetland conservation efforts at the local level are listed in Table V-8. ²⁴

Table V-8. Examples of community initiatives to strengthen wetland conservation efforts

INITIATIVES

Establish overall wetland protection policies

Improve wetland mapping, inventories and related data bases

Improve public education and involvement

Strengthen performance standards for wetland uses and broader watershed uses

Improve techniques for addressing the cumulative impacts of development

Adopt a formal wetland conservation program and "Action Plan" (as part of the Comprehensive Plan) combining regulatory and non-regulatory elements

Improve administration, monitoring and enforcement of wetland regulations

7 INITIATIVES

Community wetland programs are encouraged by a number of federal programs. Some of the best known of these programs are the Coastal Zone Management Act of 1972, the National Flood Insurance Act of 1968, the Rivers and Harbors Act of 1899 and the Federal Water Pollution Control Act Amendments of 1972. Establishing and implementing a community wetland conservation program involves a number of activities. These activities are generalized in Table V-9. ²⁵

Table V-9. Activities involved in establishing and implementing a community wetland conservation program

ACTIVITIES

Establishment of general wetland goals and policies by a local legislative body through a resolution or ordinance

Organization of community support

Adoption of interim regulations (if needed) to prevent wetland alterations while mapping, policy-setting and plan implementation are carried out

Adoption of implementation "tools" such as regulations, acquisitions, tax incentives, public works policies and public education

Administration and enforcement of the program

Program monitoring

6 PROGRAM ACTIVITIES

Wetland Conservation Policy

A duly-adopted wetland conservation policy serves as a guide for local comprehensive land use planning, public facilities planning, public land use management, regulation, land acquisition, tax assessment and related municipal programs. This policy should relate wetlands to broader hydrologic and biological systems and prohibit wetland development or degradation unless certain conditions are met. These conditions may include all or some of those listed in Table V-10. ²⁶ The burden should be on the developer to show compliance with the wetland policy.

Table V-10. Conditions for allowing wetland alteration

CONDITIONS

No alternative development sites are available

All hazards and nuisance threats are ameliorated

(CONTINUED)

Table V-10. Conditions for allowing wetland alteration (continued)

CONDITIONS

Essential wetland functions are preserved

The long-term community benefits of the development greatly exceed the benefits of development of an alternative site

All feasible measures are taken to minimize construction impacts

5 CONDITIONS

Wetland Regulations

There are a number of regulatory tools that communities can use to control land use and conserve wetland resources. Commonly used land use regulations include zoning, subdivision controls, building and sanitary codes, special codes and performance standards. The effectiveness of these regulations in conserving wetlands is discussed in the individual subsections below.

Wetland Zoning

Wetland zoning regulations are the most common type of wetland protection employed at the local level. These zoning regulations are adopted as a primary or overlay zone within a broader comprehensive zoning ordinance, or as a separate wetland ordinance. Floodplain zoning and special wetland protection by-laws and ordinances are included in the latter category of wetland regulations.

Zoning regulations consist of a map showing wetland boundaries and a written text listing prohibited and permitted uses and standards for special permit uses. These regulations may be based on a specific wetland regulatory statute, coastal zone, shoreland or wild and scenic

river statute, or broader zoning enabling authority. Usually a zoning board of adjustment, planning board, or special board (e.g., a conservation commission) is authorized to evaluate applications for wetland permits.²⁷

Communities frequently adopt comprehensive zoning ordinances that place wetlands and other highly valuable or unique lands subject to development pressures into conservation, open space or low-density residential zones with minimum lot sizes (typically, 2 to 60 acres). Lot size restrictions are often combined with siting controls and regulations on tree-cutting, grading, filling, dredging, construction of roads and other activities. This approach to land use regulation does not offer complete wetland protection. A considerable degree of protection may, nevertheless, be achieved if each proposed use is carefully evaluated and efforts are made to require that development be located on upland areas. Furthermore, the requirement for larger lots tends to reduce the overall density of development so that less wetland will be disturbed.²⁸ Table V-11 gives an overview of wetland zoning.

Subdivision Controls

Subdivision regulations are another regulatory tool for conserving wetlands in the community setting. Subdivision regulations are usually adopted on a community-wide basis and not solely for wetland protection. These regulations typically require that subdividers prepare detailed "plat" maps which must be approved by the local planning board prior to division of lots for sale or construction of buildings. To be approved, plats must comply with all applicable zoning and land use regulations.

OVERVIEW OF WETLAND ZONING

Purposes	Regulatory Standards	Advantages	Limitations
<p>1. Protect wildlife habitat, scenic beauty, and provide flood storage, wetland recreation opportunities by control of grading, filling, dredging, tree-cutting, type and density of wetland uses, buffer area uses.</p> <p>2. Protect public safety and prevent nuisances by prohibiting dangerous uses (e.g., chemical factories in flood hazard areas), unreasonable increases in flood heights due to floodway encroachments, threats to safety by location of quasi-public uses such as motels in flash-flood areas, water pollution from location of onsite waste disposal and solid waste disposal in wetland areas.</p> <p>3. Promote most suitable and economic use of community lands as a whole by implementing comprehensive land use plans allocating wetland areas to use consistent with wetland values and hazards.</p> <p>4. Reduce the cost of public facilities and assist in the implementation of facility plans for roads, sewer, water, schools, etc. by preventing or limiting the type and density of development in wetland areas.</p>	<p>1. Delineate wetland areas, prohibit destructive use, and apply performance standards to other uses.</p> <p>2. Delineate floodway areas and prohibit new structural uses and land alterations that will individually or cumulatively increase flood heights or velocities beyond defined levels.</p> <p>3. Establish flood protection elevations and protection standards for floodway and flood fringe areas and uses.</p> <p>4. In some instances, abate existing wetland uses of a nuisance nature and require flood proofing with major alteration of flood fringe uses.</p>	<p>1. The major tool of comprehensive planning to promote the most suitable use of lands throughout a community.</p> <p>2. Can incorporate wide range of provisions relating to wetland management and other objectives.</p> <p>3. Can separate wetlands into zones depending upon flood hazard and other factors and apply varying standards to the zones.</p> <p>4. Most common tool in preserving wetland areas.</p> <p>5. Can be applied (in some areas) to existing uses with a nuisance character.</p>	<p>1. May "take" private property if too restrictive.</p> <p>2. Does not regulate sale or transfer of lands.</p> <p>3. Often weakened by irrational variances and exceptions.</p> <p>4. Is largely prospective in nature (applies only to new uses) and usually unsuccessful when applied to high-value, nonnuisance existing uses.</p> <p>5. Usually does not incorporate detailed building design standards.</p> <p>6. Many states require prior comprehensive, community-wide planning, although this requirement has not been strictly enforced.</p>

Most subdivision ordinances contain specific provisions prohibiting the subdivision of flood-prone areas, and require that lots be suitable for building and on-site waste disposal if public sewers are not provided. These requirements, combined with the provisions that subdividers provide recreation and open spaces, give the community bargaining power for the conservation of wetlands. Additional wetland protection is provided by "cluster" subdivision provisions, commonly adopted to encourage subdividers to group buildings together in one portion of the subdivision so that other areas can be maintained as open space.²⁹ Table V-12 gives an overview of wetland subdivision regulations. Table V-13 highlights the steps involved in adopting and implementing local zoning and subdivision regulations.

Building Codes

Many communities have adopted building codes to control the design and materials used in structures. Building codes rarely contain reference to wetlands, although several typical provisions (e.g., requirements that buildings be elevated above the regulatory flood protection elevation and that buildings be located on suitable foundation materials) indirectly provide protection for wetlands if adequately enforced. Building codes do not, however, prevent filling, ditching, draining or other wetland alterations.³⁰

Sanitary Codes

Sanitary codes regulate the use of private waste disposal and septic tank systems. These regulations usually prohibit septic tanks and leaching fields in high groundwater areas and within specified

OVERVIEW OF WETLAND SUBDIVISION REGULATIONS

Purposes	Regulatory Standards	Advantages	Limitations
<p>1. Prevent victimization and fraud due to sale of wetland flood hazard, and peaty soil areas (structural bearing capacity and onsite waste disposal limitations) to innocent purchaser.</p> <p>2. Protect floodway areas from encroachment by roads, buildings, etc.</p> <p>3. Insure that roads, sewers, water supply, and other subdivision services are located in areas above flood elevation, or protected against flooding.</p> <p>4. Implement master and comprehensive plans including public facility components.</p> <p>5. Insure that subdivider installs drainage facilities which are consistent with community drainage system standards.</p>	<p>1. Prevent subdivision of land unsuitable for intended purposes.</p> <p>2. Require that each building site have an area above flood elevation suitable for building purposes, onsite waste disposal (where applicable), and adequate access.</p> <p>3. Require that flood hazard areas be noted on face of plat, and in some cases, the adoption of deed restrictions to control future uses in flood-prone areas.</p> <p>4. Require flood protection for sewer, water, and roads installed by subdivider.</p> <p>5. Require installation of drainage facilities or payment of fees in lieu of installation by subdivider.</p> <p>6. In some instances, require dedication by the subdivider of flood areas as parks or for other open spaces.</p>	<p>1. In many states, may be made to apply extraterritorially for urbanizing areas.</p> <p>2. Very flexible in negotiating with developer.</p> <p>3. In most states, does not require prior comprehensive planning although a street plan is often required.</p> <p>4. Can be used to require developer to provide wetland data on a case-by-case basis.</p> <p>5. Not as vulnerable to judicial attack as zoning.</p>	<p>1. Only indirectly controls use of land; must be in combination with zoning.</p> <p>2. Difficult to protect wetlands unless they are identified on maps.</p> <p>3. Does not apply to structural design or materials for future structures on subdivision land.</p> <p>4. Applies, in many instances, only to new land sales and divisions.</p> <p>5. "Loopholes" common in ordinances which permit subdividers to escape enforcement through "straw man" transactions (i.e., multiple divisions through friends, relatives).</p>

STEPS IN LOCAL WETLAND REGULATION

Step	Commentary	Zoning	Subdivision
1. Data Gathering	<p>Often the most expensive and time-consuming step in the adoption of legally sound and rational regulations. A variety of data may be needed to (1) identify floodway and flood fringe limits; (2) establish regulatory protection elevations; (3) identify vegetation types; (4) identify soils.</p> <p>Not all data need be gathered at once. The ultimate data used for regulation will determine the rationality of the regulation. Two approaches are often combined: (1) initial data gathering to identify wetland limits gathered in advance of adoption of regulation; (2) case-by-case development of more specific data when building permit applications are submitted.</p>	<p>Enabling acts usually make no mention of data needs; but data are essential for sound regulations. Available data will determine whether an interim "freeze" ordinance or other regulations are adopted.</p>	<p>Enabling acts make no mention of data needs, but sound data is essential for sound regulations. Protection elevations and floodway limits are desirable prior to adoption of regulations but may be determined on a case-by-case basis.</p>
2. Prior Comprehensive Planning	<p>Detailed and geographically comprehensive planning is not legally required prior to adoption of most wetland regulations. Nevertheless, regulations must be rational and based upon sound data. Planning is usually the responsibility of consultant or in-house land-use planners acting under the direction of a community planning commission.</p>	<p>Enabling acts often require adoption of a "comprehensive plan." This requirement has not been strictly enforced by the courts. However, some measure of community-wide planning is essential if flood plain regulations are to assist in the allocation of lands throughout a community to their most appropriate uses. Community plans are important in floodway delineation.</p>	<p>Some enabling acts require adoption of a "master plan" prior to adoption of subdivision regulations. Requirement has not been strictly enforced. Master plans showing proposed community public works are important if the subdivider is required to install sewer, water, roads and drainage facilities consistent with overall community needs.</p>
3. Drafting of Regulations	<p>Usually the responsibility of a consultant or resident land-use planner cooperating with a city attorney, planning commission, city council, etc. Often a "boiler plate" job with use of model ordinances or ordinances from another community.</p>	<p>Enabling acts generally require preparation of both a text and map. Drafting is often accomplished by the planning commission.</p>	<p>Usually undertaken by the planning commission cooperating with the city or county council.</p>

Step	Commentary	Zoning	Subdivision
4. Notice of Public Hearings	Required by law prior to adoption of regulations. Major public input occurs during the hearing process. Often many hearings are held on proposed regulation.	Enabling acts require at least 1 hearing with public notice prior to adoption. Zoning map which determines where particular regulations will apply is often the most controversial subject at hearing.	Enabling acts require hearing with public notice.
5. Adoption of Regulations	For all regulations, adoption usually requires a majority of a quorum of the local legislative body (city, county, town, village, or borough council) after public notice and hearing. Regulations must be "published" after adoption, usually in the local newspaper. Written regulations and text must be available at a public place (zoning office, etc.) for inspection by interested individuals.	Enabling acts specify that adoption is responsibility of city, county, village, town, or borough council.	Enabling acts usually specify that adoption is the responsibility of the city, county, village, town, or borough council. However, adoption may be the responsibility of the planning commission.
6. Administration	Administration of wetland zoning ordinances logically requires engineering and biological expertise to insure that proposed development meets the standards set out in the ordinance. Since zoning and subdivision ordinances often rely upon case-by-case determination of flood hazards, expert technical assistance is important. Typically, some administrative body such as a zoning board of adjustment or conservation commission is authorized to issue variances or special exceptions in hardship cases or where fact-finding is needed.	Building permits (if required) are generally issued by the zoning administrator or conservation commission. Enabling acts typically authorize the issuance of variances and special exceptions by the zoning board of adjustment which conducts fact-finding activities. Special-exception and special-permit uses are widely used in wetland ordinance.	Enabling acts typically establish the planning commission as the "plat review" agency. Preliminary and final plat procedures and specifications are often defined in some detail.

