LEVEL

SNOHOMISH ESTUARY

WETLANDS STUDY

Volume IV

DELINEATION OF WETLAND BOUNDARIES

by

Marc E. Boule and G. Bradford Shea

ANDREW L. DRISCOLL, CONSULTANT

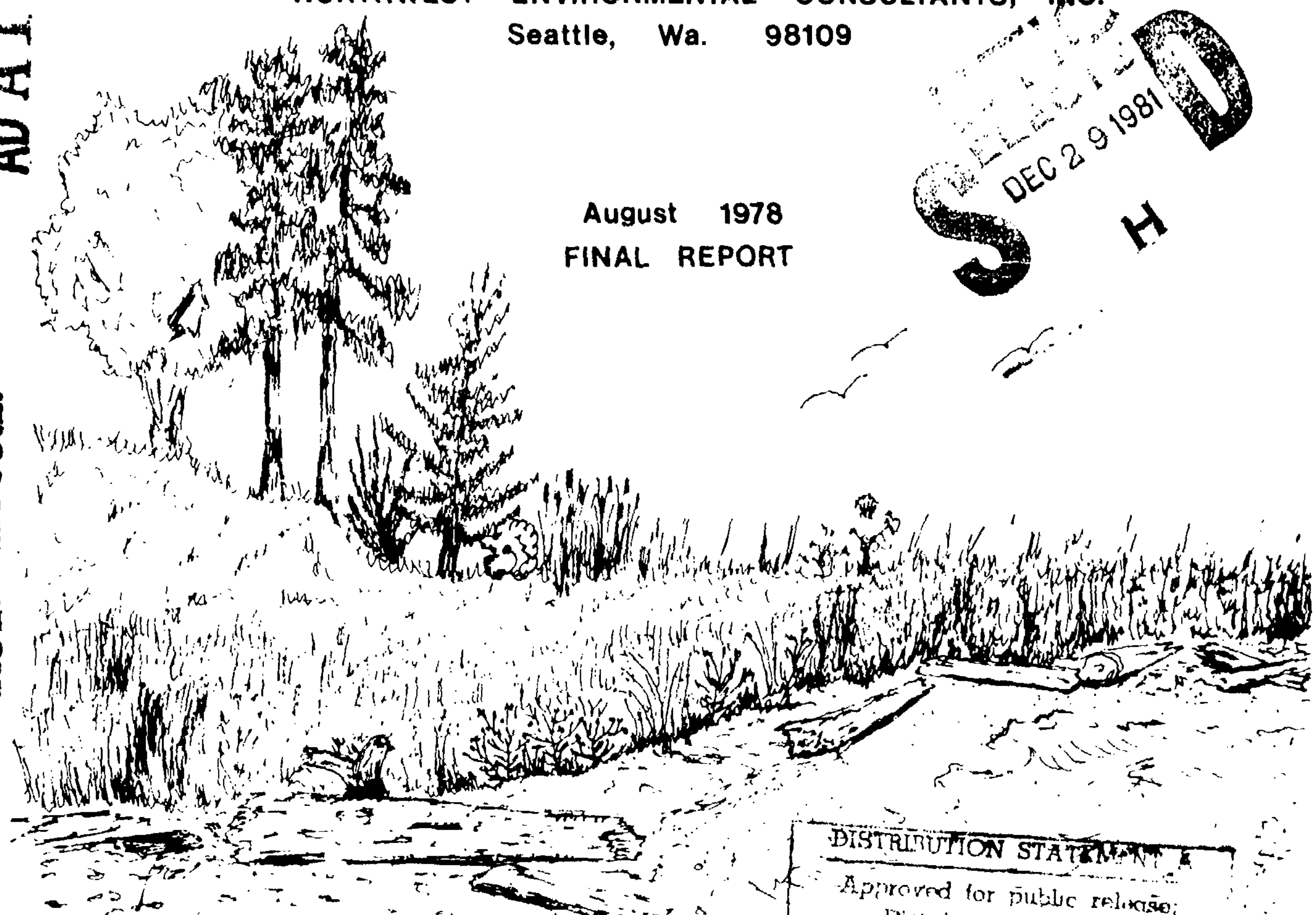
in association with

NORTHWEST ENVIRONMENTAL CONSULTANTS, INC.

Seattle, Wa. 98109

August 1978

FINAL REPORT



Prepared for

U.S. Army Corps of Engineers

Seattle District

81 12 23 166

Contract DACW67-77-C-0082

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A108985	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Snchomish Estuary Wetlands Study: Vol. IV, Delineation of Wetland Boundaries		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Marc E. Boule, Andrew L. Driscoll, G. Bradford Shea		8. CONTRACT OR GRANT NUMBER(s) DACW67-77-C-0082
9. PERFORMING ORGANIZATION NAME AND ADDRESS Northwest Environmental Consultants, Inc. Seattle, Washington 98109		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineers, Seattle District P.O. Box C-3755/4735 East Marginal Way South Seattle, WA 98124		12. REPORT DATE August 1978
		13. NUMBER OF PAGES 121
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC ELECTE DEC 29 1981 D H

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Vol I - Summary
Vol II - Base Information and Evaluation
Vol. III - Classification and Mapping
Vol IV - Delineation of Wetland Boundaries

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Snohomish River
Wetlands
Estuaries
Boundaries
Washington (State)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Wetlands boundaries in the Snohomish River Basin were delineated according to Army Corps of Engineers (Corps) definition presented in Corps permit regulations (33 CFR 323.2). These definitions are based primarily on occurrence of wetland vegetation and concepts relating the presence of such vegetation to conditions of soil saturation. The delineation of wetland boundaries defines to some degree a jurisdictional context for other portions of the Snohomish Estuary Wetlands Study, of which this is a part.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

412...

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Field investigations of the estuarine and riverine portions of the Basin were carried out during 1977 and 1978, coupled with analysis of color infrared and black and white aerial photographs of the area. These investigations and analyses led to the establishment of a recommended boundary line for "adjacent wetlands" as defined in Corps permit regulations (33 CFR 323.2(c)). Boundary lines have been delineated on the 1:6000 scale map and 1:12,000 scale black and white aerial photographs which form the major product of this study. Those wetlands not delineated within the boundary lines have, in some cases, been indicated or "flagged" as areas where existing permit regulations definitions do not provide specific guidance on whether a permit would be required in that wetland. Other wetlands in the study area have been neither delineated nor flagged; these wetlands are under Corps authority, but discharges of dredged or fill material in these wetlands are authorized by nationwide permits (33 CFR 323.4).

The primary geophysical and hydrologic processes and features which have influenced wetland development in the Snohomish Basin are:

- Tidally influenced watertables
- Long term variability of water level
- Natural berm formation
- Point bar and gravel bar formation
- Oxbow lake formation

The two main ecological features are:

- Transition zones
- Succession

The determination of adjacent wetlands can be made by analysis of these factors wherever the influence of man-made structures is not significant.

VOLUME IV

SNOHOMISH ESTUARY WETLANDS STUDY

Delineation of Wetland Boundaries

Prepared for

U.S. Army Corps of Engineers
in accordance with
Contract No. DACW67-77-C-0070

by

Marc E. Boule, Principal Investigator, Co-Author
G. Bradford Shea, Principal Author, Co-Investigator

August 1978

AUTHORIZATION

This study was performed under Contract Number DACW67-77-C-0082 with the U.S. Army Corps of Engineers, Seattle District. This final report documents the field studies and supplements other study products (maps, photo-maps, and a photo-essay).

STUDY TEAM

The study team consisted of Andrew L. Driscoll (consultant), Marc E. Boulé (consultant), and G. Bradford Shea and Douglas J. Canning (Northwest Environmental Consultants, Inc.).

Driscoll provided project management and administration. Boulé was principal field investigator and co-author. Shea was principal author and special field consultant. Canning was general editor of the report and co-field investigator. Production staff included Ruth Pittman and Joellyn Shea.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

1. Wetlands boundaries in the Snohomish River Basin were delineated according to Army Corps of Engineers (Corps) definitions presented in Corps permit regulations (33 CFR 323.2). These definitions are based primarily on occurance of wetland vegetation and concepts relating the presence of such vegetation to conditions of soil saturation. The delineation of wetland boundaries defines to some degree a jurisdictional context for other portions of the Snohomish Estuary Weltands Study, of which this is a part.

2. Field investigations of the estuarine and riverine portions of the Basin were carried out during 1977 and 1978, coupled with analysis of color infrared and black and white aerial photographs of the area. These investigations and analyses led to the establishment of a recommended boundary line for "adjacent wetlands" as defined in Corps permit regulations (33 CFR 323.2(c)). Boundary lines have been delineated on the 1:6000 scale maps and 1:12,000 scale black and white aerial photographs which form the major product of this study.* Those wetlands not delineated within the boundary lines have, in some cases, been indicated or "flagged" as areas where existing permit regulations definitions do not provide specific guidance on whether a permit would be required in that wetland. Other wetlands in the study area have been neither delineated nor flagged; these wetlands are under Corps authority, but discharges of dredged or fill material in these wetlands are authorized by nationwide permits (33 CFR 323.4).

3. Often, natural factors or man-made structures influence the selection of areas to be defined as adjacent wetlands. Those wetlands meeting the criteria as "adjacent" are included within the delineated boundary, while uplands and other wetlands are not. The geophysical, ecological, and human factors influencing the Snohomish wetlands, discussed below in summary fashion, are intended as a guide for boun-

*Maps are available for review at Seattle District, U.S. Army Corps of Engineers.

dary map use. Mapping decisions and an expanded discussion of these factors can be found in the Results and Discussion section of this report.

4. The primary geophysical and hydrologic processes and features which have influenced wetland development in the Snohomish Basin are:

- Tidally influenced watertables
- Long term variability of water level
- Natural berm formation
- Point bar and gravel bar formation
- Oxbow lake formation

The two main ecological features are:

- Transition zones
- Succession

The determination of adjacent wetlands can be made by analysis of these factors wherever the influence of man-made structures is not significant.

5. Water tables adjacent to the Snohomish Estuary appear to be tidally influenced. This phenomenon frequently results in formation of wetlands at elevations or in places where they would not ordinarily be found. Since these conditions appear frequently in the lower Snohomish estuary, areas subject to this phenomenon are designated as "adjacent wetlands" if they are functionally related and in reasonable proximity to navigable waters. Reasonable proximity was determined on the basis of the existence of biological habitats which are an integral part of the estuary, or which are hydrologically connected.

6. Fluctuations in river level or in water table level over periods of many years may result in the presence of relict wetland or upland species established as a result of different conditions at an earlier time. In these cases, wetland determination is based on

present conditions, and conforms with regulation definitions (33 CFR 323.2), as those areas which would "normally support wetland vegetation."

7. Natural berms, point bars and oxbows are formed by river erosion and deposition patterns. Wetlands of varying types are often associated with these features, sometimes grading into upland vegetation. Wetlands associated with natural berms, point bars, or oxbows are considered to be adjacent wetlands only where a clearly functioning hydrologic connection with the river system exists or where these wetlands are in reasonable proximity to the river system and may be considered to be "bordering" or "neighboring" (33 CFR 323.2).

8. Transition zones are identified wherever gradual changes from wetlands to upland vegetation associations occur. These zones are mapped in locations where the lateral extent is discernable at a 1:6,000 or 1:12,000 scale. In most parts of the estuary, what little transition zone that occurs is generally an ecotone of mixed shrub swamp species and uplands species located between the high marsh and uplands communities. In the riverine area of the basin, the transition zone is usually marked by a shift in species dominance of water tolerant and non-water tolerant plants.

9. Ecological succession from marsh to shrub swamp to swamp occurs in the estuary. The swamps are clearly wetlands and are mapped as adjacent whenever a clear functional relationship with the estuary exists or where these areas are bordering the river system, but separated by a dike or other barrier. In the riverine areas, scattered brush-form trees succeed to a thicket, accompanied frequently by a gradual elevational change. Successional transition zones in the riverine area are not geographically stable. Over varying time periods they will migrate or be obliterated. The process of succession was considered in determining the location of boundaries which were mapped at their present location. Imperceptable annual boundary shifts can be expected in the

estuary. However, annual changes in riverine areas can be expected to be quite noticeable.

10. Actions causing man-made alterations to the Snohomish River system consist of:

- Placement of dredged or fill material
- Culvert and tidegate installation
- Drainage ditch construction
- Dike construction

These alterations have in most cases converted wetlands to uplands and in rare instances created adjacent wetland areas.

11. Deposition of dredged or fill material generally converts wetlands to upland systems. In some instances, peripheral wetlands creation may occur around such fills, due to drainage alterations. Filled areas known to previously contain wetlands are mapped as uplands. Peripheral wetlands, if functionally connected to the river or estuary are mapped as such. Drainage ditch systems behind nonfunctioning tidegates permit the continued existence of wetlands in many portions of the estuary. Where tidally influenced wetlands occur behind dikes due to open tidegates or culverts, these functionally connected wetlands are mapped as adjacent wetlands.

12. Dikes are a major feature both of the estuary and the upriver basin. Due to the extensive diking, many wetland - upland transitions in the Snohomish Basin occur abruptly, within a lateral distance of a few feet. These abrupt transitions are mapped as a single line. In places, dikes occur in a double dike configuration, with the older dike lower or decayed, and water-ward of the newer, functional dike. The older dike is mapped as wetland in cases where it is surrounded by wetland vegetation, even when a thin strip of upland vegetation remains on the dike crest. A few dikes are permeable to water seepage. Functionally connected wetlands behind these dikes are mapped as adjacent wetlands, as are wetlands immediately behind non-permeable dikes.

I. INTRODUCTION

1. The Seattle District, U.S. Army Corps of Engineers (Corps), has conducted a wetlands review of the Snohomish Estuary and adjacent areas under the authority contained by Corps permit regulations (33 CFR 320.4(b)). By providing a comprehensive factual base of information, the Snohomish Estuary Wetlands Study (SEWS) will assist the Seattle District in administering Corps' regulations. This report represents a portion of that study, the delineation of wetlands boundaries in the estuary and river basin as defined in regulations (33 CFR 323.2) pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and the Clean Water Act of 1977 (PL 95-217).

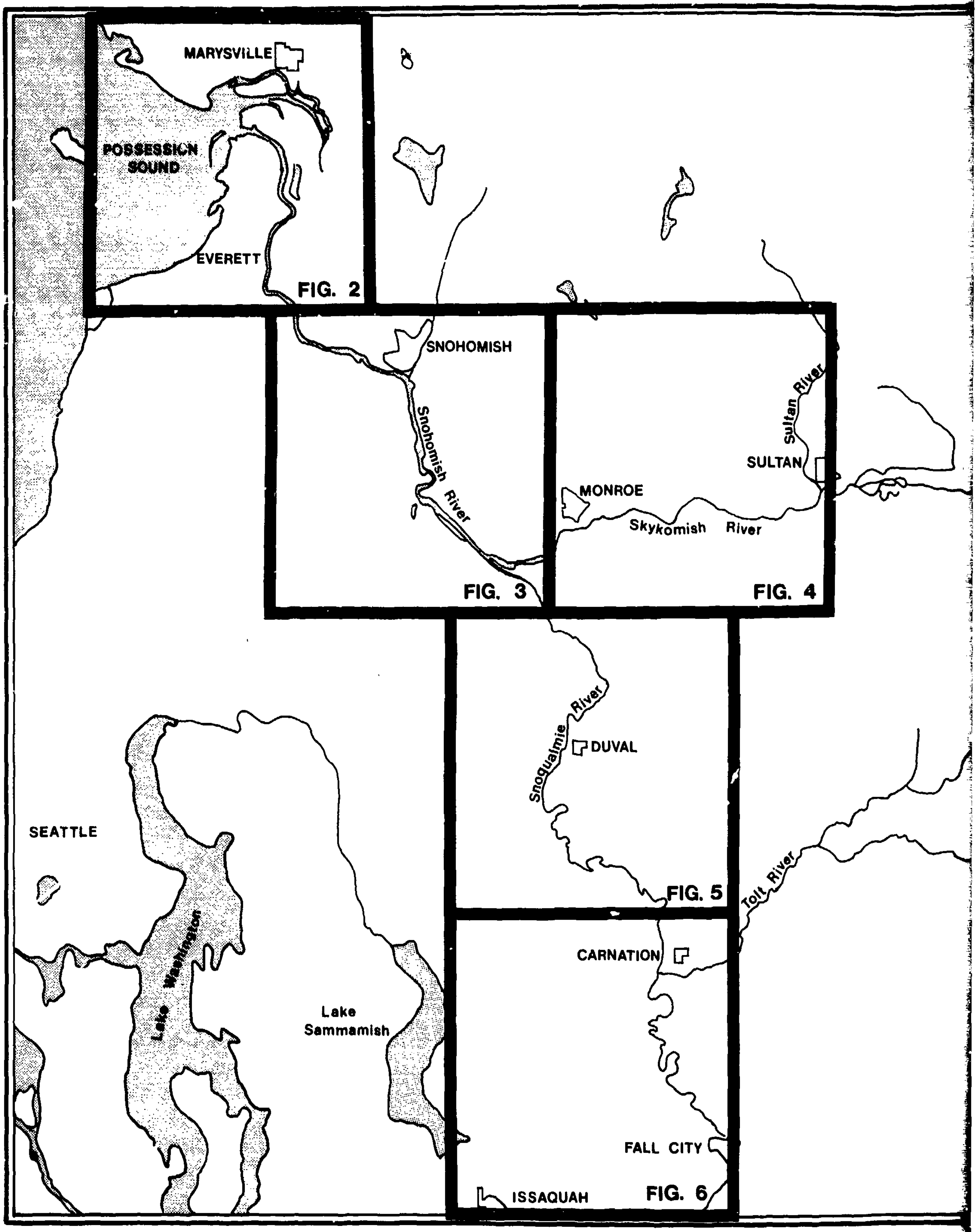
2. For the purposes of this portion of the SEWS project, the study area is defined to include the waterbodies listed below:

- Port Gardner
- Tulalip Bay
- Quilceda Creek (south of Marine Drive)
- Snohomish River and Estuarine Sloughs
- Non-tidal portions of the Snohomish, Skykomish and Snoqualmie Rivers upstream to the upper limits of navigable waters of the United States

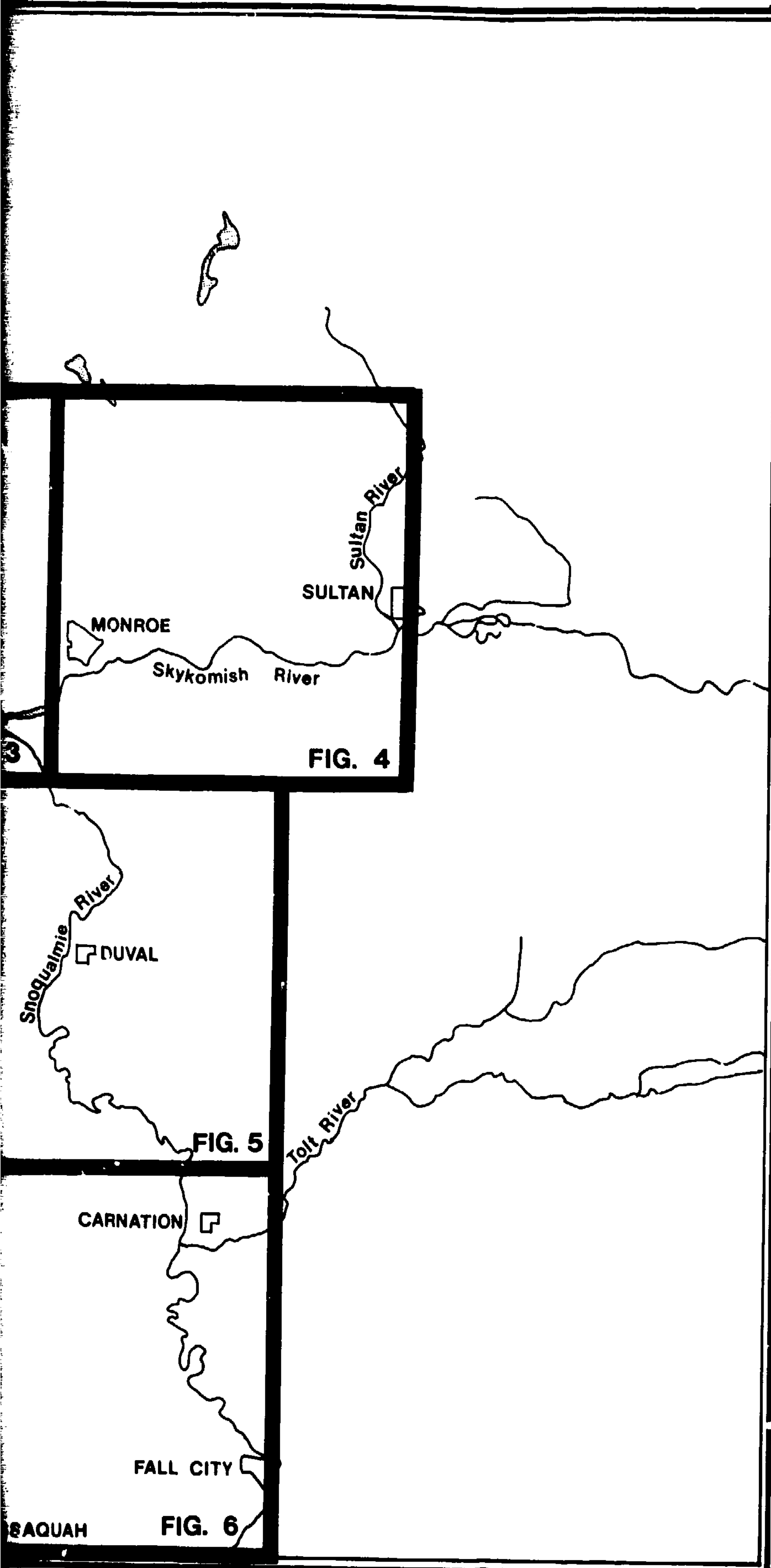
as well as all wetlands adjacent to these water bodies. The study area (Figure 1) is keyed to five maps (Figures 2 - 6) which provide a detailed view of segments of the river basin.

A. AUTHORITIES

3. Under Section 10 of the Rivers and Harbors Act of 1899, the Corps has regulatory authority over structures or work in navigable waters of the United States. These activities include dredging, filling, and construction (see Appendix B). Until 1968 the Corps' regulatory program under Section 10 was administered only "to protect navigation and the navigable capacity of the nation's waters" (Fed. Reg. 42:138). Since 1968, however, the Corps has considered other factors in evaluating


MARYSVILLE
POSSESSION SOUND
EVERETT
FIG. 2
SNOHOMISH
Snohomish River
FIG. 3
Sultan River
SULTAN
MONROE
Skykomish River
FIG. 4
Snoqualmie River
DUVAL
FIG. 5
SEATTLE
Lake Washington
Lake Sammamish
Tolt River
CARNATION
FALL CITY
ISSAQUAH
FIG. 6

1



KEY MAP FOR THE SNOHOMISH RIVER BASIN

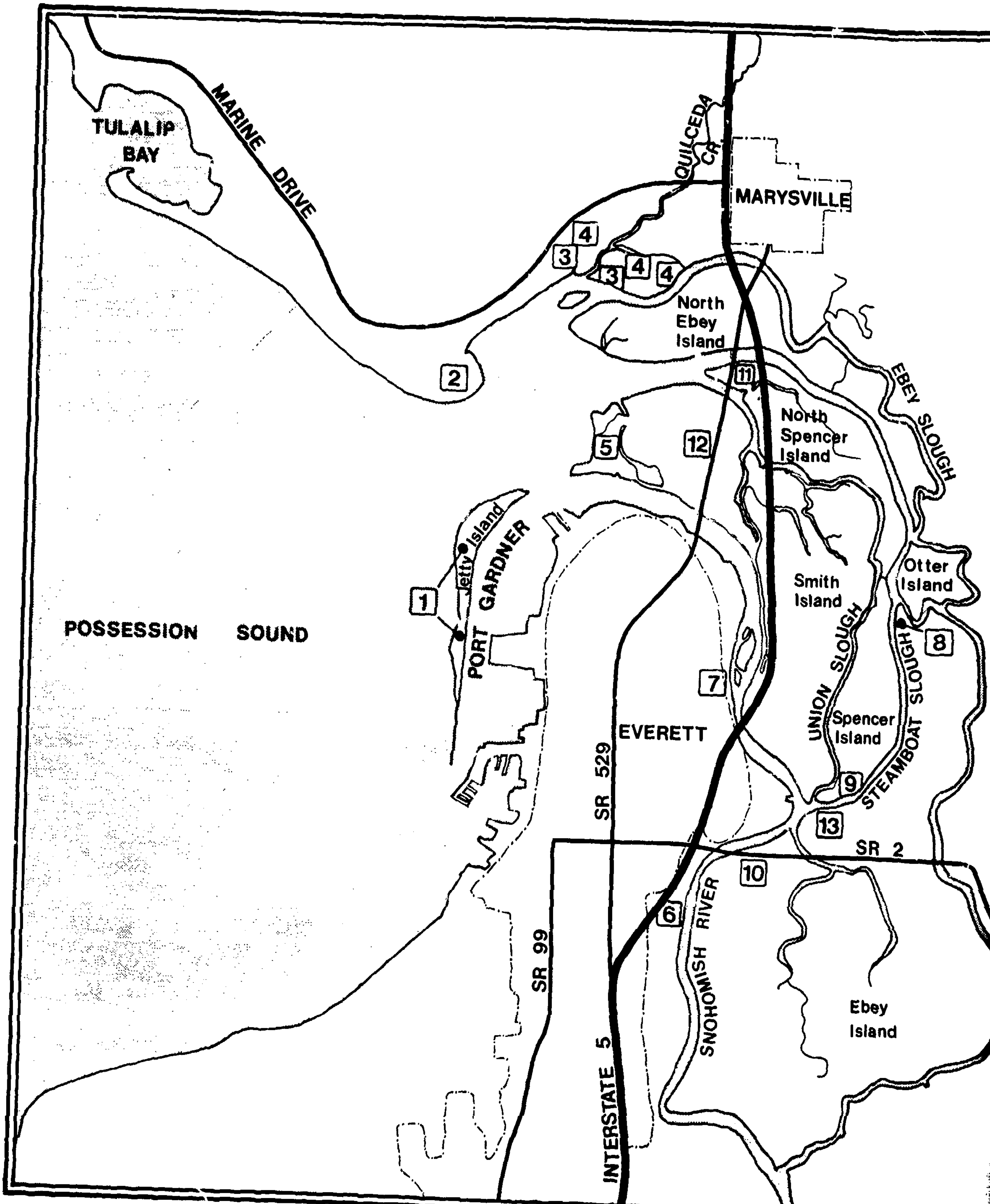
FIGURE 1

N

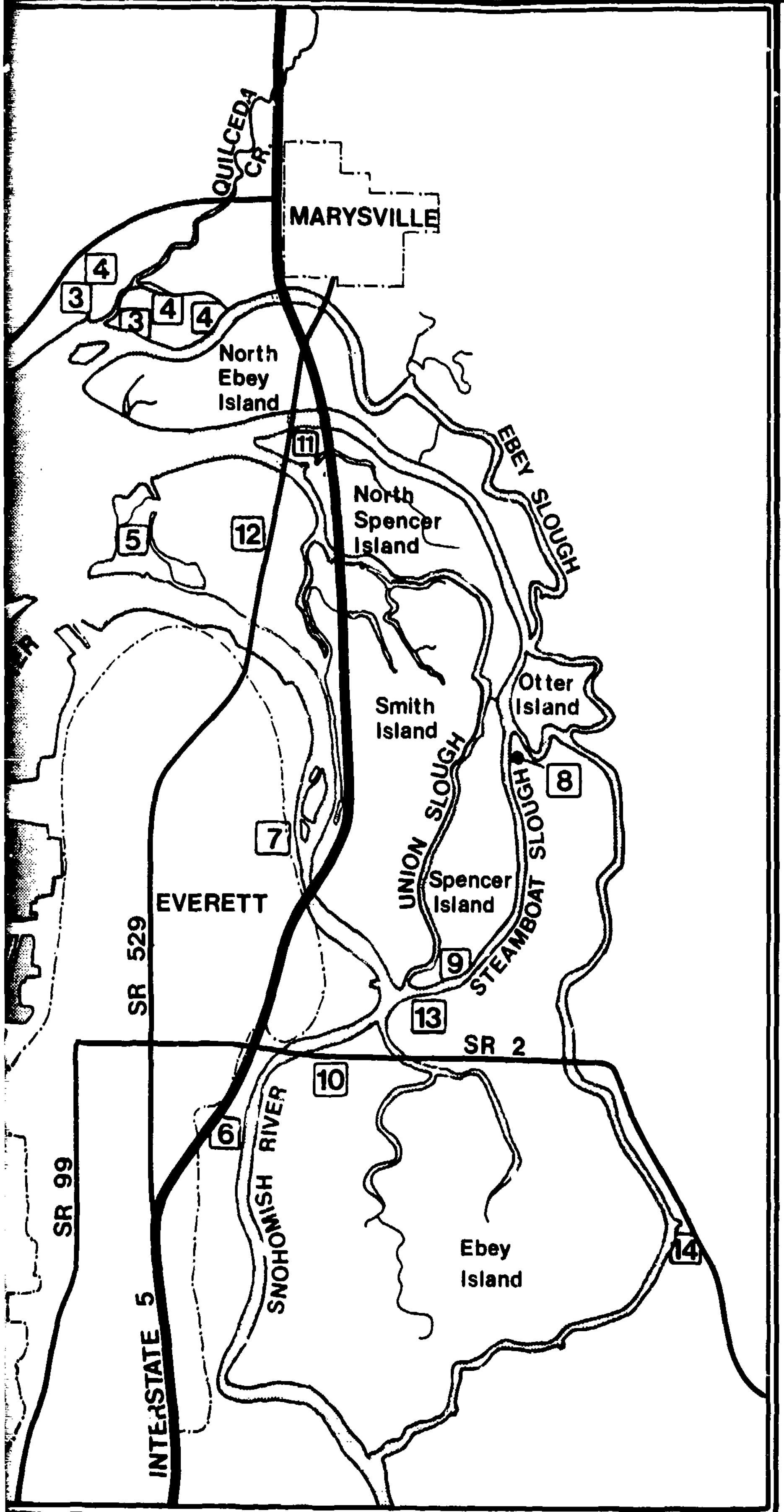
Scale in Miles

0 5 10

SNOHOMISH ESTUARY WETLANDS STUDY



TULALIP BAY
MARINE DRIVE
QUILCEDA CR.
MARYSVILLE
North Ebey Island
EBEY SLOUGH
North Spencer Island
POSSESSION SOUND
Jetty Island
PORT GARDNER
Otter Island
Smith Island
UNION SLOUGH
STEAMBOAT SLOUGH
Spencer Island
EVERETT
SR 529
SR 2
SR 99
INTERSTATE 5
SNOHOMISH RIVER
Ebey Island
1
2
3
3
4
4
4
5
6
7
8
9
10
11
12
13