Step	Commentary	Zoning	Subdivision
7. Enforcement	Enabling acts establish fines and other penalties including jail sentences for violation of regulations. Local district attorney is responsible for initiating enforcement actions, enabling acts, and injunctions to prevent breach of regulations.	Enabling acts specify penalties, but are varied.	Enabling acts specify penalties, but are varied.
8. Amendment	Enabling acts usually establish amendment procedures in some detail.	Enabling act amendment procedures are often more complicated than initial adoption, particularly where landowners protest a change.	Enabling act amendment procedures are usually identical to procedures for initial adoption.

distances from water bodies. If adequately enforced, these regulations can effectively control development in rural wetlands. Like building codes, sanitary codes do not prevent filling, dredging or other activities damaging to wetlands.³¹

Special Codes

Communities often adopt special codes to regulate land use. Examples of this type of regulation include special codes for timber harvesting, grading, mosquito control, application of pesticides, solid waste disposal, disposal of urban runoff, surface and ground water extraction, watershed uses, air and water pollution emissions, and surface water uses (e.g., swimming, boating, etc.). These regulations, if adequately enforced, provide some protection to wetlands and the surrounding watershed.³² Table V-14 provides a comparison of four of the common regulatory tools (zoning, subdivision, building code, special regulation ordinances) discussed above.

Performance Standards

Performance standards can be used separately or as a component of other land use regulations to control development and conserve wetlands. These standards can be used to protect the wetland and adjacent buffer areas from development impacts that will harm the natural functions and values of the wetland system. Performance standards accomplish this by requiring that a proposed use meets certain standards that will insure against the use causing (or having the potential to cause) adverse impacts. Table V-15 provides some examples of wetland impacts that can be prevented through the use of performance standards.³³

TABLE V-14

A COMPARISON OF COMMON REGULATORY TOOLS

Tool	Distinguishing Features	Application To New Uses	Application to Existing Uses	Who Administers
Zoning	<ol style="list-style-type: none"> 1. Map and text. Regulates type of use and provides minimum specifications for uses in each zone. 2. A tool of comprehensive planning. 3. Does not regulate land division or provide detailed standards for building design or materials. 	<ol style="list-style-type: none"> 1. Wide potential in regulating construction, land alteration, tree-cutting, many other aspects of land use. 	<ol style="list-style-type: none"> 1. Some potential for eliminating existing wetland uses, particularly nuisance floodway or flood fringe uses. 2. Often requires that existing uses be brought into conformity upon their abandonment, destruction, or need for substantial repair. 	<ol style="list-style-type: none"> 1. Zoning administrator issues most permits. 2. Board of Adjustment issues variances and special exceptions.
Subdivision	<ol style="list-style-type: none"> 1. Text only. Applies to sale and division of land. Approval of "plat" required. 2. Does not in itself regulate type of land use. Regulations apply uniformly. 	<ol style="list-style-type: none"> 1. Wide potential in requiring disclosure of flood hazards, insuring that lands are suitable for intended purposes, and requiring installation of public facilities by subdivider. 	None	<ol style="list-style-type: none"> 1. Planning Commission.
Building Code	<ol style="list-style-type: none"> 1. Text only. Applies to building design and materials. Building permit required. 2. Does not regulate use of land or division of land. 	<ol style="list-style-type: none"> 1. Wide potential in establishing detailed construction standards including structural flood proofing measures. 	<ol style="list-style-type: none"> 1. Usually none; however, housing codes (a variety of building code) apply to existing as well as new uses. 	<ol style="list-style-type: none"> 1. Building Inspector.
Special Wetland Regulation By-law	<ol style="list-style-type: none"> 1. Text only (usually but may also incorporate a map. Typically adopted pursuant to special wetland regulation statute or home rule powers. 2. Does not typically regulate use of land. 	<ol style="list-style-type: none"> 1. Wide potential in regulating construction, land alteration, tree-cutting, many other aspects of land use. 	<ol style="list-style-type: none"> 1. Usually none. 	<ol style="list-style-type: none"> 1. Local legislative body, conservation commissions, building inspector.

Table V-15. Examples of wetland impacts prohibited by performance standards

PROHIBITIONS

Infilling of wetlands or other modifications of natural topographic contours

Disturbance or destruction of natural flora and fauna

Influx of sediment or other materials causing increased water turbidity

Removal of wetland soils

Reduction in wetland water supply

Interference with wetland water circulation

Reduction or increase in wetland nutrients that will damage wetland vegetation and wildlife

Influx of toxic chemicals

Thermal changes in the wetland that damage wetland vegetation and wildlife

Destruction of natural aesthetic values

10 PERFORMANCE STANDARD PROHIBITIONS

Performance standards usually employ a combination of quantified and unquantified criteria aimed at the impacts of use rather than their type. Performance standards are valuable regulatory "tools" because (1) they reduce wetland protection to a relatively discrete and understandable set of principles that may be applied to all types of uses without endless repetition of guidelines for each use, and (2) they permit an examination of the impact of each individual use in terms of its specific design characteristics and specific values and hazards at the site. ³⁴

A community may wish to combine performance standards with more specific standards for land uses that threaten its wetlands. Using a combined approach, wetland regulations can provide added specificity

while maintaining a basic performance standard orientation. Specific performance standards for protecting freshwater wetland functions are provided in Table V-16.

Non-Regulatory Programs

Regulations are the primary wetland conservation tool used in most communities. The political, legal and administrative drawbacks that plaque adoption and enforcement of regulations, however, make it unwise for communities to rely exclusively on statutes and ordinances to implement wetland protection programs. Regulations should be supplemented by non-regulatory techniques to increase their effectiveness and achieve wetland objectives unattainable through regulation.

It is beyond the scope of this report to discuss all the non-regulatory options for wetland conservation. Two of the most useful of these techniques are worth noting: tax incentives and acquisition programs. Unlike regulations, these management approaches offer incentives or rewards for preserving wetlands.

Tax incentives for wetland conservation fall into four (4) categories. These are (1) preferential real estate taxes, (2) income taxes, (3) state and federal estate taxes, and (4) gift taxes. Wetland acquisition may be accomplished through gifts from private individuals or organizations, devises or through purchase of a fee or lesser interest. Land acquisition is often used by local governments to protect wetlands from urbanization and increased demand for recreational uses along coastal and inland waters. ³⁵

The private sector has been highly successful in conserving wetlands at the local and regional levels. Wetland conservation efforts by the private sector can be divided into four (4) categories; namely:

PERFORMANCE STANDARDS FOR PROTECTING FRESHWATER WETLAND FUNCTIONS

Standard	Common Uses Requiring Control	Impact of Uncontrolled Uses	Application of Standard
Prevent filling of wetland by sand, gravel, solid wastes, structures, etc.	<ol style="list-style-type: none"> 1. Land fill operations; 2. Dredge and spoil disposal; 3. Construction of roads, dikes, dams, reservoirs; 4. Activities on adjacent lands or in the watershed causing sedimentation such as agricultural operations, timber cutting, road building, urban runoff, mining operation, channelization. 	<p><u>Irreversible</u> without great expense.</p> <ol style="list-style-type: none"> 1. Destruction of flood storage and flood conveyance capability; 2. Accelerated runoff; 3. Destruction of wildlife and vegetative values; 4. Reduced ground water infiltration; 5. Destruction of scenic, recreation, education, pollution control functions. 	<ol style="list-style-type: none"> 1. Control wetland filling and activities which require filling such as dwellings, factories, roads through use restrictions or performance standards; 2. Establish buffer areas to reduce sedimentation from upland sources; 3. Establish performance standards for upland uses.
Protect vegetation from cutting, trampling, grading, etc.	<ol style="list-style-type: none"> 1. Forestry (some instances); 2. Pollution from urban runoff, solid waste disposal, liquid waste; 3. Filling, grading; 4. Soil removal; 5. Construction of utility lines; 6. Off-road vehicles; 7. Agriculture. 	<p><u>Reversible</u> unless a species is destroyed or the basic substrate is no longer suitable for revegetation.</p> <ol style="list-style-type: none"> 1. Accelerated runoff, higher sediment yields; 2. Damage to wildlife habitat; 3. Reduced pollution control function (filtering); 4. Increased water velocities, erosion; 5. Destroy storm barriers; 6. Reduced recreational, educational values (some instances). 	<ol style="list-style-type: none"> 1. Adopt tree-cutting and other regulations pertaining to vegetation removal; 2. Restrict the use of off-road vehicles; 3. Regulate grading, filling, soil removal, building construction, pollution sources.
Protect wildlife (fish, birds, reptiles, mammals).	<ol style="list-style-type: none"> 1. Habitat destruction (all types); 2. Filling, grading, dredging; 3. Highway construction and vehicular traffic through wetlands; 4. Off-road vehicles; 5. Hunting; 6. Collecting. 	<p><u>Reversible</u> (sometimes)</p> <ol style="list-style-type: none"> 1. Destruction of endangered species (sometimes); 2. Change in vegetation type, (e.g., removal of muskrats may alter the composition of wetland); 3. Reduced recreation, scenic, education, scientific study opportunities; 4. Reduced commercial fishing, harvesting of fur and game species. 	<ol style="list-style-type: none"> 1. Protection of wildlife food supply and habitat; 2. Protect buffer areas; 3. Control use of off-road vehicles; 4. Regulate hunting.

Standard	Common Uses Requiring Control	Impact of Uncontrolled Uses	Application of Standard
Protect source of light energy for plants by controlling wetland turbidity	<ol style="list-style-type: none"> 1. Dredging operations; 2. Urban Runoff; 3. Filling and grading for site preparation; 4. Road building; 5. Timber Harvest; 6. Agricultural runoff; 7. Mining. 	<p><u>Reversible</u></p> <ol style="list-style-type: none"> 1. Destruction of vegetation; 2. Destruction of aquatic life; 3. Disturbance of wildlife habitat; 4. Decreased recreation, educational, scientific study functions. 	<ol style="list-style-type: none"> 1. Establish performance standards for wetland uses and uses in upland areas contributing sediment and other material; 2. Provide buffer areas.
Control Extraction of Wetland Soils	<ol style="list-style-type: none"> 1. Grading; 2. Mining (Sand and Gravel deposits); 3. Dredging, channelization; 4. Topsoil removal; 5. Muck farming; 6. Construction of reservoirs. 	<p><u>Irreversible (depends)</u></p> <ol style="list-style-type: none"> 1. Disturbance or destruction of vegetation and wildlife habitat; 2. Turbidity in waters; 3. Decreased recreation, education, wildlife values. 	<ol style="list-style-type: none"> 1. Control of mining, dredging, lagooning; other soil removal.
Protect Wetland Water Supply (Quantity)	<ol style="list-style-type: none"> 1. Agricultural drainage; 2. Channelization of streams; 3. Pumping of streams, lakes, ground water supplies; 4. Establishment of dikes, levees, blocking exchange of flood waters; 5. Drainage for mosquito control projects; 6. Upstream reservoirs. 	<p><u>Reversible (depends)</u></p> <ol style="list-style-type: none"> 1. Destruction or deterioration of wetland vegetation; 2. Reduced aquifer recharge; 3. Disturbance or destruction of species which depend upon wetlands for breeding, feeding, nutrients; 4. Increased salinity (in some instances) resulting in damage to wildlife, vegetation, recreation opportunities. 	<ol style="list-style-type: none"> 1. Control agricultural drainage, channelization, dams, water extractions; 2. Manage reservoirs, flood gates, etc. to maintain wetland water supply.
Maintain free circulation of wetland waters	<ol style="list-style-type: none"> 1. Filling, grading, buildings; 2. Dikes, dams, levees, roads; 3. Irrigation projects. 	<p><u>Reversible (depends)</u></p> <ol style="list-style-type: none"> 1. Deprive wetland plants and animals of nutrients from flood flows, other sources; 2. Prevent the feeding and breeding of aquatic species in wetland areas; 3. Build-up of salinity (in some instances). 	<ol style="list-style-type: none"> 1. Require that bridges and roads be constructed with minimum impedece to natural drainage; 2. Design floodgates to maintain water action; 3. Control construction of dikes and levees; 4. Require that wetland structures be elevated on pilings.

Standard	Common Uses Requiring Control	Impact of Uncontrolled Uses	Application of Standard
Protect natural nutrient sources (principally phosphorous and nitrogen)	<ol style="list-style-type: none"> 1. Upstream reservoirs; 2. Dikes, dams, levees which prevent periodic flooding of wetland and deposition of nutrient-rich sediments. 	<p><u>Reversible</u></p> <ol style="list-style-type: none"> 1. Reduced wetland wildlife, vegetation; 2. Reduced scenic, educational, scientific values. 	<ol style="list-style-type: none"> 1. Regulate dikes, dams, levees.
Prevent damaging influx of nutrients	<ol style="list-style-type: none"> 1. Urban runoff throughout watershed; 2. Grading and fill operations; 3. Sewage disposal discharge; 4. Use of septic tanks; 5. Agricultural runoff throughout watershed. 	<p><u>Reversible (depends)</u></p> <ol style="list-style-type: none"> 1. Accelerated filling of wetlands with no outlet; 2. Anaerobic bottom conditions, fish kills possible; 3. Accelerated growth of aquatic plants (undesirable in some circumstances); 4. Tendency, in some instances, toward a monoculture; 5. Altered plant and animal species; 6. Fly and odor nuisances (possible). 	<ol style="list-style-type: none"> 1. Water pollution controls; 2. Sanitary codes prohibiting septic tanks in wetlands and buffer areas; 3. Fill and grading regulations; 4. Regulations for agricultural activities to minimize nutrient inflows.
Prevent influx of toxic chemicals	<ol style="list-style-type: none"> 1. Application of pesticides, algicides to wetlands directly for mosquito control, weed control, algae control; 2. Urban runoff from sheet flow and storm sewers; 3. Municipal and industrial sewage disposal. 4. Application of pesticides to agricultural, forestry uses throughout the watershed. 	<p><u>Reversible (depends)</u></p> <ol style="list-style-type: none"> 1. Destruction of wetland wildlife including rare and endangered species; 2. Destruction of vegetation (in some instances); 3. Threats to the public safety from eating fish, shellfish, waterfowl exposed to toxic chemicals. 	<ol style="list-style-type: none"> 1. Tight control of toxic chemicals throughout watershed areas; 2. Tight point source pollution controls; 3. Maintenance of wetland buffers.
Prevent damaging thermal changes	<ol style="list-style-type: none"> 1. Reservoirs; 2. Utility plants (serious offender); 3. Industrial uses; 4. Sediment loadings from road building, agriculture, etc. 	<p><u>Reversible (sometimes)</u></p> <ol style="list-style-type: none"> 1. Destruction of wetland wildlife, alteration in species composition; 2. Decrease in recreation, scientific study, educational activities. 	<ol style="list-style-type: none"> 1. Thermal pollution standards for point source discharges; 2. Control of road-building and agriculture to reduce water turbidity, sedimentation.

SELECTED PUBLIC WETLAND PROTECTION TECHNIQUES

Approach	Objective	Incidence of Costs	Advantages	Limitations
Education of landowners (films, manuals, workshops, conferences, etc.)	<ol style="list-style-type: none"> 1. Encourage private protection of wetlands; 2. Encourage private balancing of benefits and costs. 	<ol style="list-style-type: none"> 1. Private landowners, private organizations bear cost of protection. Community may pay for education efforts. 	<ol style="list-style-type: none"> 1. Appeals to private land ethic; 2. Politically attractive; 3. Maximizes landowner options. 	<ol style="list-style-type: none"> 1. Some landowners not responsive; 2. Time-consuming.
Environmental Impact Statement Requirements	<ol style="list-style-type: none"> 1. Require consideration of short-term and long-term costs and benefits in decision-making. 	<ol style="list-style-type: none"> 1. Developers, public agencies. 	<ol style="list-style-type: none"> 1. Requires a careful analysis of factors, by decision-makers; 2. Exposes project to public review. 	<ol style="list-style-type: none"> 1. Impact review does not in itself protect wetlands unless impact requirements are combined with regulations; 2. May be costly.
Public or Private Open Space Acquisition for Parks, Wildlife Areas, Floodways in Fee or Easements Through Gift, Purchase, Devise	<ol style="list-style-type: none"> 1. Protect wetland permanently from private development; 2. Reduce flood losses; 3. Protect scientific and educational use of wetland; 4. Permit hunting, other recreational uses. 	<ol style="list-style-type: none"> 1. Public pays but receives multiple benefits. 	<ol style="list-style-type: none"> 1. No problem of constitutionality of uncompensated "taking"; 2. Permanent; 3. Active public use of land possible; 4. B.O.R. and other Federal grants may be available for open space acquisition; 5. Particularly attractive in urban areas. 	<ol style="list-style-type: none"> 1. Costly; 2. Political opposition is common to large scale land acquisition; 3. Creates public land management requirements.
Land Use Regulations	<ol style="list-style-type: none"> 1. Protect health and safety from flooding, erosion, pollution; 2. Prevent nuisances; 3. Prevent fraud; 4. Protect wildlife, aesthetic values, other wetland values. 	<ol style="list-style-type: none"> 1. Landowner must bear cost of adjustments, Community bears cost of adoption and administration of regulations. 	<ol style="list-style-type: none"> 1. Low cost to government; 2. Promote economic and social well-being; 3. Promote most suitable use of lands; 4. Can be put into effect immediately. 	<ol style="list-style-type: none"> 1. Must not violate state and federal constitutional provisions; 2. May not be adequately enforced; 3. Cannot protect all wetlands; 4. Generally do not apply to governmental uses; 5. Limited application to existing uses.

Approach	Objective	Incidence of Costs	Advantages	Limitations
Conservation Re-strictions (Easement or deed restrictions between property owner and government restricting development)	1. Prohibit continued private development while permitting continued private ownership of lands.	1. Private landowner; but, he may also receive benefits.	1. Low cost to government; 2. Provides basis for reduction in property tax; 3. Voluntary, may be politically acceptable.	1. Expressly authorized in only small number of states; 2. Does not permit public use of land.
Real Estate Tax incentives	1. Encourage private landowners to hold land in open state; 2. Reduce burden of restrictions.	1. Government has lowered tax revenues but also receives benefits.	1. Encourages voluntary protection; 2. Reduces burden on landowner and threat of law suit.	1. Reduced local tax revenues; 2. Not authorized in all states; 3. May not curb speculation in some instances.
Water level maintenance, Impoundment, pumping, other management techniques	1. Stabilize wetland water levels; 2. Increase wetland area; 3. Improve waterfowl, wildlife habitat; 4. Reestablish natural species.	1. Generally public bears the costs but may also be carried out by private individuals and organizations.	1. Enhances waterfowl, wildlife habitat; 2. Compensate for affects of prior drainage, or other damage.	1. Costly, in some instances; 2. Maintenance required; 3. May disturb natural flora and fauna.

SOURCE: Jon A. Kusler, "Wetland Protection: A Guidebook for Local Governments" (Washington, D.C.: The Environmental Law Institute, 1977), pp. 142-143.

1. Wetland protection through deed restrictions, covenants and easements;
2. Wetland protection by citizen groups;
3. Citizen participation in wetland education and regulatory programs; and
4. Citizen lawsuits. ³⁶

Citizen organizations that have played a major role in wetland conservation in this country include the Audubon Society, the Nature Conservancy, the Sierra Club, the National Wildlife Federation and local citizen organizations. Table V-17 provides a comparison of selected public and private wetland protection techniques.

Wetland Use Principles

Whether wetland conservation efforts originate in the public or private sector, they require organization, participation and the support of the local government. Wetland conservation programs should reflect basic principles and standards of wetland use that pertain to wetland hazards and values as well as broader objectives for the protection and management of community wetlands. These principles embody the concept of "appropriate use" of wetlands to protect natural ecosystem functions and the health, safety and welfare of the community. Some of the principles to consider in developing a wetland conservation program include those listed in Table V-18. ³⁷

Table V-18. Wetland use principles

PRINCIPLES

Wetland activities should not destroy or damage wetland functions considered essential to community safety and general welfare

(CONTINUED)

Table V-18. Wetland use principles (continued)

PRINCIPLES

Wetland activities should not cause damaging increases in flood heights or velocity or be damaged by flooding

Water activities should not cause water pollution or destroy natural pollution control functions

Buildings, roads and other structures should not be constructed in areas lacking adequate soil bearing capacity

Wetland activities should be conducted so as to minimize wetland impacts

The burden of proof to demonstrate the appropriateness of activities that damage or destroy wetlands should be shifted to those proposing such activities

Wetland activities should be consistent with broader community land and water use, plans and regulations

7 WETLAND USE PRINCIPLES

Conclusions

In this report, I have attempted to highlight the major construction activities that impact wetlands and raise some wetland conservation issues relative to these impacts. A significant body of literature has been generated on this topic and is available as input into the planning process.

Wetlands are what the name implies -- "wet lands". They are transitional lands where water is the primary factor influencing the environment. The "National Wetlands Classification System" recognizes five (5) major wetland systems and six (6) wetland classes in the United States. Wetlands may be called by many different common names but they share important characteristics and provide valuable natural functions. These values can be broadly grouped into (1) hydrologic and hydraulic values, (2) water quality maintenance values, (3) food chain values, (4)

habitat values, and (5) harvest and heritage values. Wetlands are dynamic ecosystems that change over time. This ecological change may be accompanied by a change in wetland values and hazards which must be recognized in conservation efforts.

The four (4) main classes of construction activities that have and will continue to severely impact our nation's wetlands are (1) general lowland construction, (2) mineral extraction, (3) dam construction, and (4) dredge and spoil placement. The impacts of these activities on wetlands range from short-term, locally-severe to complete habitat destruction. Direct loss of wetland habitat is the most devastating cause of wetland deterioration, but chronic stress and pollution take their toll as well in reduced wetland values and ecosystem functions. Furthermore, construction impacts may occur long after the project is completed and many miles from the site. The cumulative impact of construction activities in wetlands is an overall reduction in environmental quality nation-wide. Table V-19 summarizes the impacts of steps (phases) of construction in wetland habitats.

Immediate wetland conservation efforts are needed to slow the rate of wetland alteration and thus the long-term consequences of construction activities. Some wetlands need complete protection if their "gene pools" and values are to survive. All wetlands need to be considered in the community planning process. Additional research is needed to promote our understanding of wetland ecology and the "inter-connectedness" of man and nature. This knowledge needs to be applied to the impact assessment and decision-making processes at all levels of government. It must also be used to restore degraded wetlands and establish effective performance standards.

IMPACTS OF STEPS OF CONSTRUCTION IN WETLAND HABITATS*

Step	Specific Activities	Impact	Suggestions for Reducing Impact
1. Onsite Activities Prior to Construction (Most Structural Uses).	A. Surveying carried out to define terrain features, minor clearing of vegetation, placement of stakes; B. Engineering borings; C. Percolation tests.	A. Some destruction of natural vegetation, disturbance of wildlife due to transport of equipment to and from site, disposal of materials from drilling.	A. Use of air photo techniques wherever possible; B. Regulation of survey methods and equipment, including time of year in which borings occur.
2. Construction of Access Roads (Most Structural Uses).	A. Tree-cutting, vegetation removal; B. Excavating, filling.	A. Destruction of natural vegetation, wildlife, interference with natural drainage, sedimentation.	A. Location of roadways on upland sites, wherever possible; B. Confinement of tree-cutting and filling to immediate roadway; C. Requirements that natural drainage and circulation be maintained through elevation of roadway on pilings, installation of culverts; requirements that measures be taken to reduce erosion and sedimentation.
3. Establishment of Construction Camp (Larger Projects Such as Roads, Bridges, Dams, Reservoirs).	A. Tree-cutting, grading, filling; B. Installation of electricity, water supply, telephone.	A. Destruction of wildlife, vegetation; interference with natural drainage; increased sedimentation.	A. Location of construction camp at upland site wherever possible, maintenance of a wetland buffer strip.
4. Materials Storage (Most Structural Uses).	A. Grading, dumping, filling.	A. Interference with drainage, pollution and sedimentation may result from stored materials such as sand and gravel (depending upon materials).	A. Material storage on upland sites; B. Maintenance of wetland buffers; C. Installation of measures to reduce erosion from stored materials.
5. Clearing of Site (Many Structural and Nonstructural Uses).	A. Vegetation removal.	A. Destruction of wildlife habitat; destruction of storm and erosion barriers; destruction of scenic beauty; increased erosion; increased runoff. B. Disturbance or destruction of all wetland functions; blockage of flood flows; destruction of habitat; water pollution from eroded fill.	A. Vegetation removal only where absolutely necessary; B. Revegetation.

*This table is based in part upon discussion in Reznat Darnell, *Impacts of Construction Activities in Wetlands of the United States*, U.S. Environmental Protection Agency. Ecological Research Service, EPA-600/3-26-045 (Springfield, Virginia: National Technical Information Service, 1976).