SNOHOMISH ESTUARY

FIGURE 2

Legend

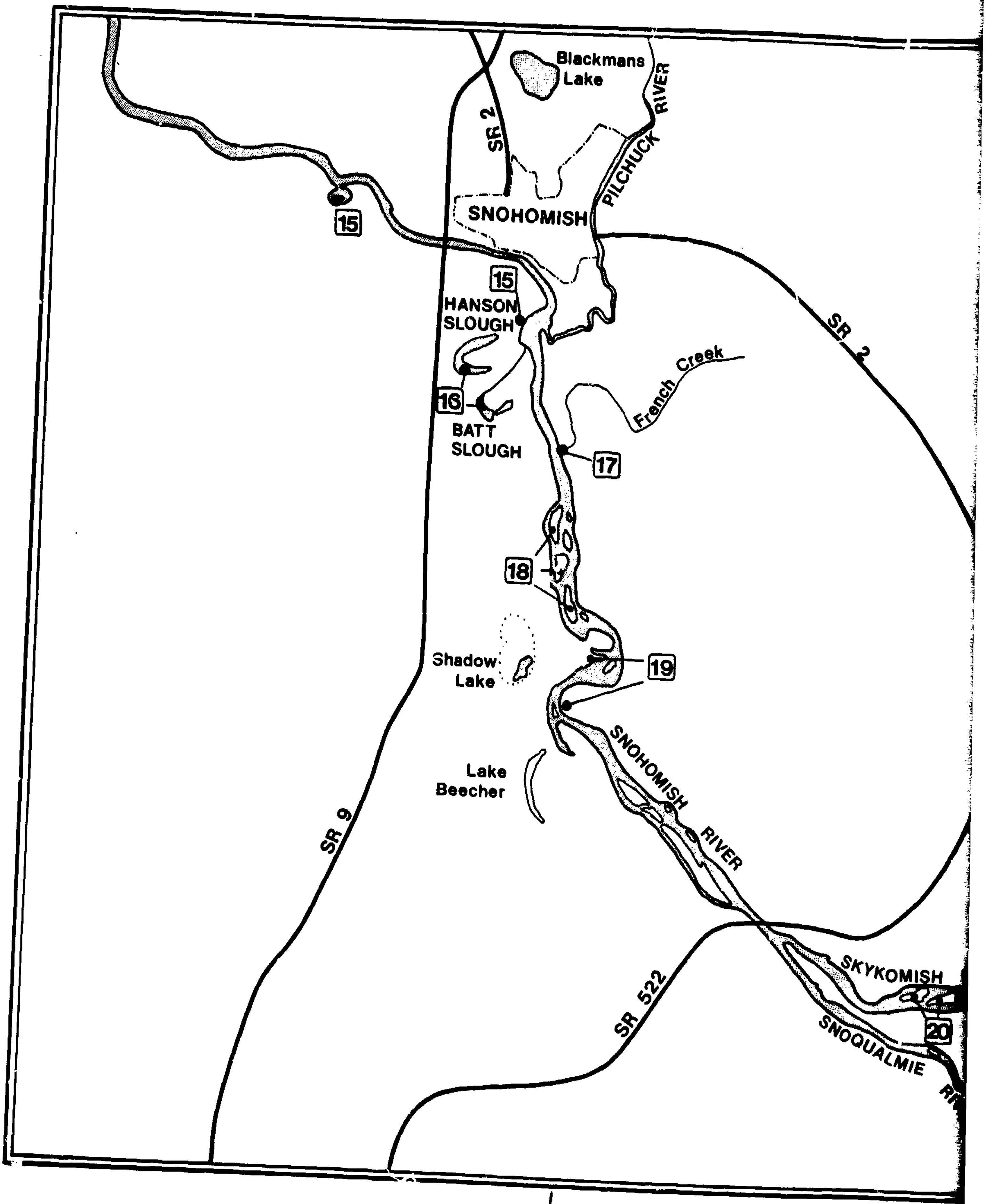
1. Jetty Island Wetlands
2. Priest Point Wetlands
3. Quilceda Cr. (Marine Wetland)
4. Quilceda Cr. (Fresh Wetland)
5. West Smith Island
6. Lowell Wetlands
7. Water Level Fluctuation
8. Natural Berm
9. Natural Berm
10. Highway 2 Wetlands
11. Highway Fill Wetlands
12. Drainage Ditch Wetlands
13. Permeable Dike
14. Permeable Dike

N

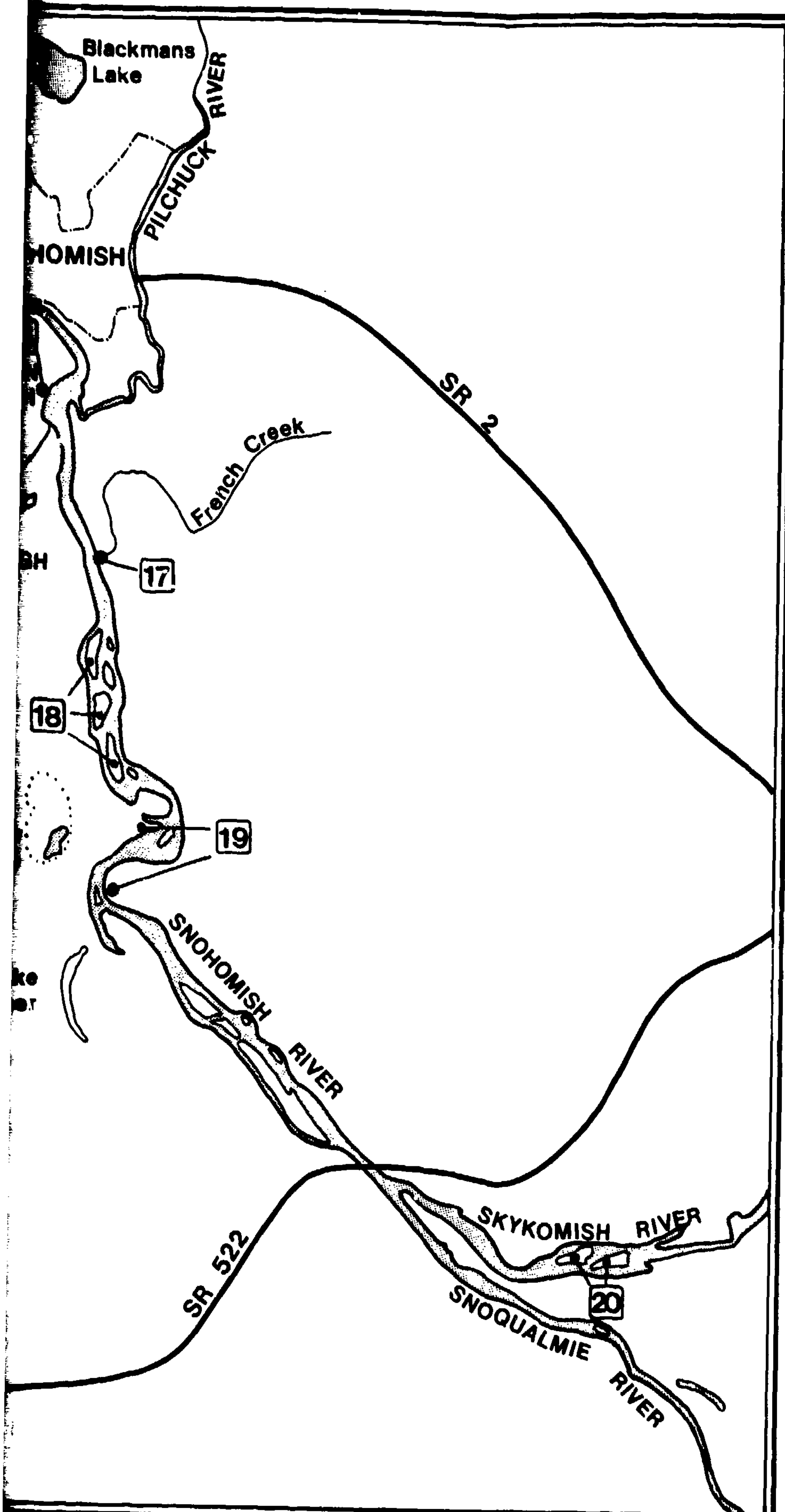
Scale in Miles

0 ½ 1 2

SNOHOMISH ESTUARY WETLANDS STUDY



Blackmans Lake
SR 2
PILCHUCK RIVER
SNOHOMISH
15
15
HANSON SLOUGH
16
BATT SLOUGH
French Creek
17
SR 2
18
Shadow Lake
19
Lake Beecher
SNOHOMISH RIVER
SR 9
SR 522
SKYKOMISH
20
SNOQUALMIE



SNOHOMISH RIVER AND CONFLUENCE

FIGURE 3

Legend

- 15 Tidal Marsh
- 16 Oxbow Lakes
- 17 Flood Gate
- 18 Gravel Bars
- 19 Point Bar Complex
- 20 Gravel Bars

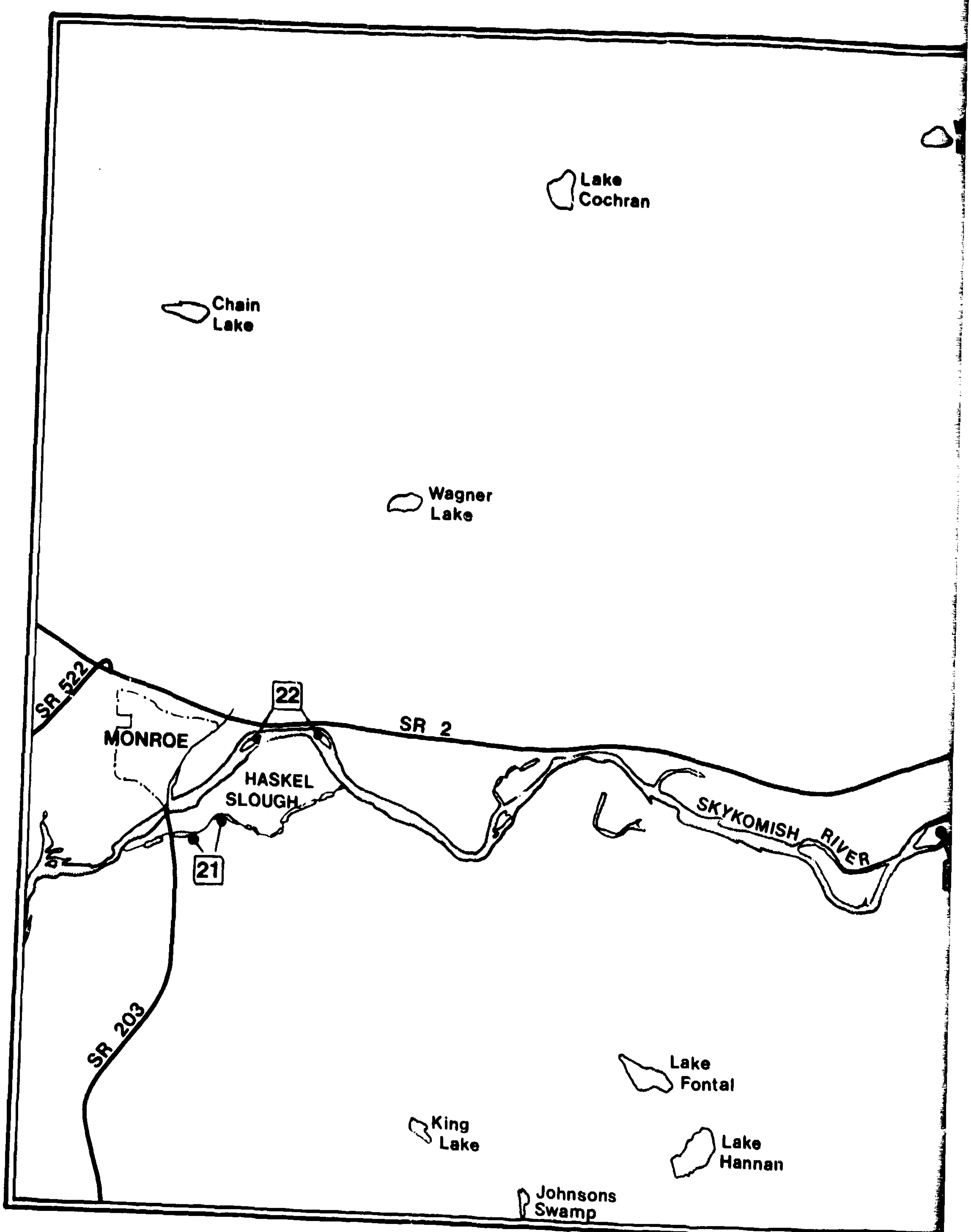
N

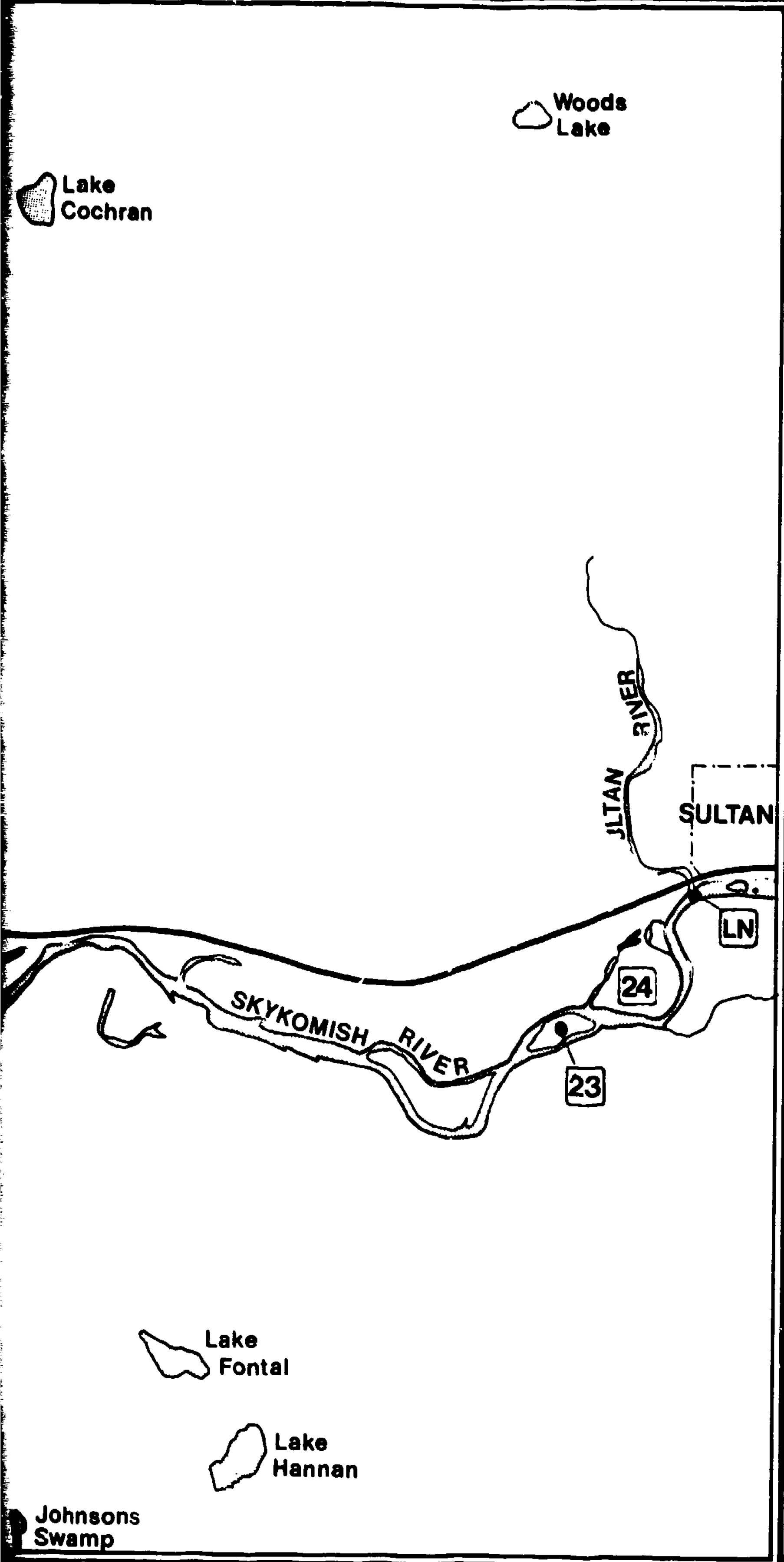
Scale in Miles

0 ½ 1 2

SNOHOMISH ESTUARY WETLANDS STUDY

1 2


Lake Cochran
Chain Lake
Wagner Lake
SR 522
22
MONROE
SR 2
HASKEL SLOUGH
SKYKOMISH RIVER
21
SR 203
Lake Fontal
King Lake
Lake Hannan
Johnsons Swamp