Step	Specific Activities	Impact	Suggestions for Reducing Impact
6. Earth Excavation and Fill (Most Structural Uses).	A. Filling of wetland area, grading of natural wetland contours, removal of peaty soils.		A. Confinement of fill to wetland margins and less sensitive wetland areas; B. Maintenance of natural drainage through fill and grading contours, currents, etc.; C. Rip-rap and revegetation to stabilize fill, reducing erosion.
7. Foundation Preparation and Construction (Most Structural Uses).	A. Dumping of crushed stone and other foundation material; installation of pilings; mixing and pouring of concrete installation of public facilities (sewer, water).	A. Water pollution (in some instances) from mixing and pouring concrete.	A. Cofferdams, settling ponds temporarily confine runoff from concrete mixing and pouring.
8. Disposal of Excess Excavated Materials (Most Structural Uses).		A. Erosion, water pollution, additional filling of wetland with consequential impacts.	A. Disposal of excavated site material at upland; B. Rip-rap and revegetation to quickly stabilize and fill denuded areas.
9. Major Construction Activity.	A. Erection of basic structure, accessory uses; roofing, siding, installation of major fixtures.	A. Pollution by sediment, debris from construction site, oil and other residuals from installation of parking areas.	A. Use construction design and practices to minimize wetland impact such as elevation of structure on pilings; B. Temporary settling ponds, other measures to reduce pollution.
10. Site Restoration and Clean-up.	A. Removal of litter, excess materials, back filling, landscaping, planting of trees and grasses, fertilization.	A. Pollution from litter, backfilling, landscaping operations, use of fertilizers; B. Filling of wetland by landscaping.	A. Confinement of fill to upland areas; B. Temporary settling ponds; C. Measures to reduce erosion on denuded surfaces.

In recent years, I have observed an increasing sophistication in the regulation of wetland uses at all levels of government. More wetland acreage is also being protected through non-regulatory means. Nevertheless, incremental losses of wetlands continue to erode the resource base. Virtually all wetlands in the United States are threatened to some extent by activities within the wetland itself or within the surrounding watershed. The seriousness of an individual threat or combined threats differs from region to region and from wetland to wetland.

Each day, thousands of individual landowners make decisions about how wetlands will be used. Our land use policies must reflect the identify and motivations of these landowners and the economic forces that affect them. Rapidly rising prices for all types of undeveloped land will continue to influence the allocation of land resources among uses and among users -- and threaten unaltered wetlands. It is time to ask ourselves some hard questions; specifically:

1. How do we manage already altered wetlands?
2. How do we limit further wetland alteration?

Robert Lemire suggests five (5) principles to deal effectively with growth and change in his book Creative Land Development: Bridge to the Future.³⁸ I think these principles relate equally well to wetland conservation efforts. These five principles are:

1. The need to save what needs to be saved;
2. The need to build what needs to be built;
3. The need to deal fairly with the dollar interest of landowners;
4. The need for private sector as well as public sector involvement; and

5. The need for planning initiatives, not simply regulatory reaction.

Over two decades ago, President John F. Kennedy referred to conservation as "the highest form of national thrift".³⁹ Yet, today we still have not answered some fundamental questions about the ecological, social and economic worth of wetlands; namely:

1. What is a wetland worth to society in its natural state?
2. What is a wetland worth to someone with a financial stake in its destruction?
3. How much acreage must be preserved in order to maintain the services wetlands now provide?
4. What do we now know about the structure, functions and uses of wetlands in their natural state that can aid in assessing the ecological, economic and social consequences of further wetland degradation?
5. How can we work with and use these wetland resources to our benefit?

Many people today recognize that wetlands should be protected, but there remain many difficult questions about how protection and proper use are to be accomplished; including:

1. How do various wetland types differ?
2. How much wetland acreage has been lost?
3. How much wetland acreage do we need?
4. What useful functions do they serve in their natural state?
5. What useful functions do they serve in their altered state?
6. What useful functions do they serve in their restored state?

7. What are the most effective means of conserving wetland resources?

We do not know exactly how many wetlands we have already lost, or how many we can afford to lose. We are only now beginning to understand and appreciate the values that wetlands provide and the risks they pose to development. Although financial benefits may accrue to individuals from a wetland alteration project, undisturbed wetlands offer benefits to all. Wetlands in their natural state will continue to provide benefits for future generations. It is time to decide to what degree we will protect our nation's wetlands (See Table V-20).

Whether we elect to save our wetlands will not be a scientific decision but rather a social decision made up of an infinite number of small and large choices and actions in which each of use can play a part. Enlightened public policies and wise, enforceable legislation will come about only through our dedication to environmental principles and hard work.

I believe comprehensive planning, combined with simplified zoning and subdivision controls which include mechanisms for effectively managing natural resources, will go a long way in conserving wetlands at the community level. Innovative planning approaches that combine regulatory and non-regulatory conservation techniques will enhance wetland conservation at all levels of government. Above all, I believe it is time to define and embrace a new "land ethic" that recognizes wetlands for what they are -- valuable components of the natural landscape, not wastelands!

ALTERNATIVES FOR WETLAND PROTECTION

Degree of Wetland Protection	Factual Situation	Regulatory Standards	Comment
1. No Protection: Wetland destruction and use (residential, commercial, industrial) permitted without concern for wetland values or hazards.	Community with no planning or zoning and wishing to optimize the tax base.	No control over wetland uses.	Laissez faire approach often resulted in destruction of prime habitat and scenic beauty, flood losses, conflict between landowners, extraordinarily expensive public services, and inefficient use of community costs may exceed increases in tax base.
2. Limited protection: Some wetland development permitted while attempting to reduce flood losses and protect wildlife.	Community with no planning or zoning wishing to optimize the tax base but with some concern for flood damages and wildlife.	No regulation of wetland uses but mapping and marking of areas for educational purposes, construction of flood warning systems, distribution of educational materials, refusal to construct sewer or water in flood areas, requirements that environmental impact statements be filed for new development.	Mapping of wetland and other techniques to appraise the public of wetland areas may reduce victimization and facilitate rational private decisions consistent with public welfare. Refusal to extend public facilities into wetland areas will indirectly influence private use.
3. Considerable protection: Small amount of wetland development is permitted while holding wetland losses to a reasonable level through application of performance standards.	Community with little undeveloped remaining land and need for industrial, commercial or residential sites.	Application of regulatory performance standards to reserve floodway and essential wetland areas (e.g. habitat for rare or endangered species) in an open condition and require that structural uses in outer areas be protected against flooding, and designed to minimize impact upon wetlands.	A performance standards approach permits some use of wetland areas while holding losses within acceptable limits.
4. Total protection: Prohibit all wetland development to hold lands in an open condition for wildlife, scenic beauty, recreation, flood storage, etc.	Community with need for open space lands; alternative sites available for development.	Application of tight open space regulations to prohibit private use. Public acquisition of wetland.	Some open space regulations have been successfully attacked as a "taking of property." However, such regulations may be relatively inexpensive and may be sustained where economic uses remain for the land. Public acquisition is often expensive but offers multiple open space benefits.

FOOTNOTES

Chapter V

1. Rezneat M. Darnell, Impacts of Construction Activities in Wetlands of the United States, in collaboration with Willis E. Pequengnat, Bela M. James, Fred J. Benson and Richard A. Defenbaugh, U.S. Environmental Protection Agency, Ecological Research Service, EPA-600/3-26-046 (Springfield, Virginia: National Technical Information Service, 1976), 272.

2. Ibid.
3. Ibid.
4. Ibid., 273.
5. Ibid., 275.
6. Ibid.
7. Ibid., 277.
8. Ibid., XXIV.
9. Ibid.
10. Ibid.
11. Ibid.
12. Ibid., XXV.
13. Ibid., 278.
14. Ibid., 279.
15. Ibid., 280.
16. Ibid., 281
17. Ibid., 283-284.
18. Ibid., 286-287.
19. Ibid., 287-288.
20. Ibid., 292.
21. Ibid., 293.
22. Ibid., 292.

FOOTNOTES

Chapter V (continued)

23. Jon A. Kusler, Wetland Protection: A Guidebook for Local Government, in collaboration with Corbin C. Harwood (Washington, D.C.: The Environmental Law Institute, 1977), Preface.
24. Ibid., 1-2.
25. Ibid., 1.
26. Ibid., 2-3.
27. Ibid., 181-185.
28. Ibid., 188.
29. Ibid., 185-186.
30. Ibid., 186.
31. Ibid.
32. Ibid., 187-188.
33. Ibid., 3.
34. Ibid., 126.
35. Ibid., 260 and 274.
36. Ibid., 285-312.
37. Ibid., 79-94.
38. Robert Lemire, Creative Land Development: Bridge to the Future (Lincoln, Massachusetts: Massachusetts Association of Conservation Commissions, Massachusetts Audubon Society, 1987).
39. John F. Kennedy, "Special Message to Congress on Conservation, March 1, 1962", in Our Nation's Wetlands: An Interagency Task Force Report (Washington, D.C.: Government Printing Office, 1978), 54.

Examine each question in terms of what is ethically and aesthetically right as well as what is economically expedient. A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.

--"The Land Ethic," by Aldo Leopold,
A Sand County Almanac

APPENDIX A
WETLANDS CHARACTERISTICS

Wetland Type	Region of Largest Acreage	Representative Vegetation (North)	Representative Vegetation (South)
INLAND FRESH			
Seasonally Flooded Basins or Flats	Mississippi north	Varies with flood duration, lowland hardwood trees, smartweed, wild millet, fall panicum, tealgrass, chufa, cyperus	Same
Inland Fresh Meadows (Sedge Meadow)	Atlantic south Mississippi north	Carex, rushes, reedtop, reedgrasses, manna-grasses, prairie cordgrass, mints	Cordgrasses, paspaluma, breakrushes
Inland Shallow Fresh Marshes	Atlantic south	Reed, whitetop, rice cutgrass, carex, giant burreed, bulrushes, spikebrushes, cattail, arrowheads, pickerel weed	Maidencane, sawgrass, arrowhead, pickerel weed, rushes, cattails
Inland Deep Fresh Marshes	Central north Atlantic south	Cattails, reeds, bulrushes, wild rice, spike-rushes, in open areas: pondweeds, naiads, coontail, watermilfoil, duckweed, water lily	Many of the same species, plus water hyacinth and water primrose in some areas
Inland Open Fresh Water	Mississippi north	Pondweeds, naiads, wild celery, coontail, watermilfoil, muskgrasses, lilies, spatterdocks	Similar, plus water hyacinth
Shrub Swamps	Mississippi north	Alders, willows, buttonbush, dogwood, swamp-privet, usually along sluggish streams	Same
Wooded Swamps	Atlantic south	Tamarack, arborvitae, black spruce, balsam, red maple, black ash, northwest: western hemlock, red alder, willows and thick mosses	Water oak, overcup oak, tupelo gum, swamp black gum, cypress
Bogs	Atlantic south Mississippi north	Leather leaf, labrador tea, cranberries, carex, cottongrass, sphagnum moss, black spruce, tamarack, insectivorous plants	Cyrilla, persea, gordonia, sweetbay, pond-pine, Virginia chainfern, insectivorous plants
INLAND SALINE			
Inland Saline Flats	Pacific south	Sparse: seablite, saltgrass, Nevada bulrush, saltbrush, burro-weed	
Inland Saline Marshes	Pacific south	Same	Alkali or hardstem bulrushes, wigeongrass, sago pondweed
Inland Open Saline Water	Pacific north Pacific south	Sago pondweed, wigeongrass, muskgrass	
COASTAL FRESH			
Coastal Shallow Fresh Marshes	Mississippi south	Redgrass, big cordgrass, carex, spikerush, sawgrass, cattails, arrowheads, smartweed	Similar, with maidencane
Coastal Deep Fresh Marshes	Mississippi south	Cattails, wild rice, pickerelweed, giant cutgrass, spatterdock, pondweeds	Similar, with water hyacinth and water lettuce
Coastal Open Fresh Water	Mississippi south	Similar, excluding water hyacinth	Scarce in turbid waters: pondweeds, naiads, wild celery, coontail, water milfoils, musk-grasses, water hyacinth
COASTAL SALINE			
Coastal Salt Flats	Central South	Sparse vegetation: glassworts, seablite, salt-grass	Similar, with saltflat grass and saltwort
Coastal Salt Meadow	Atlantic north Atlantic south	Saltmeadow cordgrass, saltgrass, blackrush, Olney threesquare, saltmarsh fleabane; Pacific coast: carex, hairgrass, jaumea	Same
Irregularly Flooded Salt Marshes	Atlantic south	Dominantly needlerush	Same
Regularly Flooded Salt Marshes	Atlantic south Mississippi south	Atlantic and Gulf coasts: salt marsh cordgrass Pacific Coast: alkali bulrush, glasswort, arrowgrass Open areas: wigeongrass, eelgrass or sago pondweed	Same
Sounds and Bays	Central south	Eelgrass, wigeongrass, sago pondweed, musk-grass	Southeast: shoalgrass, manateegrass, turtle-grass
Mangrove Swamps	Florida only		Much red and some black mangrove

APPENDIX B

The Golet and Larson (1974) classification system for freshwater wetlands in the glaciated Northeast is based on the principle that vegetation is the most important factor determining the type and quality of wildlife habitat. In classifying wetland habitat, they selected the life form or growth habit of vegetation, rather than species composition, as a primary descriptor. Five life forms have been described in their system: trees, shrubs, emergents, surface vegetation and submergents. Each of these life form categories is further divided into subforms which represent distinct differences in structure and wildlife value.

Using these life forms and subforms, wetland classes and subclasses were developed to describe and distinguish the various seral stages of freshwater wetlands. The principle factors used to separate classes are: surface water depth during the growing seasons, water level fluctuation and the life form of the dominant vegetation. Subclasses are subdivisions within a class, based on different dominant subforms of vegetation.