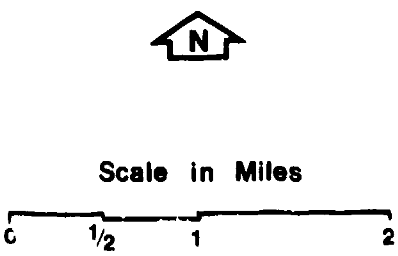


SKYKOMISH RIVER

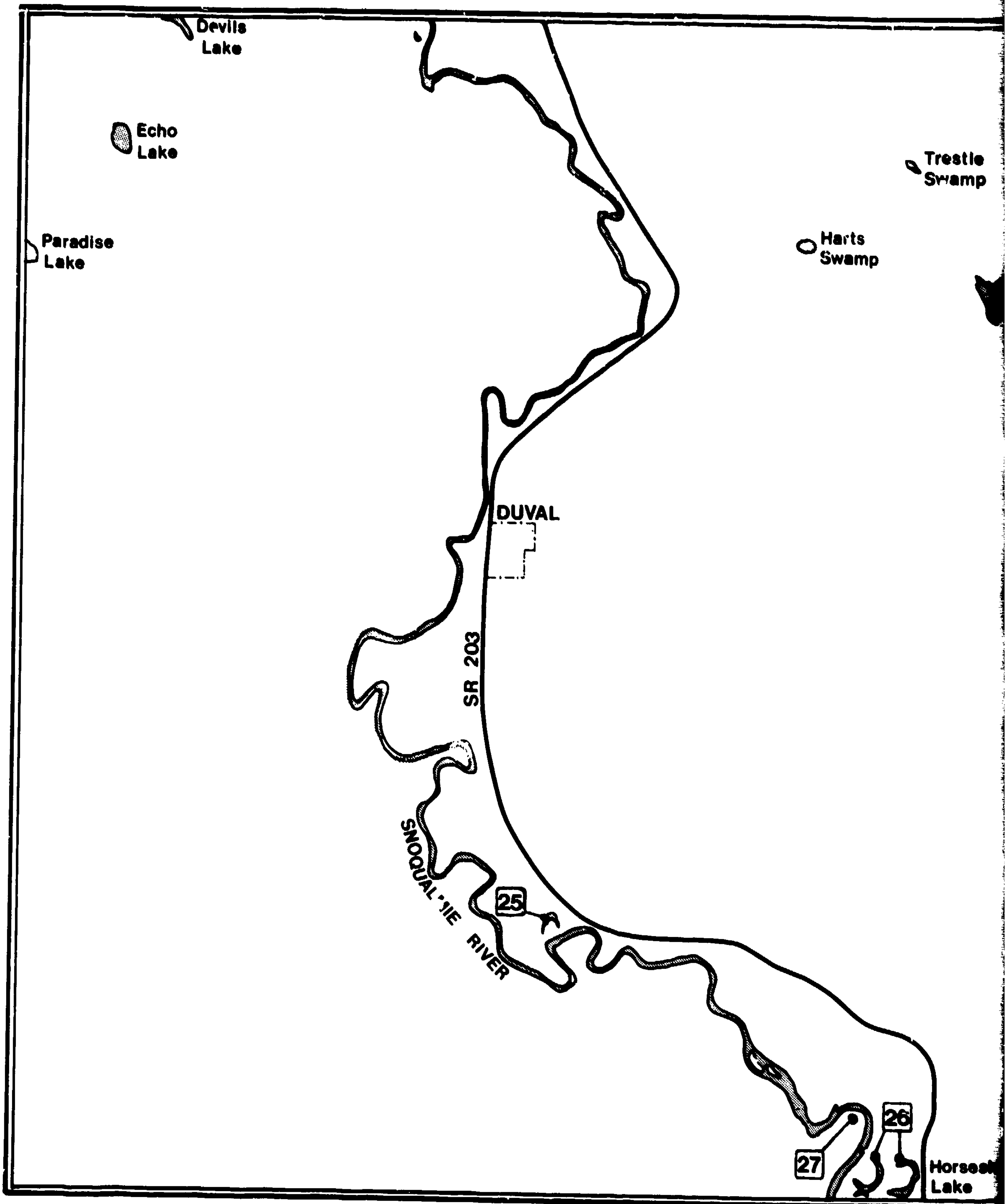
FIGURE 4

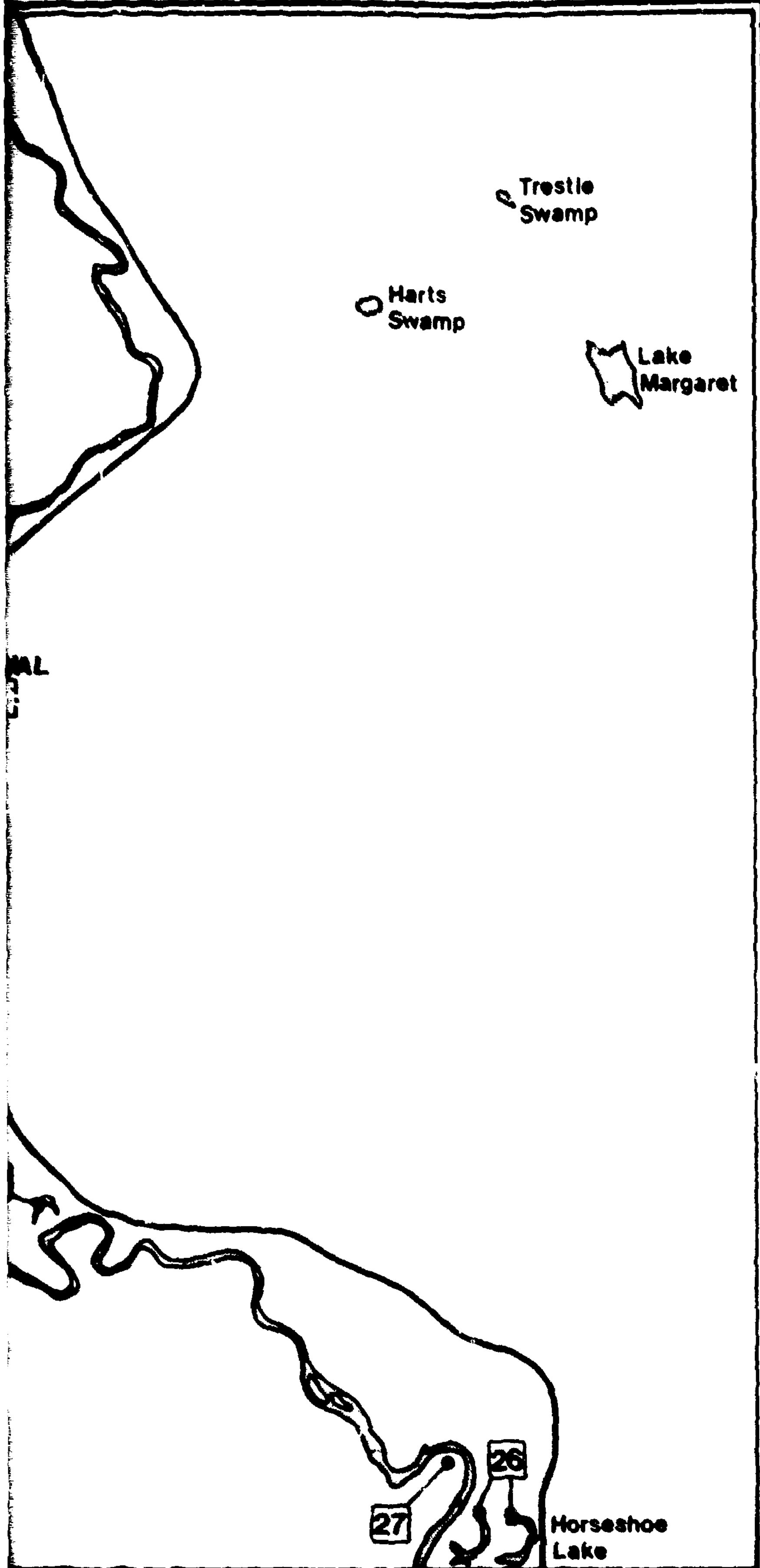
Legend

- 21 Back Slough
- 22 Gravel Bars
- 23 Successional Gravel Bar
- 24 Successional Point Bar
- LN Limits of Navigation



SNOHOMISH ESTUARY WETLANDS STUDY


Devils Lake
Echo Lake
Paradise Lake
Trestle Swamp
Harts Swamp
DUVAL
SR 203
SNOQUAL'IE RIVER
25
26
27
Horses
Lake



SNOQUALMIE RIVER —NORTH SEGMENT

FIGURE 5

Legend

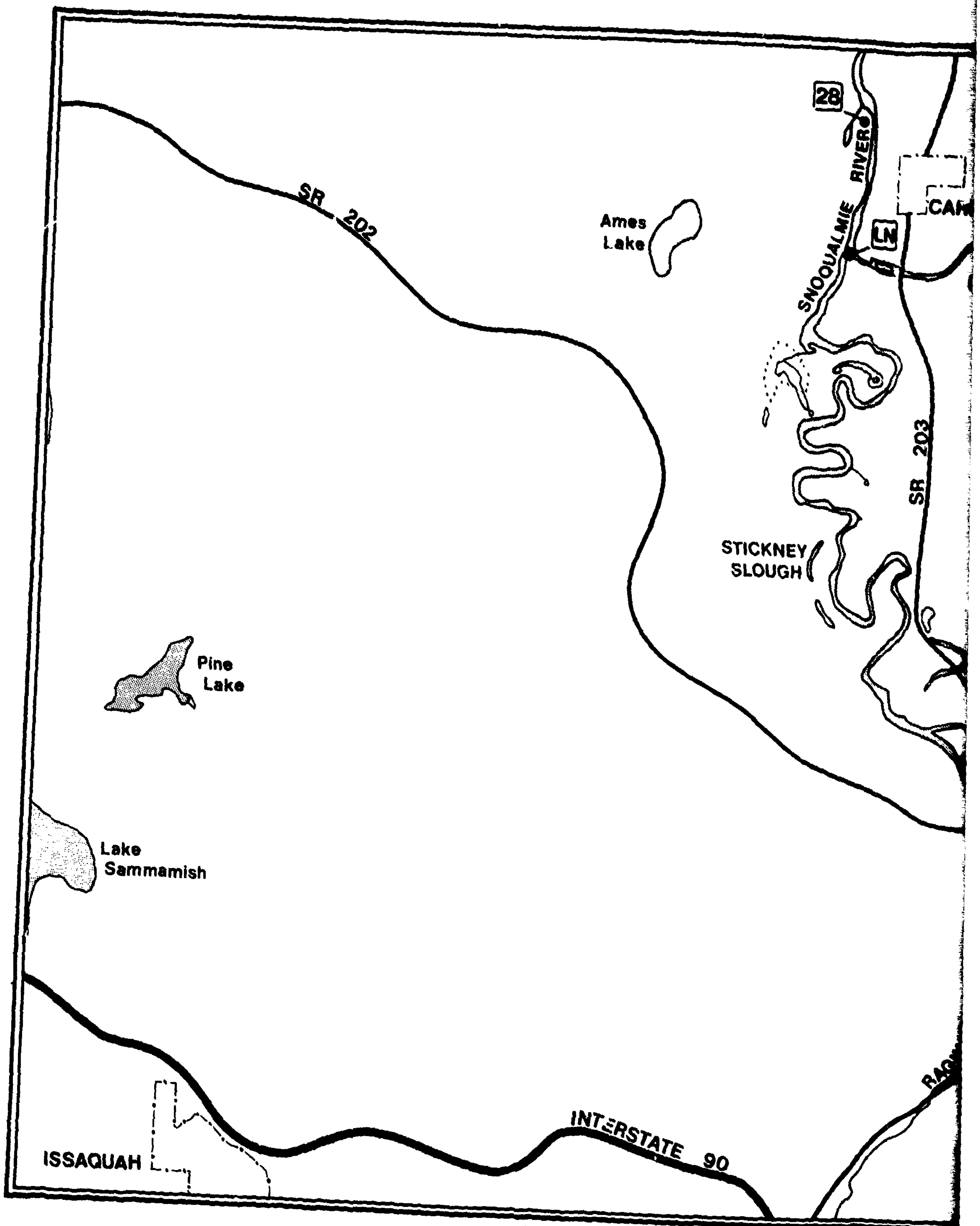
- 25 Oxbow Lake
- 26 Oxbow Lakes
- 27 Point Bar

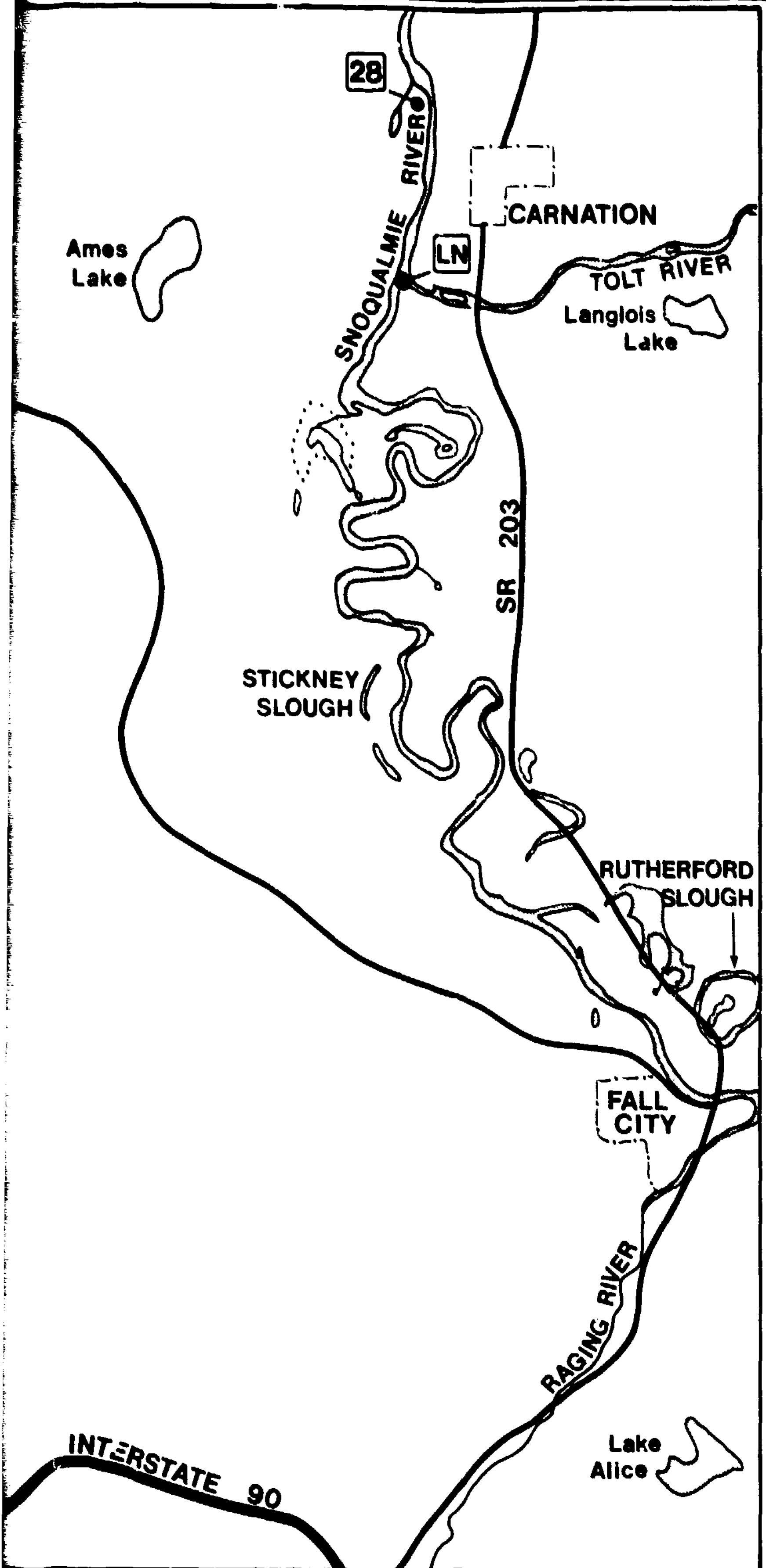
N

Scale in Miles

0 ½ 1 2

SNOHOMISH ESTUARY WETLANDS STUDY


28
SNOQUALMIE RIVER
CAI
LN
SR 202
Ames
Lake
SR 203
STICKNEY
SLOUGH
Pine
Lake
Lake
Sammamish
INTERSTATE 90
ISSAQUAH



SNOQUALMIE RIVER —SOUTH SEGMENT

FIGURE 6

Legend

28 Point Bar

LN Limits of Navigation

N

Scale in Miles

0 1/2 1 2

SNOHOMISH ESTUARY WETLANDS STUDY

permit applications for activities in navigable waters, including fish and wildlife, conservation, pollution, aesthetics, ecology, and the public interest. These additional factors reflect the increased awareness of environmental values at both public and governmental levels.

4. With the enactment of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) the Corps was assigned regulatory authority over the discharge of dredged or fill material in navigable waters of the United States. On July 25, 1975, the Corps published interim final regulations in which the concept of wetlands was included in the navigable waters of the United States (Fed. Reg. 42:138).

5. On July 19, 1977, the Corps published regulations for administering Section 404 and other permit programs. In these regulations the definition of "waters of the United States" is divided into the following categories:

1. Territorial seas, with respect to the discharge of fill material.
2. Coastal and inland waters, lakes, rivers and streams that are navigable waters of the U.S., including adjacent wetlands.
3. Tributaries to navigable waters of the U.S., including adjacent wetlands.
4. Interstate waters and their tributaries, including adjacent wetlands.
5. All other waters of the United States not identified above such as isolated wetlands and lakes, intermittent streams, and other waters that are not part of a tributary system to interstate waters of the U.S., the degradation or destruction of which could affect interstate commerce.

6. The term "adjacent" used in conjunction with wetlands means not only contiguous, but also neighboring areas in reasonable proximity but physically "separated by . . . man-made dikes or barriers, natural river berms, beach dunes and the like . . .(33 CFR 323.2(d)). "Wetlands" mean those areas that are "inundated or saturated by surface or ground-

water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 323.2 (c)). It should also be noted that in unvegetated areas, the Corps jurisdiction extends to the mean higher high water line (33 CFR 323.2(h)).

7. The Snohomish Estuary Wetlands Study, begun in 1977, is primarily concerned with Category 2 waters since wetlands of the estuary fall predominantly into that category. Study area limits are at the town of Sultan on the Skykomish River (Sultan River confluence) and at the town of Carnation on the Snoqualmie River (Tolt River confluence).

B. OBJECTIVES

8. The objectives of the overall Snohomish Estuary Wetlands Study (SEWS) are:

- To develop a classification and map of wetlands in study area.
- To delineate the wetlands boundaries as interpreted from Corps of Engineers' Section 404 permit regulations.
- To develop wetland evaluation guidelines based on relative biological importance of various wetland types and to assess the impacts of proposed activities in the Snohomish Estuary.

9. This delineation of wetland boundaries in the study area (Figure 1) was undertaken to meet the second objective. Initially, it was necessary to select a methodology for wetland transition zone delineation based on Corps regulations and a firm ecological framework. The methodology was then utilized through field studies to produce maps, photographs and descriptions of the wetland boundary. The study products are:

- This report on wetland boundaries.
- *A set of seven maps (1:6000 scale) delineating wetland boundaries in the Snohomish Estuary.
- *A set of 1:12,000 scale black and white aerial photographs of the Snohomish Estuary and navigable river waters, with the wetland boundaries delineated.
- *A series of photographs and captions illustrating some typical wetland vegetation in the estuarine and riverine portions of the Basin.

10. A discussion of approaches for developing these products is presented in the following section.

C. APPROACHES TO APPLICATIONS OF REGULATIONS

11. In order to achieve a reasonably uniform application of Corps' regulations, it is necessary that terms such as "prevalence," "typically adapted to" and "saturated soil conditions" be defined nationwide. Wetland vegetation, however, differs widely between geographical regions and often differs somewhat between estuaries in the same region due to variation in historical development, tidal regime, salinity regime and existing substrate. Since each Corps District must identify areas in which permits will be required, the national guidelines must be adapted to particular estuaries and other navigable waters.

12. There are several possible approaches for relating the regulatory definition of wetlands to a given estuary. These include:

- Identification of wetland soil conditions or tidal inundation.
- Identification of certain plant species indicative of wetland soil conditions.
- Identification of vegetative associations characteristic of wetland soil conditions.

*Maps and photographs are available for review at the Seattle District Office, U.S. Army Corps of Engineers.

13. Several physical parameters have been identified in the literature as indicators of wetland conditions. These include soil saturation, soil salinity, and frequency of inundation. These parameters have in some cases been closely correlated to wetland vegetation (see for instance McIntire et al. 1975, Boon et al. 1976, Frenkel and Eilers 1976). Distribution of these parameters could be used to delineate the extent of wetlands, Alternatively, an indicator species approach has been used in some studies (NOAA 1975). Certain plant species only grow and compete in saturated or saline soils. The presence of these "indicator species" can be used to delineate the extent of wetlands. A third approach uses a community of plant species which collectively are characteristic of wetland soil conditions. Various aggregations of species form vegetation associations indicative of the soil salinity, saturation and other parameters associated with wetlands. The dominance of this association or portions thereof can be used to delineate the extent of wetlands.

14. Each of these approaches has advantages and disadvantages. Reliance on physical parameters, such as soil salinity or inundation frequency, provides a quantitative means which can be easily stated, and excludes the complexity inherent in biological systems. At some point, however, these quantitative measures must be correlated to biological systems. Such correlation involves extensive measurements and is very time consuming. An indicator species is often easy to identify and may strongly suggest certain specifics regarding soil conditions where it is found; however, it will not necessarily be found everywhere those soil conditions exist. In addition, presence of a single indicator species may reflect a local anomaly in soil conditions or species tolerance, and therefore may not accurately delineate wetland conditions. The use of vegetative associations as indicators of wetland conditions may not be as quantitative as the other approaches described; however, it is a practical and defensible method for delineating wetlands as defined in 33 CFR 323.2. In addition, while some wetlands species may be found in an upland, wetland vegetation associations will not be found in uplands.

15. Given the necessity for extensive and time-consuming physical measurements to determine physical soil parameters, and the errors inherent in the indicator species approach, the vegetation association method was selected. The approach was found to provide a rapid means for determining the extent of wetlands under Corps jurisdiction within both estuarine and riverine areas.

16. In coastal wetlands, as in other ecosystems, vegetative associations are not, however, always defined by a sharp boundary. In some cases a transition zone or ecotone exists between wetland and upland, where some plant species from both habitats survive. Recognition of such transition zones serves to delimit the general location of the wetland-upland boundary, while making the precise position of the boundary somewhat diffuse.

17. The wetland-upland transition is the last stage of a larger transition pattern from open water to upland. The accompanying zones of wetland vegetation have been described in various sources (Odum 1971, Clark 1974). Usually the pattern proceeds in estuaries from submerged grasses (aquatic zone) through a variety of emergent plants, often rushes and sedges (emergent or intertidal zone) and ending with a high marsh zone which then grades into true upland vegetation (Figure 7). This upland vegetation seldom invades far into the true wetlands due to its inablility to withstand saturated soil conditions or (in the estuary) salt stress to which wetland plants are subject. In riverine situations, the transition pattern is somewhat different in appearance, but still represents a gradation in plant tolerance and competitive ability.

18. The zonation patterns in wetlands are not always simple, however. In particular the complex physical and biological interactions present in a transition area often result in unpredictable effects. Wetlands can be found in which natural factors cause discrepancies or even reversals in the normal patterns. Small changes in

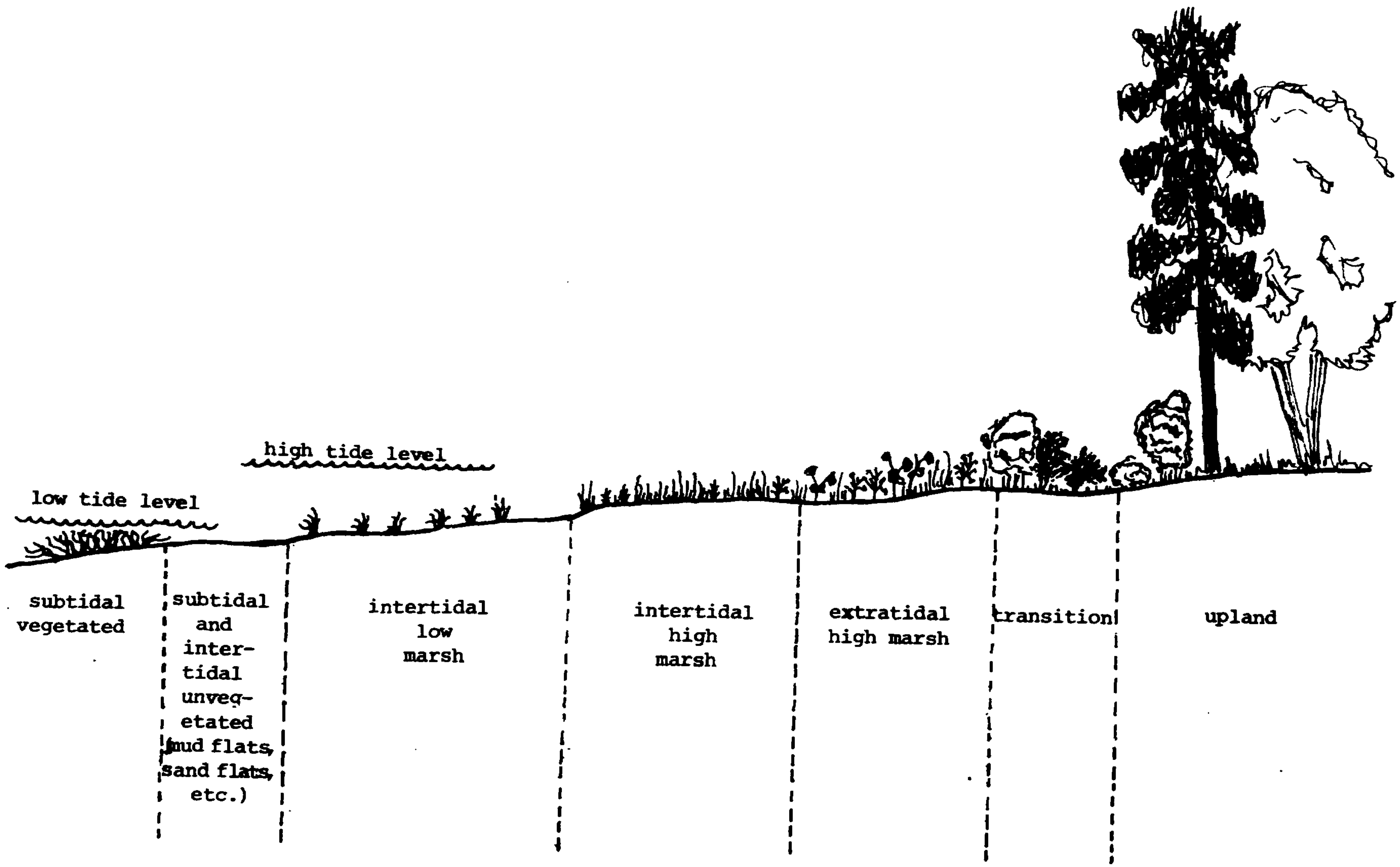


FIGURE 7. Idealized Marsh Zonation

substrate, slope, elevation or hydrology may cause anomalous patterns which are not easily explainable from a cursory site inspection. Such variations present certain difficulties in interpretation of wetland boundaries. These difficulties must be recognized and understood in order to accurately delineate wetland-upland boundaries.

D. PREVIOUS RESEARCH

19. The U.S. Fish and Wildlife Service (USFWS) began identifying the value of wetlands as early as 1953 (Martin et al. 1953), and continued that work with a nationwide wetland inventory (Shaw and Fredine 1956). This inventory, known as Circular 39, has been the basis for much of the wetlands research which has been carried out since that time. In recent years, however, the shortcomings of Circular 39 have become apparent and USFWS is now developing a more comprehensive wetland classification (Cowardin et al. 1977) to be used with a new wetland inventory.

20. In the Northwest, comprehensive wetlands research began in Oregon with the works of Jefferson (1975) and Eilers (1976). Both of these studies identified and classified wetland types in Oregon. Additionally, Eilers (1976) did extensive research into productivity, soil characteristics, inundation frequency and other aspects of Oregon wetlands. Recently, the Washington State Department of Game has mapped habitat types in the Snohomish Estuary as a part of the SEWS project (Burrell 1978).

21. Since the enactment of FWPCA several studies have been carried out to determine wetland boundaries and their correlation to various physical parameters. The pilot study for much of this research was conducted by the National Ocean Survey (NOAA 1975 p. 1) to:

- "Investigate the relationship between tidal datums and upper coastal marsh vegetation."
- "Compute the frequency on inundation for various elevations within the marsh."

This study was carried out at several locations around the United States. The Snohomish River was chosen as representative of the Northwest (Columbian) Region.

22. The NOAA study was followed by similar but more intensive work in Virginia (Boon et al. 1976) and Oregon (Frenkel and Eilers 1976). A Washington project (Northwest Environmental Consultants 1977) analyzed some of the same questions under the auspices of the Washington State Department of Ecology.

23. For a more comprehensive review of wetlands research, see Appendix A.

II. METHODS

A. INTRODUCTION

1. This study was carried out between August and November, 1977, in the Snohomish Estuary (Phase I), and between May and August, 1978, on the Snohomish, Skykomish, and Snoqualmie rivers (Phase II). Field investigations were performed from 28 September to 31 October 1977 in the estuary, and from 31 May to 18 July 1978 on the rivers. Salt wedge salinity measurements were taken in estuary waters to define the limits of influence of saline Puget Sound waters. Aerial photographs and various maps were used to assist in identification and delineation of wetland areas. Since both land and water access were necessary to approach all the areas considered, a power boat, canoe, and motor vehicle were all used in the course of the study. Observations were recorded directly on aerial photos and/or maps in the field and later transferred to the final product aerial photographs and maps. Typical plant species and communities were documented photographically. The study area is shown in Figures 1 through 6.

2. Determination of adjacent wetland boundaries was done in conformance with revised Corps regulations published 19 July 1977 under section 404 (PL 92-500) authorities. In particular, these regulations define "Wetlands" as:

> . . . those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevelance of vegetation typically adapted for life in saturated soil conditions. (33 CFR 323.2 (c))

The term "adjacent" is defined in the regulations as:

> . . . bordering, contiguous, or neighboring. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes and the like are "adjacent wetlands." (33 CFR 323.2 (d))

A preamble (42 Federal Register 138) to the Corps regulations of 19 July 1977 discusses the history and interpretation of the Section 404 regulatory program. In discussing the limits of Federal jurisdiction the statement is made that:

> . . . the landward limit of Federal jurisdiction under Section 404 must include any adjacent wetlands that form the border of or are in reasonable proximity to other waters of the United States. . . (42 Federal Register 138, Page 37128).

3. Upon initiating the study, it was determined that for purposes of delineating adjacent wetlands in the field, an adjacent wetland must be both biologically and hyrdrologically related to waters of the United States. Furthermore, fieldwork was based on the premise that the hydrologic relation must be clearly evident. Such an interpretation was based on the wetland definitions in the 25 July 1975 Interim Final Regulations. This interpretation for identification of adjacent wetlands was used throughout the field studies in both estuarine and riverine areas.

4. Ultimately, a refined interpretation of field criteria for determing adjacent wetlands was developed based on guidance of the 19 July 1977 regulations. This interpretation emphasizes biological interaction and defines more clearly the term "adjacent." In view of this refined interpretation, there are probably wetlands in the study area (particularly in the estuary) that would qualify for inclusion within the limits of Corps jurisdiction. The most obvious candidates for potential inclusion are identified on the aerial photograph boundary maps and indicated as such.

5. In both the estuarine and riverine portions of the study area it was necessary to determine the vegetation associations characteristic of wetlands and then to identify the boundaries and transitions of those associations. Wetland associations were determined on the basis of qualitative estimates of cover dominance, number dominance, and biomass dominance.

B. PROCESS FOR IDENTIFICATION OF WETLANDS AND WETLAND BOUNDARIES

6. The identification and delineation of wetland boundaries involves a clear understanding of the physical and biological processes that dominate within wetlands. The detailed characteristics of these processes may vary from region to region, requiring the investigator to acquire local background in order to evaluate specific wetland sites. This would include review of any work done in the area such as drainage basin planning, flood control reports, previous environmental impact assessments, and academic studies. From this review, the investigator may gain additional insight as to the types of wetlands and adjacent wetlands which might be present, and where they might occur within the particular study area. In this study several reconnaissance trips provided an overview of the study area prior to initiation of mapping.

7. The overview served several functions. First it allowed study team members a chance to discuss and agree on definitions of terms as they applied to this particular study area. Second, it enabled the field investigators to identify potential wetland areas. Finally, it provided information on accessability to the various areas under study.

8. The following discussion identifies the various wetland characteristics that were considered in delineating wetland boundaries. Following that is a list of questions that were asked in order to determine the wetlands status at each site considered.

9. Wetland plants are defined as being ". . . typically adapted to saturated soil conditions" (33 CFR 323.2 (5)(c)). These hydrophytes* are most commonly associated with, but not limited to, wet substrates. However, some non-hydrophytes are extremely tolerant of saturated soils, although they are more common in mesophytic (uplands) environments.

---

* Hydrophytes: Plants adapted to and dependent upon a wet (soil) environment.

Thus, any vegetation association must be assessed not only as to the presence of hydrophytic species, but also as to the various physical conditions that control their presence.

10. Physical characteristics of the substrate affect the movement of water through the soil, and therefore affect the local water regime. For example, porous, sandy soils may be drained of water quickly if the source is depleted, but they also quickly absorb available water. In contrast, clay and silt substrates retain water longer after the source has been removed, but they also absorb water more slowly. In addition, the capillarity of a substrate, its ability to draw water upward from the water table, is a function of grain size. Thus, the response of soil saturation to a fluctuating water table will vary with soil characteristics.