Freshwater wetland classes according to the Golet and Larson classification system are described in the U. S. Department of Interior-- Fish and Wildlife Service Resource Publication 116 (1974) as follows:

(1) Open water class. Open water wetland class applies to water 3-10 feet deep associated with any of the other wetland classes, but usually deep or shallow marshes. Submergent and surface vegetation are dominant life forms. Characteristic plants in this wetland class include pondweeds, wild celery, coontail, water milfoil, fanwort, muskgrass, white water lily, watershield and spatterdock. Duckweed may be present in quiet water.

Open water provides resting and feeding habitat for waterfowl and coots during migration, and courtship arenas for them during the breeding seasons. The value of this wetland class to other wildlife is limited by the lack of emergent vegetation.

(2) Deep marsh class. Deep marsh class applies to wetland with an average water depth between 6 inches and 3 feet during the growing season. Emergent marsh vegetation or aquatic shrubs are usually dominant, with surface and submergent plants present in open water areas.

Deep marshes represent the most valuable all-purpose wildlife habitat. They are used for mating, nesting, feeding and brood-rearing during the breeding season, and for resting and feeding during migration. These wetlands are attractive to diving ducks, dabbling ducks and geese. They provide valuable feeding habitat for wading birds like herons, egrets and bitterns. Stands of emergents support muskrats and nesting bird species.

(3) Shallow marsh class. Shallow marshes are wetlands dominated by robust or marsh emergents, with an average water depth of less than 6 inches during the growing season. Surface water may be present throughout the year or absent during the late summer and normally dry periods. Floating-leaved plants and submergents are usually present in open areas. Duckweed is often abundant in quiet water. Submergents are primarily shallow water species like coontail, bladderwort and waterweed. Cover plants occupy more than 50 percent, and often more than 90 percent, of the marsh area. Shallow marshes constitute the most valuable muskrat habitat.

(4) Seasonally flooded flats. Seasonally flooded flats refer to extensive river flood plains where flooding to a depth of 12 inches or more occurs annually during late fall, winter and spring. In most years, spring floods subside by early June, leaving the ground exposed. During the summer, the soil is saturated with a few inches of surface water occurring locally. Dominant vegetation is usually emergent, but shrubs and scattered trees may be present.

Seasonally flooded flats are of outstanding value to waterfowl during migration, especially during spring when shallow flood waters permit ducks access to supplies of plant seeds unavailable during the previous summer and fall. Excellent muskrat habitat is left when the water subsides and emergent vegetation flourishes. Seasonally flooded flats produce thousands of muskrats annually.

(5) Wet meadow class. Wet meadows are wetlands dominated by meadow emergents, with up to 6 inches of surface water in the late fall, winter and early spring. During the growing season, the soil is saturated and the surface is exposed, except in shallow depressions and drainage ditches. Meadows occur most commonly on agricultural lands where periodic grazing and mowing keeps shrubs from establishing.

Wet meadows provide stopping places for migrating dabbling ducks, herons and shorebirds. In the summer, this wetland class supports muskrats and birds like redwings and song sparrows which feed or nest among the emergents.

(6) Shrub swamp class. Shrub swamps are wetland dominated by shrubs where the soil surface is seasonally or permanently flooded with as much as 12 inches of water. The characteristic emergent plants

providing cover beneath the shrubs are the tussock sedge (*Carex stricta*) and sensitive fern (*Onoclea sensibilis*). Meadow or marsh emergents occupy open areas.

Shrub swamps offer habitat for a variety of upland and wetland wildlife. The kinds of wildlife present in any given area depend upon the subclass and the surrounding habitat type. Woodcock, ruffed grouse, snowshoe hare, cottontail rabbit, deer, pheasant and songbirds utilize shrub swamps.

(7) Wooded swamp class. Wooded swamps are wetlands dominated by trees. The soil surface is seasonally flooded with up to 1 foot of water. Several layers of vegetation are usually present, including trees, shrubs and herbaceous plants. Wooded swamps located along streams or near marshes are often valuable breeding areas for wood ducks, black ducks and mallards. The value of a wooded swamp increases greatly if surface water persists through the nesting period and if brood acres are available nearby. Otherwise, wooded swamps are most valuable to upland wildlife.

Because of the structural diversity of vegetation, wooded swamps probably support a greater diversity of songbirds than any other wetland type (class). Many species of warblers, fly-catchers, woodpeckers, and thrushes breed in these wetlands, along with nuthatches, vireos, rose-breasted grosbecks, hawks, owls, grackles and other species.

(8) Bog class. Bogs are wetlands where the accumulation of sphagnum moss as peat determines the nature of the plant community. Bogs commonly have floating peat mats which grow outward from the shore over the water surface if open water is present. Due to the low oxygen levels and cool soil/water temperatures, dead plant remains accumulate, rather than decomposing to form muck. Thus nutrients are bound up and the result is a dearth of valuable wildlife food plants.

Wildlife value is limited also because there is seldom much shallow water in bogs. Since the edge of the bog mat is often floating, the shoreline is bordered by deep water where emergent cover plants cannot grow. The ringneck duck is one of the few waterfowl species that regularly inhabits bogs. Being a diver, it can obtain submergent food plants unavailable to dabblers. Warblers, flycatchers and other song-birds are found in the high shrub and tree zones in the bog class. Water shrews, jumping mice and muskrats are often present but other species are limited since food is scarce and cover is unsuitable.

2-1-18. **DECLARATION OF INTENT.**—Whereas recognized that swamps, marshes and other fresh water wetlands as herein defined act as buffer zones absorption areas for flood waters, and

Whereas, all flood plains for all rivers, streams and other water courses are certain to be overflowed with water periodically in spite of all reasonable efforts to prevent such occurrences, and

Whereas, flood waters overflowing into marshes, swamps and other fresh water wetlands are not only caused more slowly downstream thus reducing the damage they may cause, but such flood waters tend to be absorbed into the ground water supply through swamps, marshes, and other fresh water wetlands thus further reducing the flood hazard and recharging the ground water resource, and

Whereas swamps, marshes, and other fresh water wetlands are among the most valuable of all wildlife habitats and are high value recreational areas as well, and whereas wildlife and recreation are widely recognized as essential to the health, welfare, and general well being of the general populace, and

Whereas swamps, marshes, and other fresh water wetlands are increasingly threatened by random and frequently undesirable projects for drainage, excavation, filling, encroachment or other form of disturbance or destruction and are currently inadequately protected from such random and undesirable projects, and

Whereas, the protection of swamps, marshes, and other fresh water wetlands from random, unnecessary, and/or undesirable drainage, excavation, filling, encroachment, or any other form of disturbance or destruction is recognized as being in the best public interest and essential to the health, welfare, and general well being of the general populace and essential to the protection of property and life during times of flood or other disaster affecting water levels or water supply, therefore, the provisions of the following sections are intended to preserve and regulate the use of such swamps, marshlands and wetlands.

2-1-19. **PUBLIC POLICY ON SWAMPS, MARSHES AND FRESH WATER WETLANDS.**—It is the public policy of the State of Rhode Island and Providence Plantations to preserve the purity and integrity of the swamps, marshes, and other fresh water wetlands of this state. The health, welfare, and general well being of the populace and the protection of life and property require that the state restrict the uses of such lands and, therefore, in the exercise of the police power such wetlands are to be regulated hereunder.

“2-1-20. **DEFINITIONS.**—The term ‘bog’ as used in this chapter shall be a place where standing or slowly running water shall be near or at the surface during a normal growing season and/or where a vegetational community shall have a significant portion of the ground or water surface covered with sphagnum moss (*Sphagnum*) and where the vegetational community shall be made up of a significant portion of one or more of, but not limited to nor necessarily including all of, the following: blueberries and cranberry (*Vaccinium*), leather-leaf (*Chamaedaphne calyculata*), pitcher plant (*Sarracenia purpurea*), sundews (*Droseraceae*), orchids (*Orchidaceae*), white cedar (*Chamaecyparis thyoides*), red maple (*Acer rubrum*), black spruce (*Picea mariana*), bog aster (*Aster nemoralis*), larch (*Larix laricina*), bogrosemary (*Andromeda glaucophylla*), azaleas (*Rhododendron*), laurels (*Kalmia*), sedges (*Caryx*), bog cotton (*Eriophorum*).

The term ‘Director’ as used in this chapter shall refer to the director of the department of natural resources.

The term ‘Flood plain’ as used in this chapter shall be that land area adjacent to a river or stream or other body of flowing water which is, on the average, likely to be covered with flood waters once every 50 years.

The term ‘Fresh water wetlands’ as used in this chapter shall include, but not be limited to, marshes; swamps; bogs; rivers; river and stream flood plains and banks; areas subject to flooding or storm flowage; areas where ground water, flowing or standing surface water or ice provide a significant part of the supporting substrate for a plant community for a significant part of the year; emergent and submergent plant communities in water bodies; and that portion of any bank which touches any inland waters.

The term ‘Marsh’ as used in this chapter shall be a place not less than one acre in extent where a vegetational community shall exist in standing or running water during the growing season and/or shall be made up of one or more, but not limited to nor necessarily including all of, the following plants or groups of plants: hydrophytic grasses (*Gramineae*), sedges (*Cyperaceae*), rushes (*Juncaceae*), cattails (*Typha*), pickerelweeds (*Pontederiaceae*), water plantains (*Alismataceae*), bur-reeds (*Sparganiaceae*), pondweeds (*Zosteraceae*), frog’s bits (*Hydrocharitaceae*), arums (*Araceae*), duckweeds (*Lemnaceae*), water lilies (*Nymphaeaceae*), water-milfoils (*Haloragaceae*), water-starworts (*Callitrichaceae*), horsetails (*Equisetaceae*),

naiads (Naiadaceae), buckwheats (Polygonaceae), arrowgrasses (Juncaginaceae), bladderworts (Utricularia), pipeworts (Eriocaulon), sweet gale (Myrica gale), buttonbush (Cephalanthus occidentalis).

The term 'River bank' as used in this chapter shall be that area of land within 200 feet of the edge of any flowing body of water or between the edge of any flowing body of water and a 20 foot contour line drawn parallel to the stream bed thalweg, whichever is closer.

The term 'Swamp' as used in this chapter shall be a place not less than 3 acres in extent where ground water shall be near or at the surface of the ground for a significant part of the growing season or runoff water from surface drainage shall collect frequently and/or where a vegetational community shall be made up of a significant portion of one or more of, but not limited to nor necessarily including all of, the following: red maple (*Acer rubrum*), elm (*Ulmus americana*), black spruce (*Picea mariana*), white cedar (*Chamaecyparis thyoides*), ashes (*Fraxinus*), poison sumac (*Rhus vernix*), larch (*Larix laricina*), spicebush (*Lindera benzoin*), alders (*Alnus*), skunk cabbage (*Symplocarpus foetidus*), hellebore (*Veratrum viride*), hemlock (*Thuja canadensis*), sphagnum (*Sphagnum*), azaleas (*Rhododendron*), black alder (*Ilex verticillata*), white alder (*Clethra alnifolia*), marsh marigold (*Caltha palustris*), blueberries (*Vaccinium*), buttonbush (*Cephalanthus occidentalis*), willow (*Salicaceae*), water willow (*Decodon verticillatus*), tupelo (*Nyssa sylvatica*), laurels (*Kalmia*).

"2-1-21. APPROVAL OF DIRECTOR.—No person, firm, industry, company, corporation, city, town, municipal or state agency, fire district, club, non-profit agency, or other individual or group, may excavate; drain; fill; place trash, garbage, sewage, highway runoff, drainage ditch effluents, earth, rock, borrow, gravel, sand, clay, peat, or other materials or effluents upon; divert water flows into or out of; dike; dam; divert; change; add to or take from or otherwise alter the character of any fresh water wetland as herein defined without first obtaining the approval of the director of the department of natural resources. Such approval will be denied if in the opinion of the director granting of such approval would not be in the best public interest. Such approval shall not be granted unless the city council of a city or the town council of a town within whose borders the project lies shall so approve. Appeal from such denial may be made to the superior court.

"2-1-22. PROCEDURE FOR APPROVAL BY DIRECTOR.—Application for approval of such a project to the director of natural resources shall be made in a

form to be prescribed by the director and provided by the director upon request. Upon receipt of the completed application accompanied by plans and drawings of the proposed project, such plans and drawings to be prepared by a certified registered engineer to a scale of not less than one inch to one hundred feet, the director will notify all land owners whose properties abut the area of the proposed project and he will also notify the town council, the conservation commission, the planning board, the zoning board, and any other individuals and agencies in any towns within whose borders the project lies who may have reason in the opinion of the director to be concerned with the proposal. The director may also establish a mailing list of all interested persons and agencies who may wish to be notified of all such applications. If the director receives any objection to the project within 45 days of the mailing of the notice of application from his office, such objection to be in writing, the director shall then schedule a public hearing in an appropriate place as convenient as reasonably possible to the site of the proposed project. He shall inform by registered mail all objectors of the date, time, place, and subject of the hearing to be held. He shall further publish notice of the time, place, date, and subject of the hearing in one local Rhode Island newspaper circulated in the area of the project and one statewide Rhode Island newspaper, such notices to appear once per week for at least three consecutive weeks prior to the week during which the hearing is scheduled. The director shall establish a reasonable fee to cover the costs of the above investigations, notifications and publications, and hearing and the applicant shall be liable for such fee.