11. Ground and surface water fluctuation is a normal response to variations in source water regime. In marine and estuarine situations fluctuation is controlled predominantly by the tides. In rivers, rainfall and snow melt, which control runoff and discharge, are the most important factors. Thus, water table fluctuations caused by tides or discharge, may result in variations in soil saturation.

12. As mentioned, river flow varies with season, with maximum flows in winter and spring, and minimum flows in late summer. Species and cover dominance within a vegetation association may also vary with season. This may reflect seasonal growth patterns and/or a fluctuating water table. In either case, the result is a plant community whose character changes through the seasons.

13. Finally, plant communities also undergo changes in composition over the long term. Succession is the gradual change in prevalent species in an areas as a result of changes in the local environment. These changes are brought about in part by the present inhabitants of the area. In aquatic or riparian habitat types the present vegetation often traps sediment; thus raising substrate elevation and creating a local

environment more suitable to other species.

14. Identification of wetlands and wetland boundaries requires not only an understanding of the processes, but also a recognition of their expression in the location and region under consideration. In evaluating the wetland status of an area, each process and its relation to the present habitat type must be considered.

15. The first step in the process is identification of the area in which the wetland boundary occurs. In simple situations where wetlands grade directly to uplands, this can be accomplished from aerial photographs. In more complex situations, areas behind dikes or berms, near tide gates, in and near oxbow lakes, on gravel bars or in back slough channels must be investigated for possible wetlands. The influences of these natural and man-made features on wetlands in the Snohomish Basin are discussed further in the Results and Discussion section.

16. Once the sites near the wetland boundary have been identified the next step in the process is identification of the vegetation present. Which species dominate the area? Are any of those species known to tolerate wide ranges of soil moisture? Are any of them hydrophillic or hydrophobic species? If a single species dominates an area, and it has a wide tolerance of soil moisture, what other species are found? What are their water tolerances?

17. Soil conditions should then be considered. Is the soil saturated at present? Is the present moisture content the usual? How often and to what extent does it fluctuate? How well does the soil hold water? How well does it drain?

18. The local water table should also be considered. Is its connection with adjacent water (riverine or estuarine) direct and apparent? Does it fluctuate on a daily or seasonal basis? If so, how much, and when? Does it fluctuate in response to adjacent water level fluctuations?

19. The timing of an investigation is also important. What were the soil moisture conditions in the spring when germination was occurring? What about late summer when high temperature and low humidity encourage extreme desiccation? Can first year shrubs be expected to survive winter floods? Also, will the now dominant vegetation remain so throughout the season? or will late starters dominate later in the season?

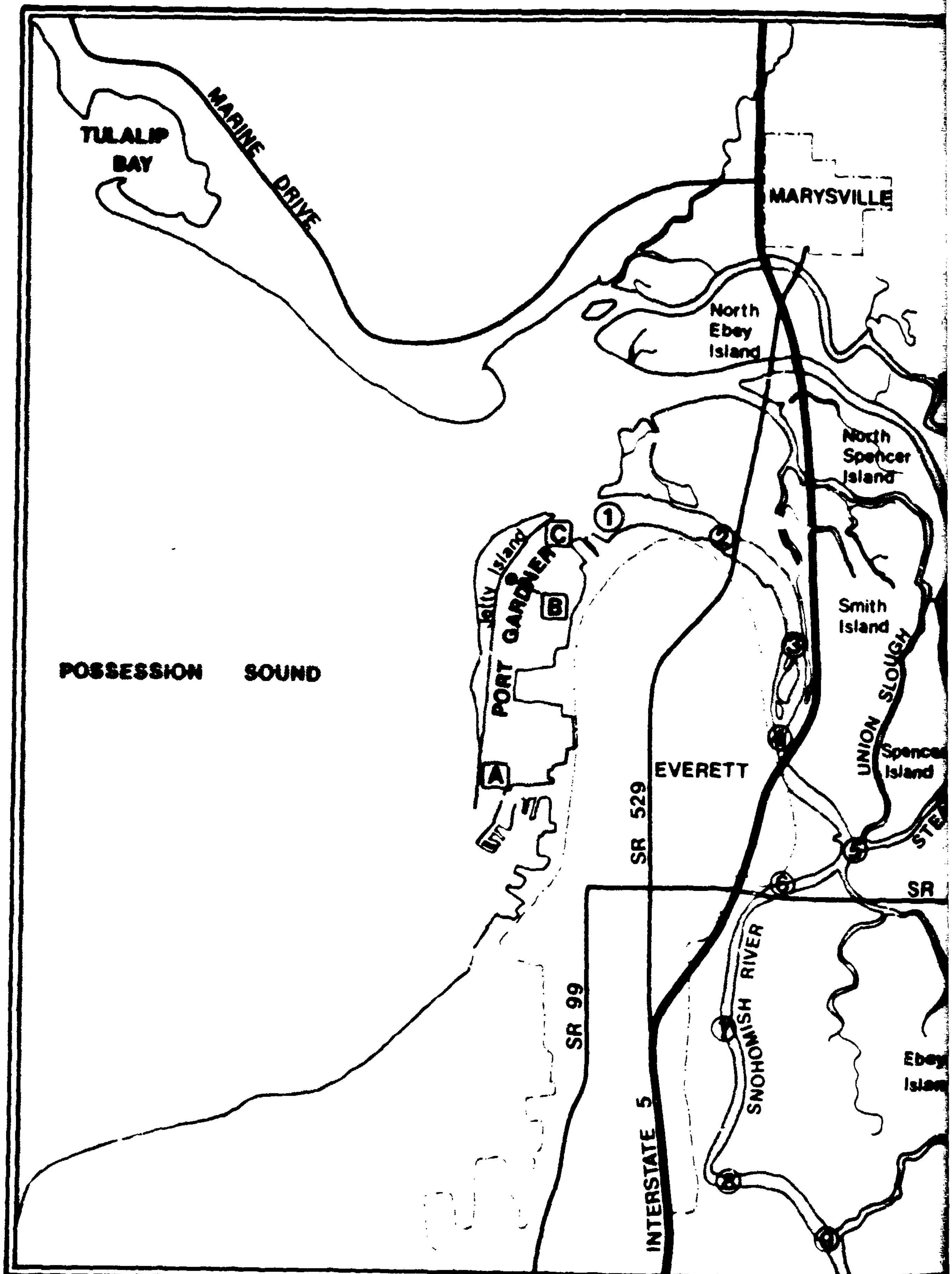
20. Finally, it is important to examine the overall context of the site. Is the successional sequence apparent? Does that sequence offer any information concerning past or future conditions on the site? Has the sequence been interrupted due to natural or man-induced disturbance? Will that interruption affect the present condition?

21. An additional factor considered in these investigations was the transistion zone. As described earlier, this is an ecotone between wetlands and uplands habitat types, where neither local environment prevails. This type of area was mapped only at sites where wetland processes appeared to be dominating but upland conditions were also apparent. Usually these were areas dominated by wetland shrubs but sufficiently dry through the summer to allow invasion by weedy upland annuals.

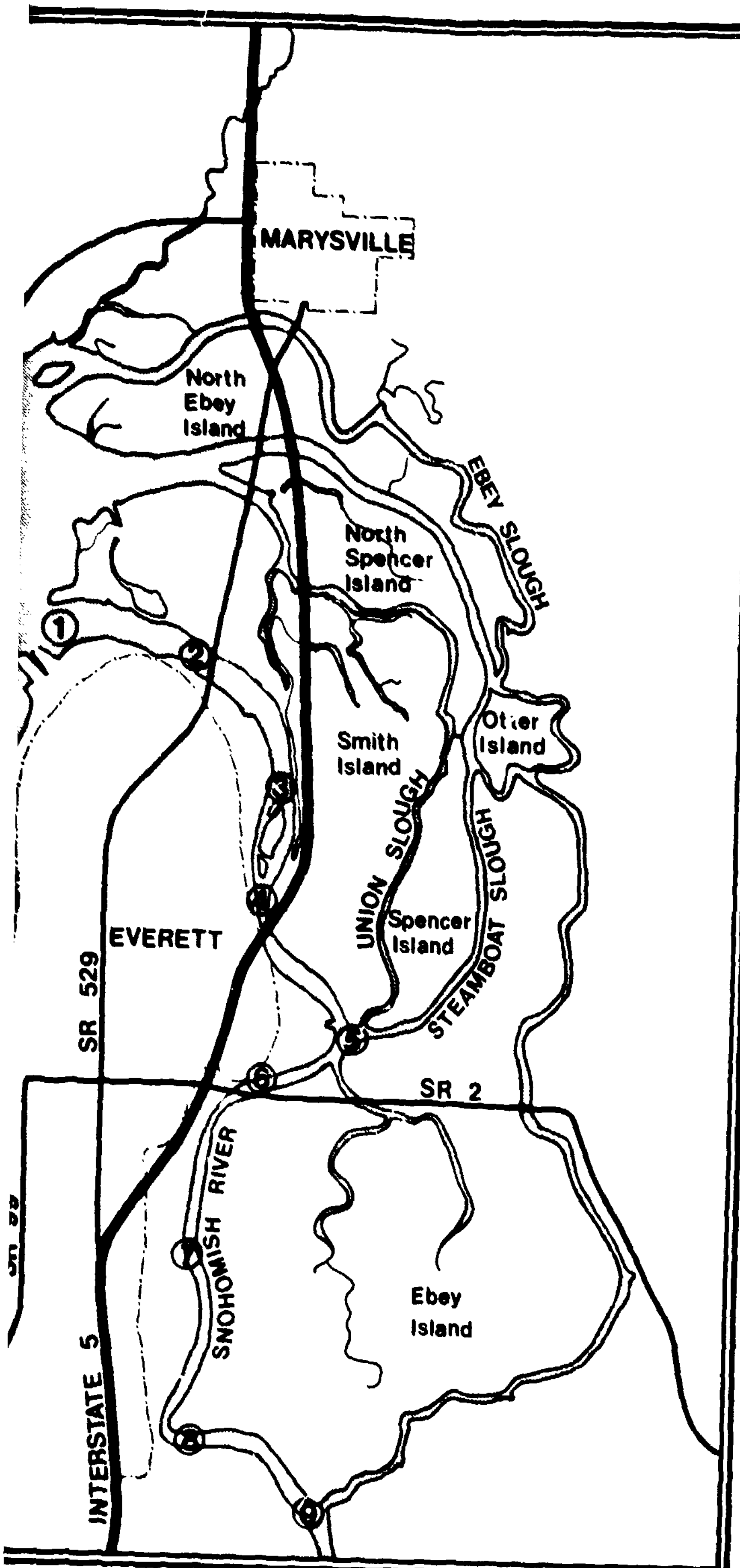
22. Throughout the course of the study it was necessary to consider all of these questions, compare the answers and then make a judgement based on the results. Sometimes the answers were clear. Often new information forced re-evaluation of previous decisions. But in every case, wetlands were delineated according to the definitions set forth in Corps regulations.

C. SALINITY DETERMINATION

23. Salt wedge salinity measurements were taken in the main channel of the Snohomish River (9 stations) and in the Everett Harbor (3 stations) portion of Port Gardner (Figure 8). Two slack water



TULALIP BAY
MARINE DRIVE
MARYSVILLE
North Ebey Island
North Spencer Island
Smith Island
Spencer Island
UNION SLOUGH
POSSESSION SOUND
Jetty Island
PORT GARDNER
A
B
C
1
EVERETT
SR 529
SR 99
INTERSTATE 5
SNOHOMISH RIVER
Ebey Island
SR



SNOHOMISH ESTUARY

FIGURE 8

SALINITY SAMPLING STATION LOCATIONS

Legend

[Z] Port Gardner Stations

(0) Snohomish River Stations

N

Scale in Miles

0 ½ 1 2

SNOHOMISH ESTUARY WETLANDS STUDY

tidal samplings were made on 31 October 1977. Salinity measurements were made with a YSI (Yellow Springs Instrument Co.) Model 33 (SCT) salinity - conductivity meter. Prior to sampling the meter was calibrated to hydrometrically determined salt solutions of 5 and 30 ppt (parts per thousand).

D. AERIAL PHOTOGRAPHS

24. Color infrared (false color) photographs of the estuary at a scale of 1:6000 and black and white photographs of the upriver portions of the study area at a scale of 1:12,000 were used in the study. The photographs were useful in identifying wetland communities, and locating man-made structures.

25. The color, tone and texture of the infrared photographs were often sufficiently detailed to allow determination of specific wetland types or even species. The black and white photographs did not provide such specific information, but were useful in determining both topographic and textural changes in the study area and its vegetation. Despite the information gained from the photographs, ground truth verification of wetland boundaries was necessary throughout the study area.

E. GROUND SURVEY EQUIPMENT

26. Field surveys to confirm photo-interpretation were carried out in the entire study area. In the estuary, a 17-foot inboard-outboard research vessel provided water access to areas of concern. In the upriver portions of the study area, where shallow water is common, a 15 foot canoe was used to gain access. Throughout the study area a four-wheel drive vehicle provided land access.

F. FINAL MAPS AND PHOTOGRAPHS

27. Wetland boundaries within the estuary were recorded on field maps of 1:6000 scale as they were determined. Boundary lines

were then transferred to a set of finished maps at 1:6000 scale and to a set of photographs at a scale of 1:12,000. In the upriver portions of the study area, boundaries were recorded on 1:12,000 scale photographs in the field and then transferred to a set of finished photos at the same scale. The finished maps and photographs have been been completed separately as part of this study and are available at the Seattle District office of the Corps of Engineers.

28. A series of 35 mm photographs showing wetland species, growth habits and communities was also produced during the field investigations. Due to the time of year, pictures of the estuary wetlands are not optimal; fall colors, dropping leaves and lack of inflorescences render indentifications from these photographs difficult. The photographs of the upriver wetlands taken in the summer offer a more discernible view of wetland characteristics. The photographs and accompanying captions were also completed as a portion of this study and are also available at the Seattle District office of the Corps of Engineers.

III. RESULTS AND DISCUSSION

1. The results of this study include four separate products. The primary product is a set of black and white aerial photos (1:12,000) with the wetland boundaries and transition zones mapped on them. The other products are: a set of maps of the estuarine portion of the study area at a scale of 1:6000 with the boundary and transition areas indicated; an album of annotated 35mm color slides and prints of the characteristic vegetation in the study area; and this report. Field data and observations substantiating the delineation and describing wetland conditions at various sites are presented below.

A. SALINITY CONDITIONS AND ESTUARINE WETLAND HABITAT DISTRIBUTION

2. Estuarine wetlands can be defined by a combination of vegetation characteristics and salinity regime. In general, one can identify marshes (herbaceous annuals and perennials) and swamps (shrubs and trees). While swamps are usually limited to fresh-water areas, both fresh-water and saline marshes are common.

3. For the purposes of grouping and classifying wetlands in the Snohomish Estuary the salinity regime was defined as follows:

Saline	17.0 - 35.0 ppt*
Brackish	0.5 - 17.0 ppt
Fresh-water	0.0 - 0.5 ppt

The boundaries of these salinity zones vary with river flow and tidal stage. For conceptual purposes, the saline zone lies west of the SR 529 bridges (old U.S. 99), while the brackish zone lies north of U.S. 2 and east and south of the SR 529 bridges. The tidal fresh-water zone extends south from approximately the Highway 2 bridges to a point approximately one mile above the town of Snohomish.

---

* Parts per thousand.

4. Each salinity zone is characterized by certain wetland plant associations. Plant species which normally can be expected in Pacific Northwest saline and fresh-water tidal marshes are listed in Tables 1 and 2. Brackish wetlands generally contain a mixture of saline and fresh-water plant species. It should be noted that some plant species have wide salinity tolerances and may occur in salinity zones different from those presented in Tables 1 and 2.

5. During the course of the study, possible exceptions to this classification of salinity zones became apparent. Plant species (e.g. *Typha* and *Picea*) which would normally be excluded by river mouth salinities were found west of SR 529. It was therefore deemed necessary to document general salinity conditions in the estuary.

6. Data from two slack water samplings appear in Table 3. At the time of sampling, surface salinity was only 0.5 ppt where SR 529 crosses the river and bottom salinity was less than 0.5 ppt where Interstate 5 crosses the river. These suggest a dominance of fresh-water flow at the surface in much of the main channel in the Snohomish Estuary. (Some precipitation did occur during the preceding 24 hours and runoff may have increased the fresh-water flow).