If no public hearing is required, or following a public hearing, the director shall make his decision on the application and shall notify the applicant by registered mail of this decision within a period of 6 weeks. If a public hearing was held, any persons who objected to the project in writing during the 45 day period provided for such objections shall be notified of the director's decision by first class mail.

In the event of a decision in favor of granting an application the director shall issue a permit for the applicant to proceed with the project. Such permits shall be valid for a period of one year from the date of issue and shall expire at the end of that time unless renewed. An extension of the identical original permit may be granted upon written request to the director by the original permit holder or his legal agent at least 90 days prior to the expiration date of the original permit. The director may require new hearings if, in his judgment, the original intent of the permit is

red or extended by the renewal or if the applicant failed to abide by the terms of the original permit in any way. The request for renewal of a permit shall follow the same form and procedure as the original application except that the director shall have the option of not holding a hearing if the original intent of the permit is not altered or extended in any significant way.

2-1-23. VIOLATIONS.—In the event of a violation of section 2-1-21 of the general laws, the director of natural resources shall have the power to order complete restoration of the fresh water wetland area involved by the person or agent responsible for the violation. If such responsible person or agent does not complete such restoration within a reasonable time following the order of the director of the department of natural resources, the director shall have the authority to order the work done by an agent of his choosing and the person or agent responsible for the original violation shall be held liable for the cost of

the restoration. Such violator shall be liable for a fine of up to \$1,000. for each such violation.

"2-1-24. NOTICE TO CEASE OPERATION AND RELIEF IN EQUITY.—Whenever any person, firm, industry, company, corporation, city, town, municipal or state agency, fire district, club or other individual or group shall commence any activity set forth in section 2-1-21 without first having obtained the approval of the director, the director may serve said person with written notice to cease said operations and/or order the removal of any such fill placed illegally on such wetlands and the wetlands restored to their original state insofar as possible; provided, however, that before such notice is given, said person shall have been given an opportunity to show cause why the order or notice of the director should not be complied with. The director may obtain injunctive relief or relief by prerogative writ whenever such relief shall be necessary in the proper performance of his duties under sections 2-1-18 to 2-1-24 inclusive."

Appendix D

POTENTIAL ENVIRONMENTAL IMPACTS OF HYDROELECTRIC POWER PROJECTS

Hydropower development projects may be major, or minor, multi-purpose, conventional "run of river", or pumped storage, and they may involve almost any kind of environmental impact. Every aquatic system consists of a vast array of physical and biological elements which interact in subtle and often unrecognized ways.

Each type of hydro development activity is attended by an identifiable set of physical and chemical alterations in the aquatic environment which may extend for many miles from the site and may persist for many years. In turn, each type of physical and chemical modification has been shown to induce a derived set of biological effects, many of which are predictable in general if not specific detail.

The most significant environmentally damaging effect of hydro development activities are direct habitat loss, addition of suspended solids and modification of water levels and flow regimes. Major construction related impacts also derive from altered water temperatures, pH, nutrient levels, and certain pollutants such as heavy metals present in discharges or in dredged materials. In order to provide the basis for rational environmental management, it is necessary to identify the potentially destructive activities and to analyze their specific effects upon the natural environments and the native biological communities of river ecosystems.

Commonly Observed Impacts: A hydroelectric dam and reservoir may have the same range of impacts as any other dam and reservoir. Important wildlife habitat may be flooded; passage up and downstream for highly valued migratory fish may be blocked and their habitat inundated, etc. A long, deep reservoir behind a high dam on an important anadromous fish-spawning stream presents the ultimate challenge to fisheries conservation measures in the need for and design of fish passage and propagation facilities. A similar dam flooding a broad or extensive valley serving as critical winter range for migratory birds and mammals is similarly an ultimate challenge to wildlife resources conservation measures with a need for the development of habitat replacement and other mitigation measures. Overall impacts of these kinds vary in size and significance according to the specific situation.

Alteration of Streamflows: Diversion and regulation of streamflow will cause other adverse impacts which can only be mitigated by dedication of minimum flow releases to the stream below the dam, re-regulation or other control of peaking flows, scheduling flows to meet critical fish maintenance or fish harvest needs, installation and proper operation of multi-level outlets for temperature and other water quality maintenance, etc. In some of the older hydroelectric projects with deep-water release structures, low dissolved oxygen problems may be encountered with release of oxygen-deficient, hypolimnial waters. This, in turn, reduces the streams' capacity to handle organic pollutants.

Reservoir Pool Level Fluctuations: As with other reservoir projects, reservoir pool level fluctuations and drawdown may be of concern in relation to biomass production, fish spawning, turbidity control, and recreational use. Usually the maintenance of a minimum fish conservation pool is not a problem because power production requires maintenance of that pool in order to operate efficiently.

Sediment and Turbidity: Environmental protection measures must be taken during the construction phase to prevent undue sediment and turbidity in the stream through run-off from disturbed lands, and to prevent unnecessary destruction of scenic, natural, historic, and other cultural values.

Obstructions to Migration of Wildlife: On some constructed projects, open conduits may present problems to migratory animals especially where the flow is rapid and deep. Deer and other animals may be lost in important number if provisions are not made for excluding them or providing escape devices for them. Suitable engineering measures should be taken to prevent interruption of migration routes.

Transmission line rights-of-way may adversely affect fauna. Direct removal of habitat, blockage of normal daily or migratory routes, creation of corridors along which some species may move and extend their range, and by creation of new habitat resulting in change in species composition of the local fauna are some possible effects of creation of a new right-of-way. Additional impacts such as bird electrocution and bird collision with the structures may occur.

Recreational Facilities: Public use of reservoirs for recreational purposes may adversely affect terrestrial habitat in areas immediately adjacent to campgrounds, roadways, and other public access areas. Habitat may be removed or altered for public use facilities; increased use of the area by people may alter use of that habitat by some vertebrate species.

Beneficial impacts may also result from the creation of fishing and other recreational facilities on the reservoir as well as creation of desirable wildlife habitat along transmission line or conduit rights-of-way.

Appendix D (continued)

POTENTIAL HYDROPOWER DEVELOPMENT IMPACTS¹

RESOURCE SYSTEM OR
ATTRIBUTE AFFECTED

IMPACT CAUSED BY:

Aquatic Biota

1. Changes in downstream and/or reservoir water quality due to:
 - a. temporary pollution from construction activities
 - b. pollution associated with operation and maintenance
 - c. gas supersaturation below dam
 - d. flooding of land, causing leaching, organic matter decay, and toxin releases*
 - e. higher temperatures and less O₂ in still waters*
 - f. silt trapping in reservoir, causing higher nutrient levels in reservoir, lower turbidity and nutrient levels downstream*
 - g. reservoir stratification*
 - h. power plant intakes in reservoir hypolimnion, or at level of particular activity
 - i. changed season thermal regime—slow to warm in spring, slow to cool in fall.*

2. Changes in downstream flows with consequent effects on spawning, migration, and other behavior patterns due to:
 - a. increased evapo-transpiration from reservoir*
 - b. reservoir filling*
 - c. increased loss to ground water accretion from reservoir*
 - d. flow management for power production.

* Denotes those impacts that occur only when a new dam is constructed or the height of an old dam is increased.

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
(Of particular significance for migratory fish)	<ol style="list-style-type: none"> 3. Other habitat changes due to: <ol style="list-style-type: none"> a. initial pulse of downstream erosion below dam caused by sedimentation in reservoir* b. increased erosion below dam caused by sedimentation in reservoir* c. increased sedimentation upstream from tributary mouths* d. creation of reservoir habitat and elimination of previous riverine environment* e. reservoir level fluctuation caused by flow management, affecting wetlands and littoral (shoreline) zone. 4. Physical impact of temporary by-pass (for migrants in either direction). 5. Dam height barrier for upstream migration.* 6. Confusion for upstream migrants below dam from tailraces. 7. Confusion above dam from still water.* 8. Danger of turbines and spill-way to downstream migrants.
Terrestrial Flora	<ol style="list-style-type: none"> 1. Habitat changes due to conversion of land to use for: <ol style="list-style-type: none"> a. reservoir* b. construction activities, including dumping of dredge spoils c. powerhouse, conduits, switching yard, etc. d. transmission lines.

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
	<ol style="list-style-type: none"> 2. Changes in natural communities above new water levels due to: <ol style="list-style-type: none"> a. rise in water table* b. reservoir level fluctuations and changing downstream flow patterns c. decreased flooding downstream, possible increased flooding slightly upstream.
<p>Terrestrial Wildlife</p>	<ol style="list-style-type: none"> 1. Habitat changes due to conversion of land to use for: <ol style="list-style-type: none"> a. reservoir* b. construction activities, including dumping of dredge spoils c. powerhouse, conduits, switching yard, etc. d. transmission lines. 2. Changes in natural communities above new water levels due to: <ol style="list-style-type: none"> a. rise in water table* b. reservoir level fluctuations and changing downstream flow patterns c. decreased flooding downstream, possible increased flooding slightly upstream.* 3. Disturbances to wildlife due to: <ol style="list-style-type: none"> a. construction activities b. operation and maintenance activities c. activities associated with changed recreational opportunities.

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
	<p>4. Disruption of wildlife movements caused by:</p> <ul style="list-style-type: none"> a. new reservoir* b. powerhouse, conduits, etc. c. transmission lines.
<p>Ecosystem Character and Integrity</p>	<ol style="list-style-type: none"> 1. Changes in aquatic ecosystems due to changes in water, velocity, temperature, turbidity, depth, retention time, bottom type, migration barriers, etc. 2. Changes in terrestrial and wetlands ecosystems due to flooding, water table fluctuations, conversion to other land uses, changes in human activity levels and accompanying air pollution and noise levels. <p>(Of particular importance are impacts that seriously disrupt all or a significant part of a functioning ecosystem, particularly one that is rare in its structure and organization very rich in its diversity and production, or contains one or more rare or endangered species.)</p>
<p>Recreation</p>	<ol style="list-style-type: none"> 1. Changes in scenic quality. 2. Loss of recreational opportunities related to the river environment (e.g., white-water canoeing).* 3. Gain of recreational opportunities related to the reservoir environment (e.g., water-skiing).* 4. Changes in recreational opportunities due to reservoir dredging. 5. Changes in fish populations. 6. Changes in wildlife populations. 7. Changes in ecosystem character affecting opportunities in nature appreciation and natural history interpretation.

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
	<ul style="list-style-type: none"> 8. Impact of pulse of sediment moving downstream and sedimentation upstream from tributary mouths, on boating. 9. Impact of changes in bottom type due to sedimentation in reservoir and increased erosion below dam on swimming and water-edge activities.* 10. Dam presents barrier to river recreation.* 11. Impact of downstream flow management on boating, swimming, etc. 12. Impact of reservoir level fluctuation on recreational facilities.
<p>Aesthetics, Scenic Quality</p>	<ul style="list-style-type: none"> 1. Changes in aquatic biota (especially algal blooms and macrophyte proliferation). 2. Changes in terrestrial biota (especially dying vegetation from flooding and/or water table fluctuations). 3. Creation of biologically impoverished reservoir littoral zone from drawdown. 4. Changes in water-edge conditions along reservoir, and downstream and upstream river landscapes, from erosion and sedimentation. 5. Changes in water quality (from construction activities, etc.). 6. Scenic impact of low flows downstream. 7. Scenic impact of dam, powerhouse, switching year, transmission lines. 8. Loss of river landscape.* 9. Creation of reservoir landscape.*
<p>Sites of Historical, Cultural, or Archaeological Value</p>	<ul style="list-style-type: none"> 1. Activities that may destroy, alter, provide access to, or in other ways affect sites of interest: <ul style="list-style-type: none"> a. flooding*

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
	<ul style="list-style-type: none"> b. alteration of dam facilities c. construction of dam facilities d. changes in recreational patterns.
<p>Socio-economic and Economic Conditions</p>	<ul style="list-style-type: none"> 1. Changes in power availability and cost. 2. Changes in recreation and tourism related to: <ul style="list-style-type: none"> a. changes in recreational opportunities b. change sin scenic quality c. changes in sites of historic, cultural, or archaeological value d. changes in water quality. 3. Infusion of money from construction activities and revenues to operators. 4. Changes in land use affecting productive activities (e.g., drowning of farm lands). 5. Changes in water supply (impacts on withdrawals and discharges).
<p>Community Life</p>	<ul style="list-style-type: none"> 1. Influx of people (for both construction and operation and maintenance). 2. Infusion of money. 3. Changes in recreational opportunities, scenic quality, water quality, historic and cultural sites. 4. Further changes from economic development and/or disruption spurred by power plant development. 5. Frustration or satisfaction stemming from: <ul style="list-style-type: none"> a. ability to participate in decision making b. concurrence of perceived and actual development effects.

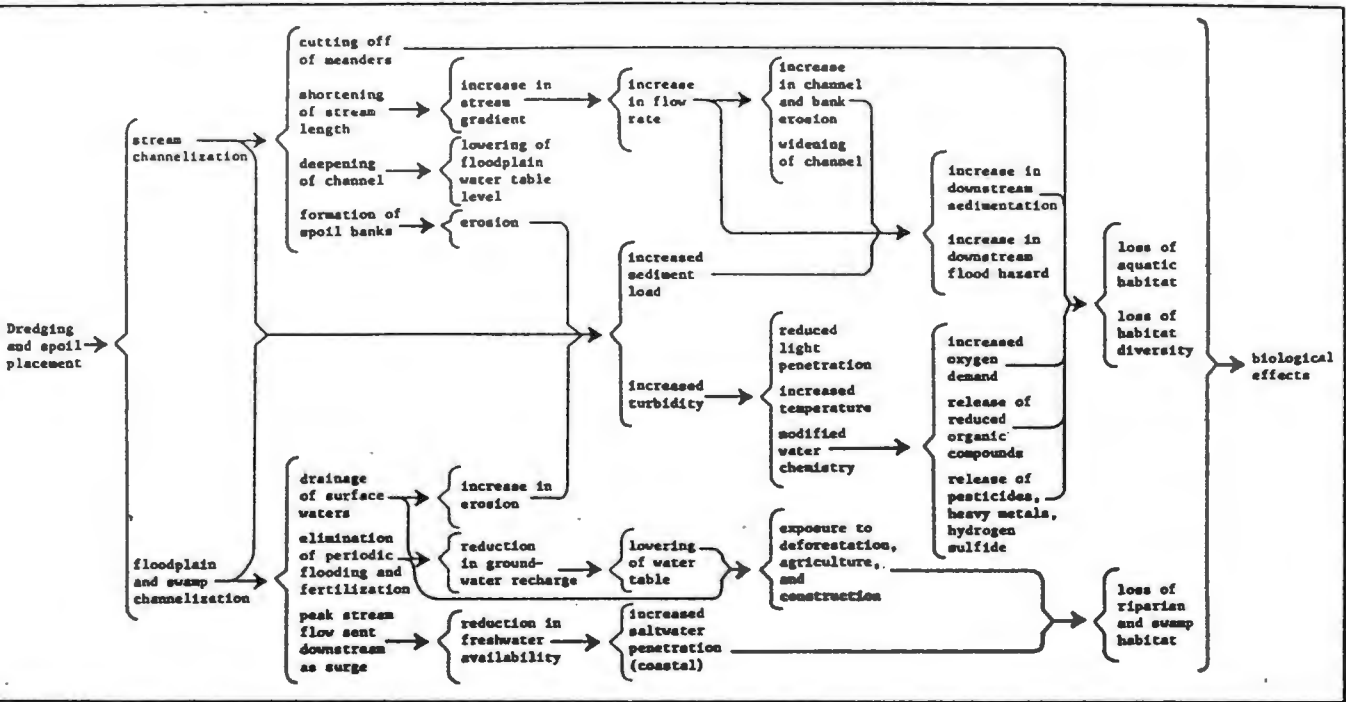
RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
	<p>6. Changes in tension or cohesion caused by different distributions of the benefits and costs of development.</p>
<p>Individual Welfare</p>	<ol style="list-style-type: none"> 1. Loss of land to hydropower. 2. Changes in recreational opportunities, scenic quality, water quality. 3. Changes in water supply (impacts on withdrawals and discharges). 4. Changes in standard of living. 5. Frustration or satisfaction stemming from: <ol style="list-style-type: none"> a. ability to participate in decision making b. concurrence of perceived and actual effects of development. 6. Changes in frequency of flooding.
<p>Water Supply</p>	<ol style="list-style-type: none"> 1. Impacts on water available for withdrawals and dilution of discharges due to: <ol style="list-style-type: none"> a. In reservoir: <ul style="list-style-type: none"> --greater storage than river* --fluctuating reservoir levels b. Downstream: <ul style="list-style-type: none"> --decreased average flows from: <ul style="list-style-type: none"> -increased evapo-transpiration from reservoir* -increased loss from reservoir to ground water accretion* -filling of reservoir (temporary)* --changes in flow patterns from flow management --elimination or creation of pools for storage due to sedimentation and erosion. 2. Impacts of sedimentation on water intakes and waste discharge pipes.

RESOURCE SYSTEM OR ATTRIBUTE AFFECTED	IMPACT CAUSED BY:
Water Quality (Downstream and/or in Reservoir)	<ol style="list-style-type: none"> 1. Temporary pollution from construction activities. 2. Pollution associated with operation and maintenance. 3. Gas supersaturation below dam. 4. Flooding of land, causing leaching, organic matter decay, and toxin release.* 5. Changed seasonal thermal regime; slow to warm in spring, slow to cool in fall.* 6. Higher temperatures and less oxygen in open, still waters.* 7. Slit trapping in reservoir, causing higher nutrient levels in reservoir, lower turbidity and nutrient levels downstream.* 8. Reservoir stratification.* 9. Power plant intakes in reservoir hypolimnion.

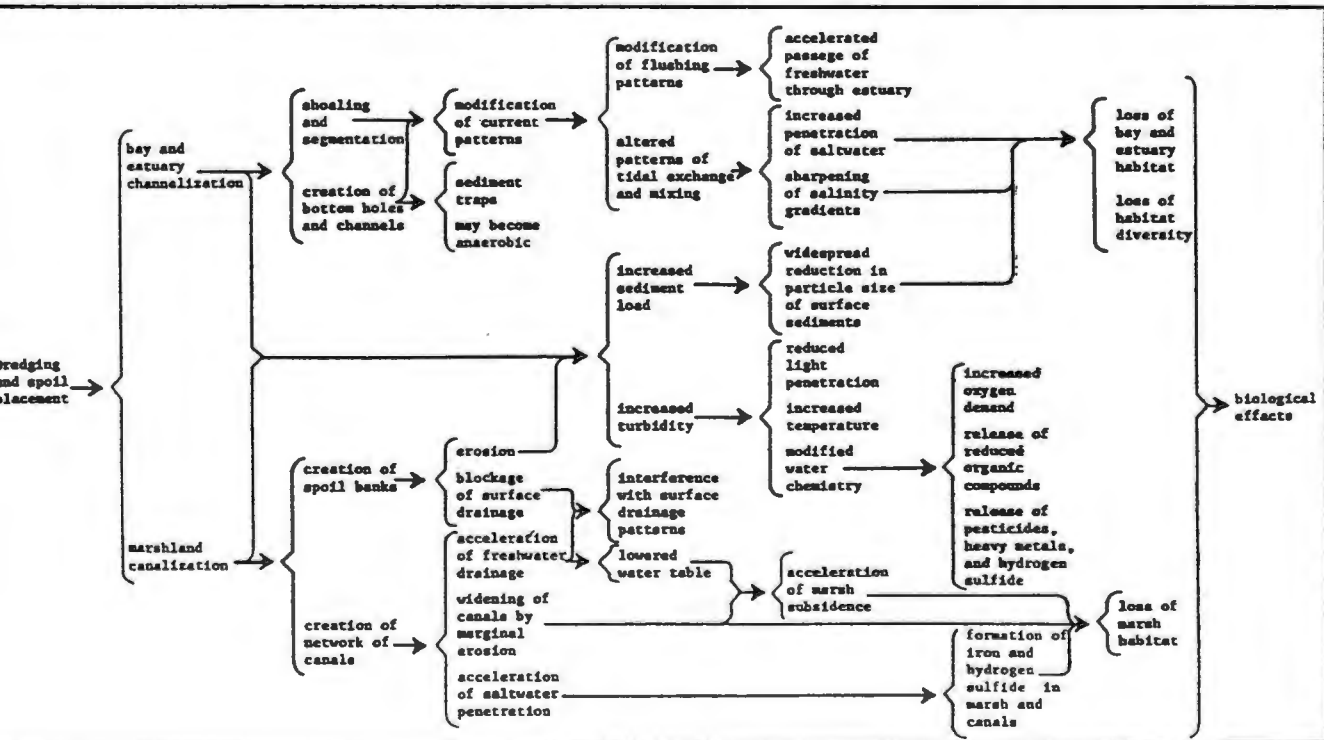
¹Based on findings of the New England River Basins Commission, Hydro Study Management Team, 1981.

APPENDIX E

Factor analysis of the effects of channelization on streams, swamps, and floodplains. Only the major physical and chemical events are presented.*

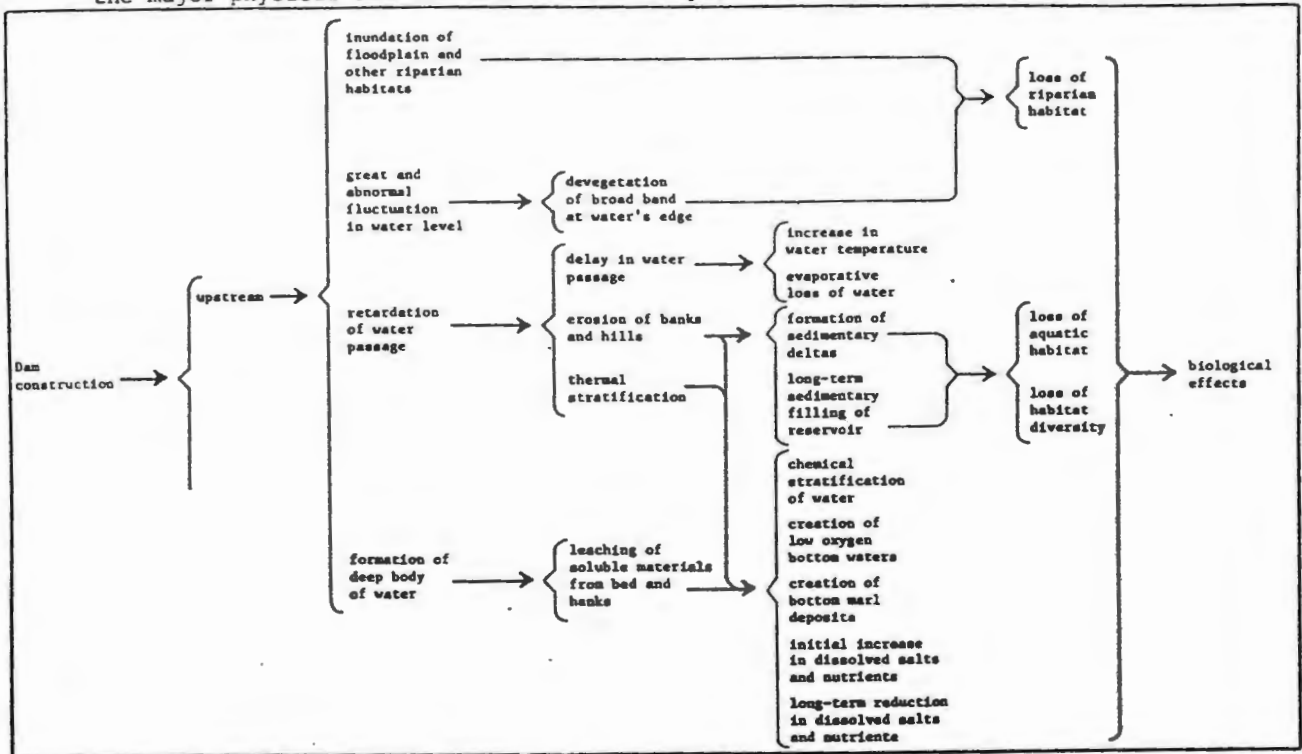


Factor analysis of the effects of channelization and canalization on bays, estuaries, and marshlands. Only the major physical and chemical events are presented.*

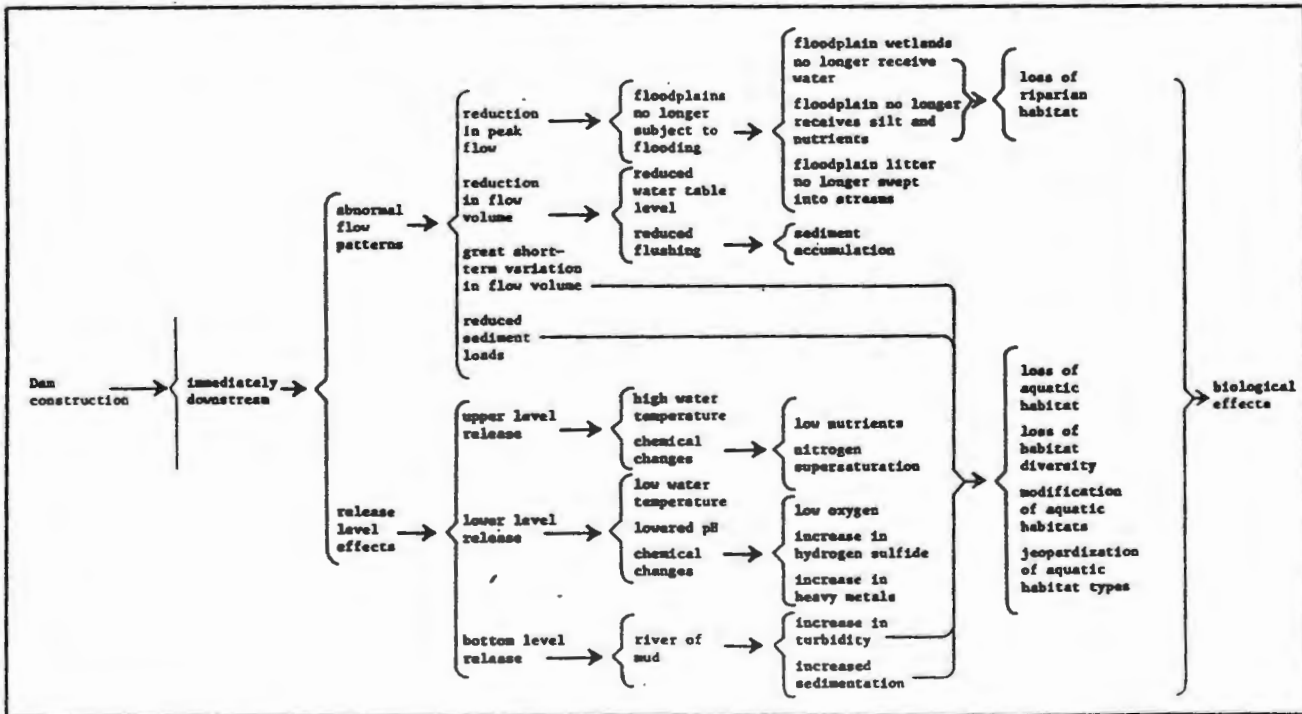


*From Darnell, Reznat M. 1976. Impacts of Construction Activities in Wetlands of the U.S. U.S. Environmental Protection Agency, Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon. EPA-600/3-76-045.