7. Despite the dominance of fresh-water flow in the estuary, tidal influence occurs several miles upstream from the confluence of Ebey Slough with the river. As a result, many of the wetlands in the Snohomish Estuary are tidal fresh-water marshes and swamps. Such tidal fresh-water marshes are generally scarce in comparison with saline and nontidal fresh-water marshes, and have not been extensively studied (Doumlele 1976).

B. ESTUARINE WETLAND COMMUNITIES

8. Examples of representative types of wetlands in each salinity zone are discussed below. Each site is located by number in Figure 2.

TABLE 1

SALINE WETLAND SPECIES

Scientific Name	Common Name
Agrostis alba	Bentgrass
Atriplex patula	Orache, Silverscale
Carex lyngbyei	Sedge
Distichlis spicata	Saltgrass
Glaux maritima	Saltwort
Grindelia integrifolia	Gumweed
Hordeum brachyantherum	Barley
Jaumea carnosa	Jaumea
Juncus spp.	Rush
Oenanthe sarmentosa	Water parsley
Plantago maritima	Plantain
Potentilla pacifica	Pacific silverweed
Scirpus maritimus	Seacoast bulrush
Spergularia macrotheca	Sand spurry
Triglochin maritimum	Arrowgrass

TABLE 2
FRESH-WATER WETLAND SPECIES

Scientific Name	Common Name
Angelica genuflexa	Kneeling angelica
Angelica lucida	Seacoast angelica
Aster subspicatus	Douglas' aster
Caltha spp.	Marshmarigold
Cornus stolonifera	Swamp dogwood
Epilobium grandulosum	Willow-herb
Galium trifidium	Bedstraw
Glyceria grandis	Reed mannagrass
Lcnicera involucrata	Honeysuckle
Lotus corniculatus	Birdsfoot-trefoil
Lysichitum americanum	Skunk cabbage
Physocarpus capitatus	Ninebark
Picea spp.	Spruce
Polygonum spp.	Smartweed
Potentilla pacifica	Pacific silverweed
Rosa nutkana	Nootka rose
Rosa pisocarpus	Wild rose
Salix hookeriana	Coast willow
Salix lasiandra	Pacific willow
Salix scouleriana	Scouler willow
Scirpus acutus	Hardstem bulrush
Scirpus validus	Softstem bulrush
Senecio triangularis	Ragwort
Sium suave	Water parsnip
Spirea douglasii	Spirea
Typha spp.	Cat-tail
Veratrum viride	False hellebore

TABLE 3

SALINITIES IN THE SNOHOMISH RIVER AND PORT GARDNER BAY (High Tide, 10/31/77)

Minutes before/after high tide at Everett, WA	Station Number*	Salinity (ppt)			Depth (meters)		
		Surface	Mid	Bottom	Surface	Mid	Bottom
-37	A	19.0	26.0	27.0	0.3	6.0	10.0
-32	B	18.5	26.5	27.0	0.3	5.0	10.5
-25	C	17.0	25.5	26.5	0.3	3.0	6.0
-17	1	7.0	16.8	24.0	0.3	1.5	3.0
- 7	2	< 0.5	24.0	24.5	0.3	4.0	9.0
- 1	3	< 0.5	15.5	21.0	0.3	3.5	7.0
+ 8	4	< 0.5	<0.5	6.3	0.3	4.5	9.0
+15	5	< 0.5	<0.5	< 0.5	0.3	2.0	4.0
+21	6	< 0.5	<0.5	< 0.5	0.3	3.0	6.0
+27	7	< 0.5	<0.5	< 0.5	0.3	3.0	7.0
+38	8	< 0.5	<0.5	< 0.5	0.3	3.5	6.0
+47	9	< 0.5	<0.5	< 0.5	0.3	2.5	5.0

* Refer to Figure 8 for location of stations.

Saline Marsh Communities

9. Jetty Island (Figure 2, Site 1), Priest Point (Site 2), small marsh pockets along the Everett shoreline, the west end of Smith and North Ebey islands, and marshes near the mouth of Quilceda Creek (Site 3) comprise the only marshes regularly exposed to saline conditions. Due to the structure and substrate of Jetty Island, the low marsh communities contain sparse emergent plants (Salicornia sp., Carex lyngbyei), mixed with brown algae (Fucus sp.). Upper marsh communities are mixed sedge (Carex spp.), arrow grass (Triglochin maritimum), plantain (Plantago maritima), seablight (Suaeda sp.), orache (Atriplix sp.), and saltgrass (Distichlis spicata). Those areas at the upper edge of the high marsh are apparently inundated only infrequently and comprise a narrow transition to uplands in a few spots on the island. In general, the ground rises sharply to a field-dune association dominated by upland varieties of sedge (Carex) and dunegrass (Elymus).

10. The high marsh community at Priest Point is dominated by bentgrass (Agrostis spp.), rush (Juncus effusus), and aster (Aster subspicatus). Scattered bushes (Lonicera involucrata, Pyrus fusca and Rubus spp.) are also found. The high marsh area has been mapped as a transition area, with a drainage ditch as an upper boundary. This community appears to have been limited in its natural extent by this ditch.

11. The shoreline marshes at Quilceda Creek (Site 3) are dominated more by emergent plants than are those at Jetty Island. Sedge (Carex), arrowgrass (Triglochin) and pickleweed (Salicornia) are the principal genera found in the low marsh regions at the mouth of the creek. Above the low marsh community is found a typical high marsh community, consisting of grasses (Agrositis alba, Deschampsia cespitosa), aster (Aster subspicatus) and water parsley (Oenanthe sarmentosa).

Brackish and Fresh-water Wetlands

12. The Snohomish Estuary receives its major fresh-water input from upstream, resulting in a relatively gradual salinity gradient (parallel to the waterways) from the river mouth, up the main channel and sloughs. There is also a considerable fresh-water input from the surrounding uplands. Near the river mouth and at Quilceda Creek this results in a relatively steeper groundwater salinity gradient moving upslope away from the river (or slough). Thus saline marsh grades immediately into brackish and fresh wetland followed by upland vegetation. This gradation is most prominant at Quilceda Creek (Sites 3 & 4) and also occurs at the western end of Smith Island (Site 5).

13. At Quilceda Creek, the wetlands proceeding from the water form a low saline marsh followed by a high marsh community (see paragraph 11). Beyond and elevationally above the high marsh is a brackish/fresh-water marsh of cattails (Typha spp.) and bulrush (Scirpus validus). Finally, a brackish swamp, dominated by spruce (Picea sitchensis), wild rose (Rosa spp.) and twinberry (Lonicera involucrata) is located above and beyond the brackish marsh. A diagramatic illustration of this progressive series of wetland communities is shown in Figure 9.

14. In other portions of the estuary, such as West Smith Island (Site 5), brackish or fresh-water wetlands consisting of cattails (Typha spp.) and bulrush (Scirpus spp.) are found. These are the more familiar brackish fresh-water marshes described by numerous researchers (e.g. Shaw and Fredine 1956).

15. At West Smith Island, the upper portion of the wetland zone is a high marsh meadow. The meadow vegetation consists of rush (Juncus balticus) mixed with silverweed (Potentilla pacifica) and aster (Aster subspicatus). This grades into an association of upland field grasses including fescue (Festuca rubra), bentgrass (Agrostis sp.), aster (Aster subspicatus) and yarrow (Achillea millefolium). In portions of the meadow, wetland shrubs such as myrtle (Myrica gale)

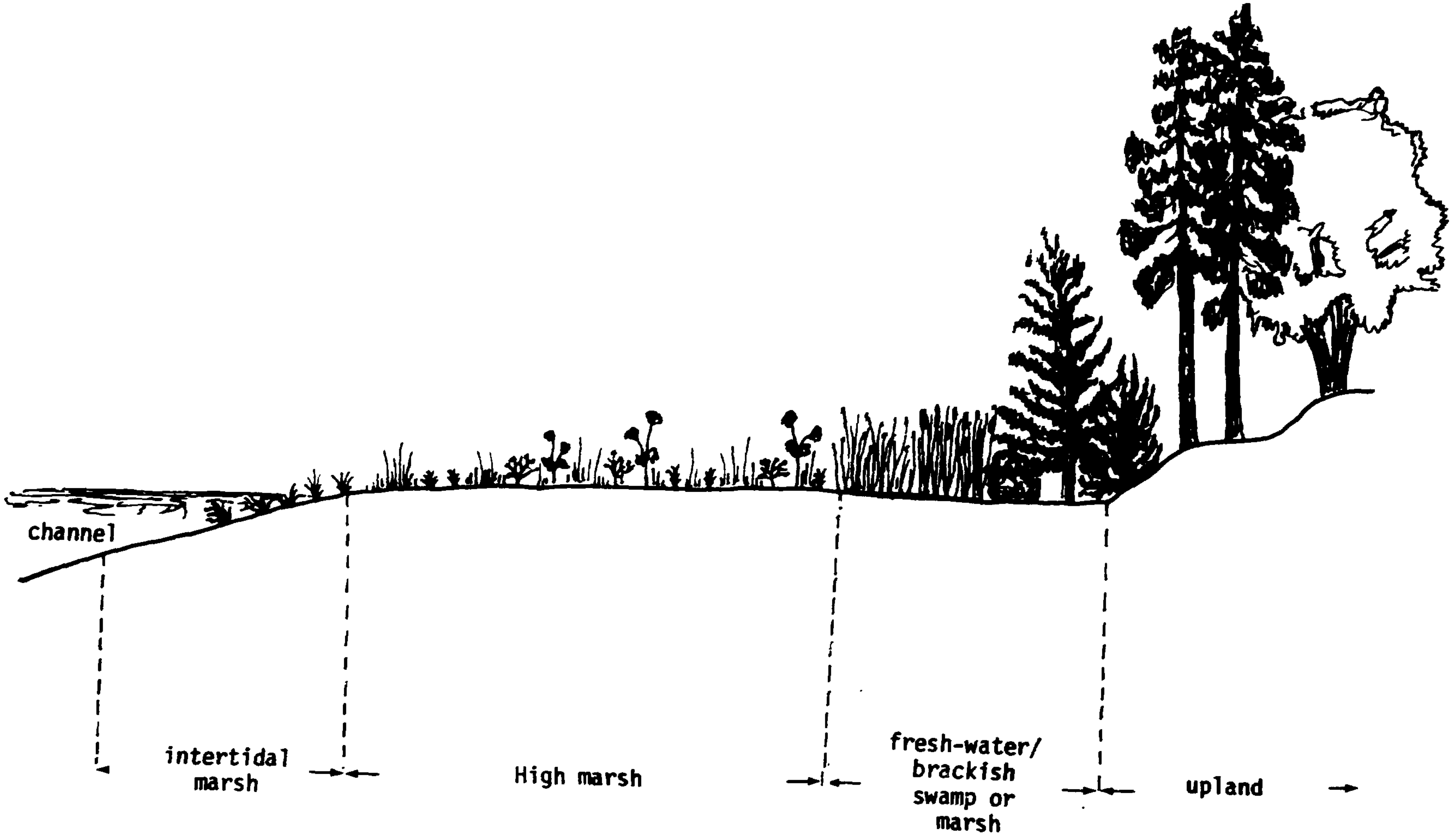


FIGURE 9 Wetland community gradient near Quilceda Creek

and twinberry (Lonicera involucrata) are found, either isolated or clustered in a dense shrub zone.

16. For purposes of this study, both high marsh and swamp communities are generally interpreted as an adjacent wetland as defined in 33 CFR 323.2. The swamp community has been found to constitute a transition zone in some instances. In others, the wetland-upland boundary is a sharp line due to abrupt topographic changes at the upland edge of the swamp.

17. The low and high marshes have been described in the preceeding section. The fresh-water community, both tidal and nontidal, is a swamp dominated by shrubs or occasionally small trees. Commonly occurring shrubs include wild rose (Rosa nutkana, R. pisocarpa), twinberry (Lonicera involucrata) and spiraea (Spiraea douglasii). Spruce and willow (Picea sitchensis, Salix spp.) are the dominant trees in this community. Under some conditions, alder (Alnus rubra), and occasionally juniper (Juniperus communis) also occur. Other species include dogwood (Cornus stolonifera), salmonberry (Rubus spectabilis), ninebark (Physocarpus capitatus) and red elderberry (Sambucus racemosa). Herbaceous species which may be associated with this community include cattail (Typha latifolia, T. angustifolia) and skunk cabbage (Lysichitum americanum). A typical example example of this in the Snohomish estuary is the area adjacent to Highway 2 (Site 10). Tidal fresh-water swamp communities have not been discussed in detail in the Northwest; however, Eilers (1975) mentioned the existence of a spruce-willow (Picea-Salix) community in an Oregon salt marsh.

18. An unusual wetland, located in the vicinity of Lowell (Site 6), is a dense alder grove (Alnus rubra) with an understory thicket dominated by salmonberry (Rubus spectabilis). Ninebark (Physocarpus capitatus), dogwood (Cornus stolonifera) and twinberry (Lonicera involucrata) are scattered throught the thicket. Reed grass (Cinna latifolia) and angelica (Angelica lucida) can be found in areas of standing water. At first inspection this community appears to be

a typical alder grove. However, on closer examination, it is apparent that the soil is saturated, and pools of standing water occur in every depression. The soil is extremely soft and, in places muddy. This grove borders a large tidal area containing a shrub swamp and an extensive cattail marsh. It appears the alder and salmonberry became established in the area prior to the soil having reached its present state of saturation. Although alder will survive in a saturated area, it normally occurs in fairly well-drained soils (Sudworth 1967).

19. The Lowell site is mapped as a transition zone. It appears that if the present vegetation were removed, wetland species of either a marsh or a swamp variety would most likely become established.

RIVERINE WETLAND COMMUNITIES

20. There is less diversity of wetland community types in the riverine portion of the study area than there is in the estuary. High winter current velocities, major seasonal water table fluctuations and sterile substrates contribute to an environment tolerated by few species.

Freshwater Marsh Communities

21. Reed canary grass (*Phalaris arundinaceae*) is the prevalent herbaceous species in riverine or riparian wetland areas. This extremely tolerant species may be found on the crest of dikes or submerged in old channels. It forms dense, often monotypic stands in almost any loose, moist, sandy substrate.

22. In backmarsh* areas, where fine sediments and organics have been deposited, more common fresh-water marsh communities are found.

*Backmarsh: Old meander channels cut off at the upstream end and at least partially connected at downstream end.

Pond weed (Potamogeton spp.) is submerged, burreed (Sparganium spp.) is emergent along the water's edge, and bulrush (Scirpus spp.), rush (Juncus spp.) and bedstraw (Galium spp.) are common along the shore. Horsetail (Equisetum fluviatile) may also be found along the shore or in very shallow water. In some areas these species may all be found in a diverse community, while in other areas, monotypic stands are found.

Gravel Bar Wetland Communities

23. Gravel bar communities are made up almost entirely of willows. Three species (Salix lasiandra, S. hookeriana and S. scouleri) are found, although S. lasiandra is usually the dominant species. An occasional black cottonwood (Populus trichocarpa) may also be found. These communities are usually found on river islands or point bars, with the youngest trees closest to the water, and larger older trees back away from the shore. As these communities get older, they trap finer sediment and organics, building up a soil horizon and raising the elevation of the substrate.

C. FACTORS AFFECTING WETLANDS

24. Numerous geophysical, hydrological and ecological factors influence the distribution of adjacent wetlands. Examples of several of these have been noted in the Snohomish Estuary and upriver. Site locations referred to below are shown in Figure 2.

Geophysical and Hydrologic Factors

1) Tidal fluctuations in upland water table

25. The concept of a fluctuating water table controlled by the rise and fall of the tide has not been researched in depth, although it has been referred to in other studies. This phenomenon was observed while investigating a wetland area along the west shore of the Snohomish River, north of Highway 2 (Site 7). The water level in a shallow hole was observed to be rising slowly. This observation was further confirmed

by an increase of water depth in a drainage ditch along side the railroad tracks. Both the hole and the drainage ditch were at least 30 feet from the river bank and three feet above at the time. This probably is an exaggerated version of the "perched water table process" previously described to explain the non-saline swamps at Quilceda Creek. In this case, however, the water table level is being forced upward by the combined pressures of upland ground water and the rising tide. Wetlands which appeared to be directly influenced by tidal pressure in this fashion are mapped as adjacent wetlands.