Factor analysis of the upstream effects of dam construction on wetlands. Only the major physical and chemical events are presented.*

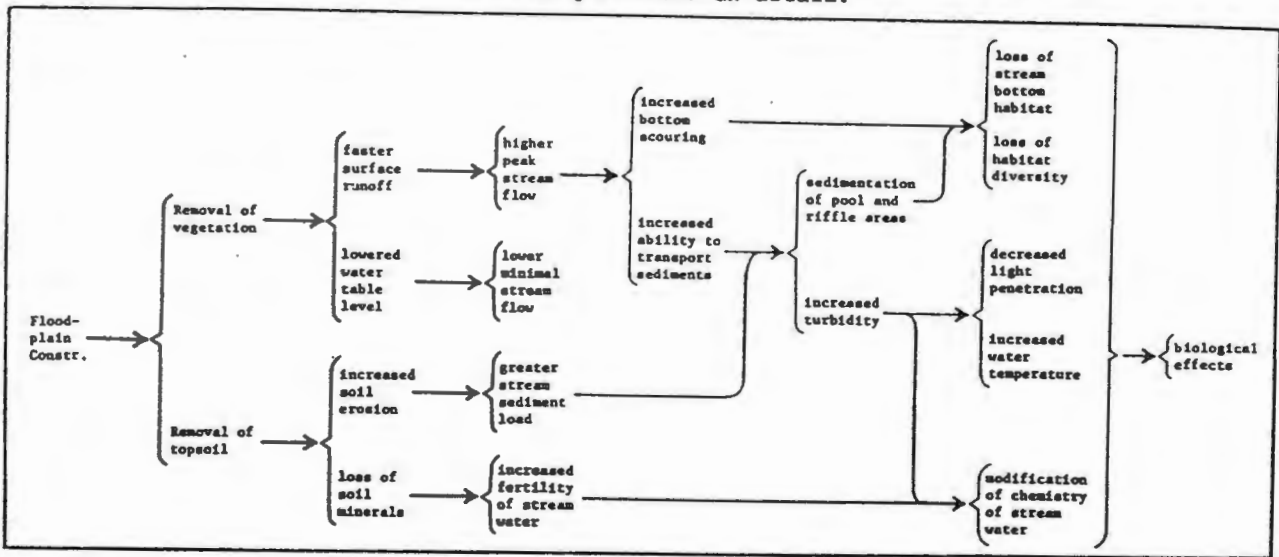


Factor analysis of the immediate downstream effects of dam construction on wetlands. Only the major physical and chemical events are presented.*

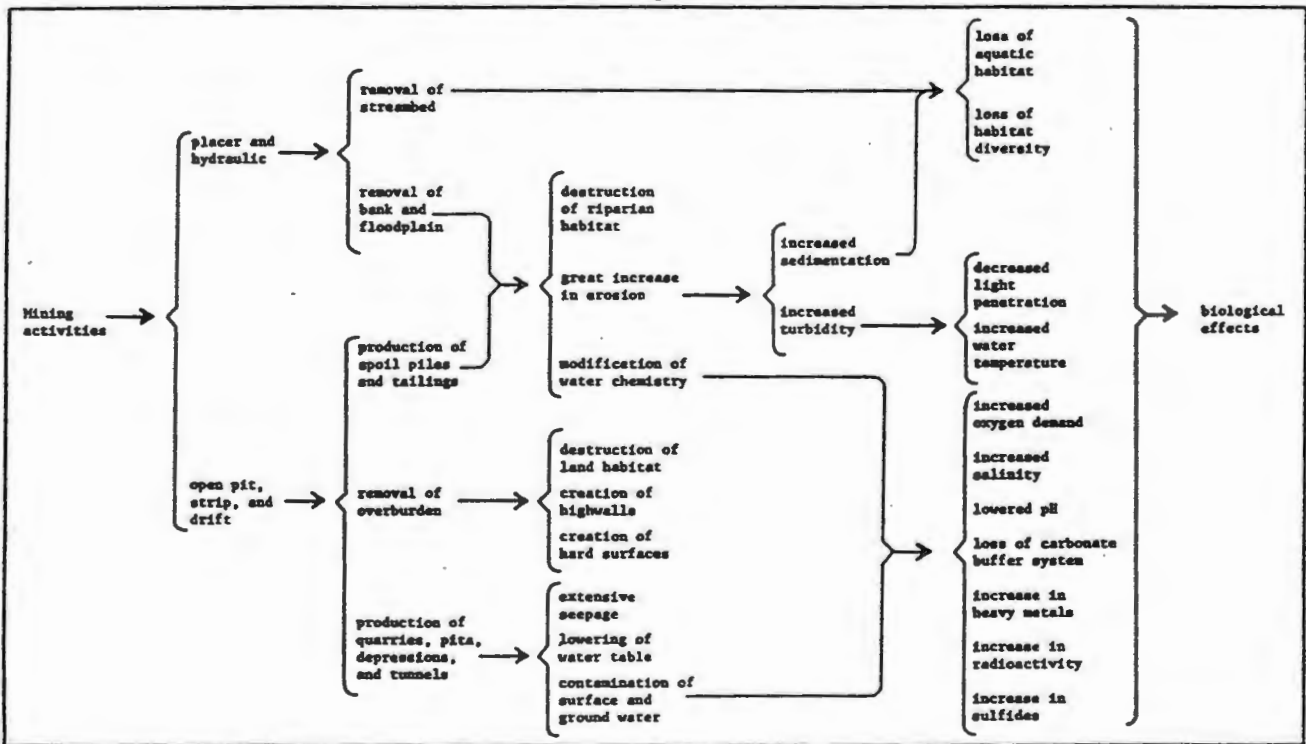


*From Darnell, Rezneat M. 1976. Impacts of Construction Activities in Wetlands of the U.S. U.S. Environmental Protection Agency, Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon. EPA-600/3-76-045.

Factor train analysis of the effects of floodplain construction on wetlands. Only the major physical events are presented in detail.*



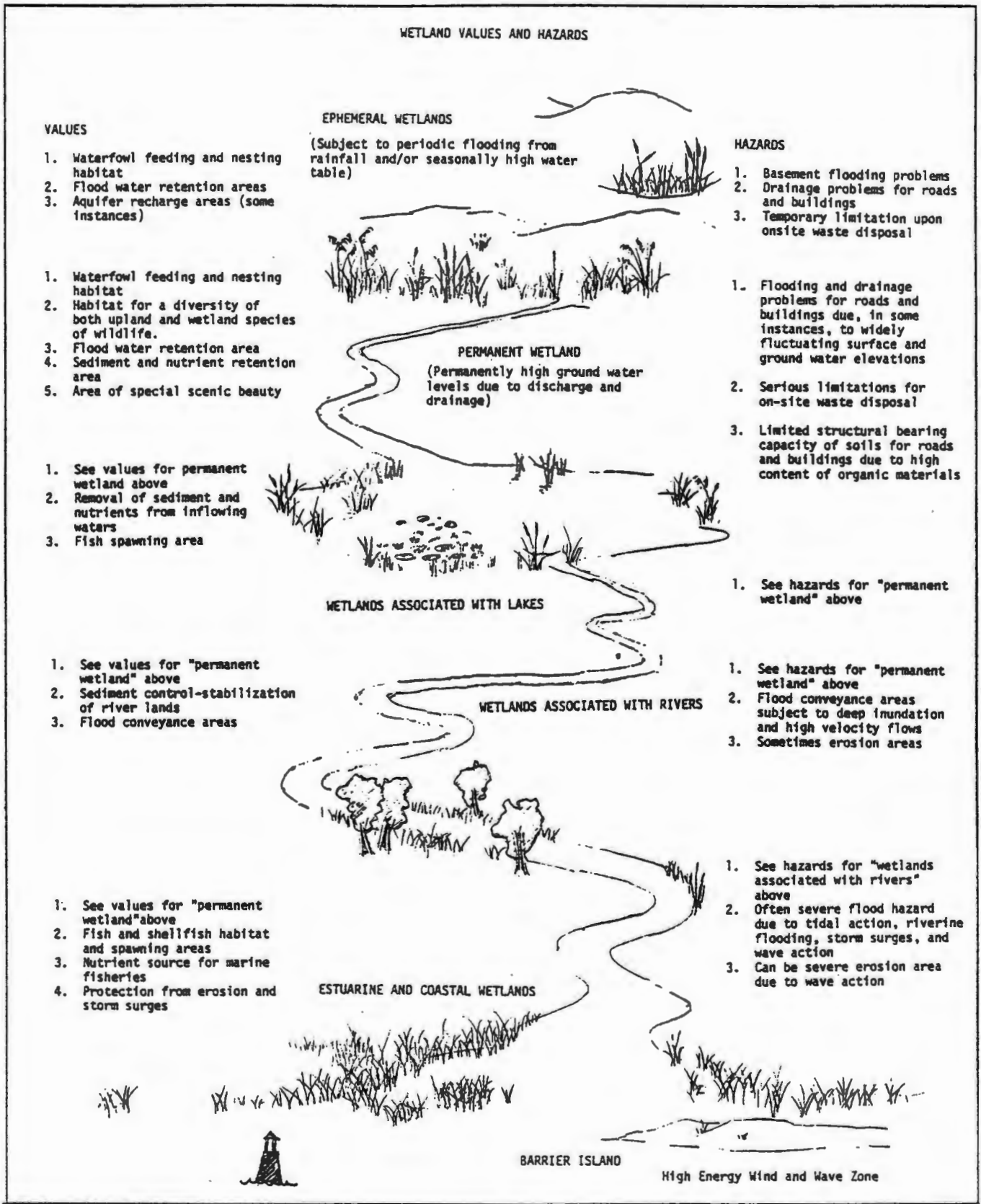
Factor analysis of the effects of mineral extraction on wetlands. Only the major physical and chemical events are presented.*



*From Darnell, Rezneat M. 1976. Impacts of Construction Activities in Wetlands of the U.S. U.S. Environmental Protection Agency, Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon. EPA-600/3-76-045.

APPENDIX F

WETLAND VALUES AND HAZARDS



VALUES

1. Waterfowl feeding and nesting habitat
2. Flood water retention areas
3. Aquifer recharge areas (some instances)

1. Waterfowl feeding and nesting habitat
2. Habitat for a diversity of both upland and wetland species of wildlife.
3. Flood water retention area
4. Sediment and nutrient retention area
5. Area of special scenic beauty

1. See values for permanent wetland above
2. Removal of sediment and nutrients from inflowing waters
3. Fish spawning area

1. See values for "permanent wetland" above
2. Sediment control-stabilization of river lands
3. Flood conveyance areas

1. See values for "permanent wetland" above
2. Fish and shellfish habitat and spawning areas
3. Nutrient source for marine fisheries
4. Protection from erosion and storm surges

HAZARDS

1. Basement flooding problems
2. Drainage problems for roads and buildings
3. Temporary limitation upon onsite waste disposal

1. Flooding and drainage problems for roads and buildings due, in some instances, to widely fluctuating surface and ground water elevations
2. Serious limitations for on-site waste disposal
3. Limited structural bearing capacity of soils for roads and buildings due to high content of organic materials

1. See hazards for "permanent wetland" above

1. See hazards for "permanent wetland" above
2. Flood conveyance areas subject to deep inundation and high velocity flows
3. Sometimes erosion areas

1. See hazards for "wetlands associated with rivers" above
2. Often severe flood hazard due to tidal action, riverine flooding, storm surges, and wave action
3. Can be severe erosion area due to wave action

* Jon Kusler. Wetland Protection: A Guidebook for Local Governments.
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Conservation is the highest form of National thrift.

--Special Message to Congress,
President John F. Kennedy
March 1, 1962