2) Long-term water level fluctuations

26. There appears to be some evidence for a rise in water levels in the estuary. First, along the south shore of Steamboat Slough near its confluence with the Snohomish River, a large cedar (Thuja plicata) stump was found. The stump was approximately 8 feet in diameter and 10 feet in height, and did not appear to have floated into its present position. This stump showed evidence of "springboard" notches, indicating the tree was cut many years ago. Located in the intertidal zone, the stump and base were covered by two to three feet of water at high tide. Since cedar normally does not survive in intertidal situations, it is reasonable to assume the water level has risen in this area. Secondly, studies of trends in sea-level rise (Hicks 1972) suggest a rise at Seattle of approximately 13 cm (0.4 ft.) between 1920 and 1970. A sea-level rise of less than one half foot is probably not sufficient to account for the present inundation of the cedar stump. However, diking and siltation of the channels has undoubtedly contributed to the rise in river water levels also. In combination, these two phenomena may provide an explanation for the present tidal elevation of the stump. Supporting information from future studies in necessary to confirm this hypothesis.

3) Natural berms

27. Construction of dikes on the islands left several small, irregularly shaped wetlands lying between the sloughs and the dikes (e.g. the northwest tip of Ebey Island (Site 8), and southwest tip of Spencer Island (Site 9)). In these areas it appears a natural berm has formed along the water's edge. An idealized cross-section of this situation is shown in Figure 10.

28. These natural berms probably form in a manner similar to natural levees along an alluvial stream. The theory of formation suggests that silt is deposited from the stream as it overflows its banks into the floodplain (Tanner 1968).

29. The berm (or levee) may rise only a few centimeters, or as much as 0.5 meter above the wetland located between it and the dike. If the berm rises high enough it may be populated by upland species, despite being surrounded by wetland. Such berms are mapped as wetlands unless the upland vegetation covers an extensive area.

30. At the southern tip of Spencer Island (Site 9), a parcel of several acres remains outside the dike. Along the southern edge of this parcel is a berm approximately 100 feet wide, of sufficient height to maintain a community dominated by alder and salmonberry. The berm is bordered on the south and west by river channels and on the north by a swamp. The swamp consists of some alder and spruce with an understory of twinberry (*Lonicera involucrata*), dogwood (*Cornus capitatus*), skunk cabbage (*Lysichitum americanum*), etc. In this case the berm was mapped as upland.

Pointbars, Back Marshes, and Oxbow Lakes

31. Pointbars, back marshes, and oxbow lakes are features that are found along the Snohomish River upstream of the town of Snohomish and long the Skyomish and Snoqualmie rivers. All these features result from the constant scouring and deposition processes involved in meander

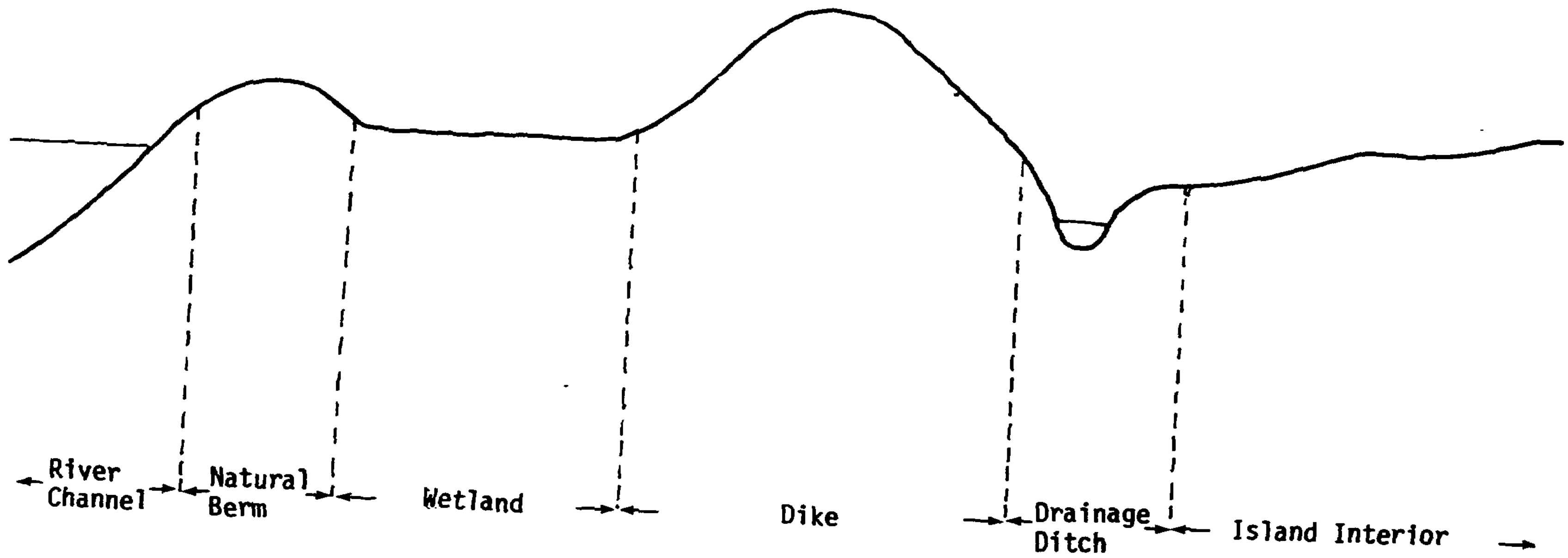


FIGURE 10 Idealized Cross Section of a Natural Berm Formation

formation. Unrestrained river meandering is a dynamic process. Locations of typical representatives of these features are indicated on Figures 3, 4, 5, and 6.

32. Pointbars are frequently formed on the inside (shallow, low water velocity region) of meanders by the deposition of sand and silt (and during floods by deposition of cobbles and gravel). Pointbars generally grow in a downstream direction. (A gravel bar is a similar island formation process in the middle of a river.) Pointbars are colonized principally by wetland vegetation. In time, as flood deposition raises the elevation of the interior of the bar, uplands species become dominant. Point bars (and gravel bars) were mapped as adjacent wetlands or transition zone depending on their present successional stage.

33. Oxbow lakes are old river meanders which have been cut off from the river, generally by a combination of gradual meander shifting and a single large flood event involving massive scouring and deposition. Oxbow lakes are frequently connected to the river at flood stages or by drainage ditches, some of which were found equipped with flood gates which prevent backflow. In the study area, no lakes were found to have a clear hydrologic connection to the rivers. Oxbow lakes generally contain at least peripheral wetlands vegetation. All oxbow lakes within the study area are not functionally influenced by the river system, and are not mapped as adjacent wetlands. However, a result of final interpretation of Corps permit regulations regarding determination of "adjacent wetlands," some of the oxbow lakes in the study area may, after individual examination, be considered adjacent wetlands. These have been indicated on the aerial photographs.

34. Back marshes are old meander channels or channels between gravel bars which have been cut off at their headward end due to deposition. These channels usually contain water as a result of backflow through their mouth and/or from river water percolation through porous bar sediments. They are thus subject to the same water level fluctuations as other portions of the river. As a result of their closed head, how-

ever, they do not experience the high current velocities and scouring associated with the rest of the river except during occasional floods. These quiet backwaters are often the location of freshwater marsh communities. Domination by reed canary grass (as along the river) is rare.

Short-term Riverine Water Level Fluctuations

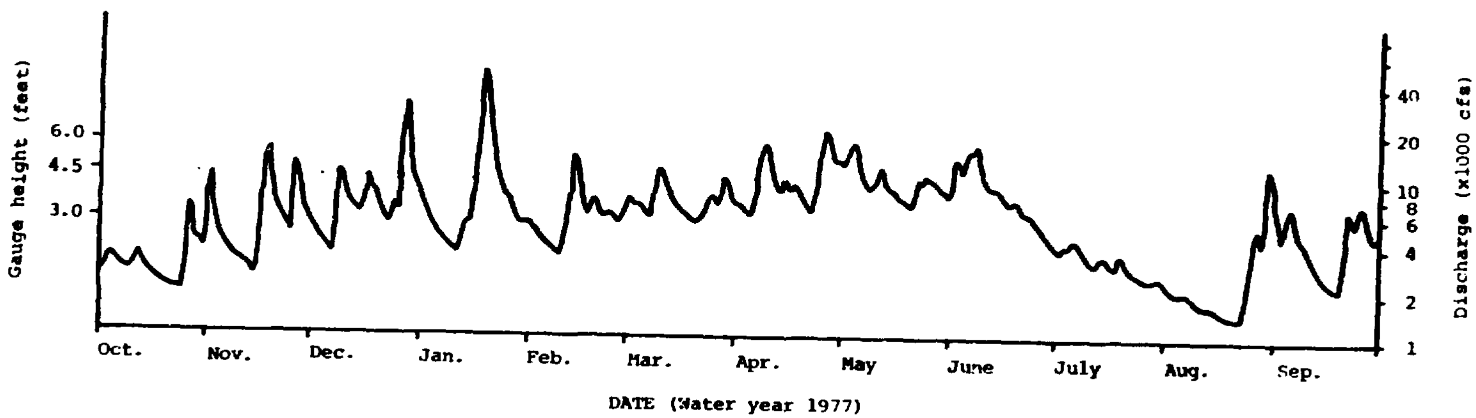
35. Most rivers demonstrate significant variations in water level on both a seasonal and daily basis. High water levels are associated with rainfall and snow melt. Fluctuation of river level and the water table is a controlling factor in the distribution of wetland plants within the riverine ecosystem.

36. The daily variation of discharge and river height at Monroe for 1977 is shown in Figure 11. Is is apparent that although river height is generally below 1.5 meters (4.5 feet) (relative gauge datum) during much of the year, water levels above this height for one to several days are not uncommon. Thus, any plants which become established on gravel bars or along the river shore must be adapted to periodic inundations. In addition, these plants must also be capable of surviving severe desiccation during low flow conditions. Willows (*Salix* spp.) and reed canary grass (*Phalaris arundinaceae*) seem to have developed characteristics necessary to tolerate these conditions.

Ecological Factors

1) Transition Zones

37. Corps regulations define wetlands as those areas that support a prevalence of wetland vegetation. Many wetlands possess transition zones in which wetlands grade to uplands through a gradual shift in the plant communities. These zones are ecotones, i.e. boundary regions which are not completely wetlands or uplands. The transition zone is inhabitated by plants characteristic of both upland and wetland associations.



Source: USGS, Unpublished data

FIGURE 11

Average daily discharge and gauge height for the Snohomish River at Monroe during water year 1977.

38. The lower limit of the transition zone is normally considered to be the lower limit of upland plants contiguous to the upland. The upper limit of this ecotone is the upper limit of wetland species contiguous with the wetland. While the term "contiguous with" defines the ecotone limits, it should be realized that an ecotone is a biological idealization that may or may not be achieved in a given situation. This is because upland plants occurring singly or in groups can often be found well into the wetland, isolated totally from the upland. These phenomena may result from slight changes in elevation, substrate composition, or water table level in that portion of the wetland. They may also be due to differences in plant genetics and hence competitive ability (inundation or salinity tolerance, etc.).

39. Boundary areas between wetlands and uplands were mapped as transition zones in cases where gradual changes in vegetation exist. In these areas, Corps permit jurisdiction covers some portion of the transition area. However, exact boundary determination in such areas requires establishment of vegetation transects and is beyond the scope of the present study. Such boundary determinations will normally be necessary when determining individual permit requirements in such cases.

40. It was originally assumed there would be transition zones between wetland and upland throughout much of the estuary. In most areas this is not the case. Throughout much of the estuary, the boundary is a narrow transition zone, often less than five feet in width. This is primarily the result of extensive diking and filling, which creates a steep slope from upland to wetland.

41. Even in an unaltered area such as that between Quilceda Creek and Interstate 5 there is no transition zone. Here the upland abruptly stops at a scarp approximately 0.3 meter (1 foot) high. Above the scarp, the vegetation is mixed coniferous and deciduous forest. Below the scarp is a spruce dominated swamp.

42. One of the few areas which can be said to have a transtion zone is located on Smith Island, immediately west of the settling ponds. Here the upper marsh is mixed cattail (*Typha*) and bulrush (*Scirpus*). Above this marsh is a meadow area, the low end of which is a high marsh association. At higher elevations this grades into an association of upland field grasses. In portions of the meadow, wetland shrubs occur in isolated patches or as a dense shrub zone. Even at this site, however, the transition zone is usually only 3 to 6 meters (10 to 20 feet) wide.

2) Succession

43. Several of the wetland areas in the Snohomish Basin are undergoing successional processes in which one type of wetland is being replaced by another. Marshes are progressing to swamps as trees and shrubs begin to dominate. On old dikes and berms, wetlands species are invading and replacing upland species. Upriver, willows are being replaced by cottonwoods as soil and hydrologic conditions change.

44. In the estuarine area, one of the most interesting phenomena is the successional process from marsh to swamp. This has a direct bearing on the definition of wetlands since many successional swamp species can also grow in dry, upland areas. Perhaps the best example of marsh-swamp succession is the wetland adjacent to the U.S. Highway 2 bridges (Site 10). This area is predominantly cattail-spiraea (*Typha* spp., *Spiraea douglasii*) dominated with a diverse mixture of other species. Also scattered through the marsh are small shrubs, mostly dogwood (*Cornus stolonifera*) and willow (*Salix* spp.). In a few areas ninebark (*Physocarpus* sp.) and spruce (*Picea sitchensis*) have become established. Given the condition of other swamps in the basin, it seems evident that this association will (if undisturbed) eventually succeed to a tideland spruce (*Picea sitchensis*) swamp, shading out most of the associated herbaceous vegetation.

45. Among the best examples of the climax situation is the spruce swamp on Otter Island, a relatively pristine wetland in the Snohomish estuary.

This swamp covers a major part of the island, except in one area previously cleared and diked for agriculture. The field shows the characteristics of a cattail marsh, with shrubby vegetation beginning the marsh-swamp succession at the same elevation and water conditions as the spruce swamp adjoining it.

46. The spruce (Picea) colonizing the wetland areas during the swamp succession tend to grow on small hummocks or on nurse logs. In the literature they have not generally been identified as a species tolerant of saturated soils (Franklin and Dyrness 1973). In the Snohomish wetlands, however, spruce have been observed at virtually the same elevations as cattails and bulrush, often in standing water. The fact that the spruce are not normally able to colonize neighboring uplands is dramatically pointed out by the sharp transitions which occur in the Quilceda Creek area. Observations in the Snohomish Estuary suggest spruce roots are able to penetrate and survive in saturated soils. Franklin and Dyrness (1972) have suggested that nurse logs provide a rich substrate in which young seedlings can become established. As a result of these observations, Picea sitchensis has been identified as a characteristic species in Snohomish Estuary fresh-water swamps. Eventually, as nurse logs decay and sediment trapping around swamp debris continues, swamps may succeed to bog and upland communities. The time scale of such successional change is too long to have any direct bearing on wetland boundary delineation for the purposes of this study.

47. In the riverine area willows (Salix spp.) are the dominant species on gravel bars. As these grow they begin to trap debris and sediment during floods. In time the substrate changes as gravel is buried below sand, and organic material is incorporated. Generation of a soil horizon and a rise in substrate elevation create an environment suitable for a wider range of species. Black cottonwoods colonize the area and begin to dominate the overstory. Thimbleberry (Rubus spectabilis), snowberry (Symphoricarpos albus) and elderberry (Sambucus racemosa) form the understory, along with hedge nettle (Stachys cooleyae),

nettle (Urtica spp.) and thistles (Cirsium spp). If this succession is unhindered by flood damage, conifers, including cedar (Thuja plicata) and Douglas fir, will ultimately become established.

48. In backmarsh areas succession appears to be about the same. Here, however, the initial pioneer is reed canary grass with bulrush (Scirpus spp.), rush (Juncus spp.), and horsetail (Equisetum spp.) becoming established some time afterwards. Willows ultimately invade and soon dominate, leading to the same process described above.

Effects of Man-Made Structures on Adjacent Wetlands

49. The extensive development of the Snohomish Estuary has resulted in numerous structures which function to drain the wetlands and/or protect agricultural or industrial activities from flooding. Often these structures complicate the interpretation of marsh-upland boundaries. Examples of these structures and some of their effects on wetlands are discussed here. Site locations refer to Figure 2.

1) Fills

50. In many parts of the estuary, filled areas directly border wetlands. This has the effect of reducing the transition zone to a very narrow strip or eliminating it entirely. This simplifies the designation of wetland boundaries based on aerial photographs.

51. Filled areas may be associated with industrial activities, commercial development or with roads and railroads. Earthfills often alter an adjacent wetland type through fresh-water runoff from the fill area. This is particularly noticeable next to the highways in the Everett-Marysville industrial corridor. In some cases this run-off may be creating small wetland areas where none would otherwise exist (See Figure 10).

52. Filled areas which are now uplands are mapped as uplands.

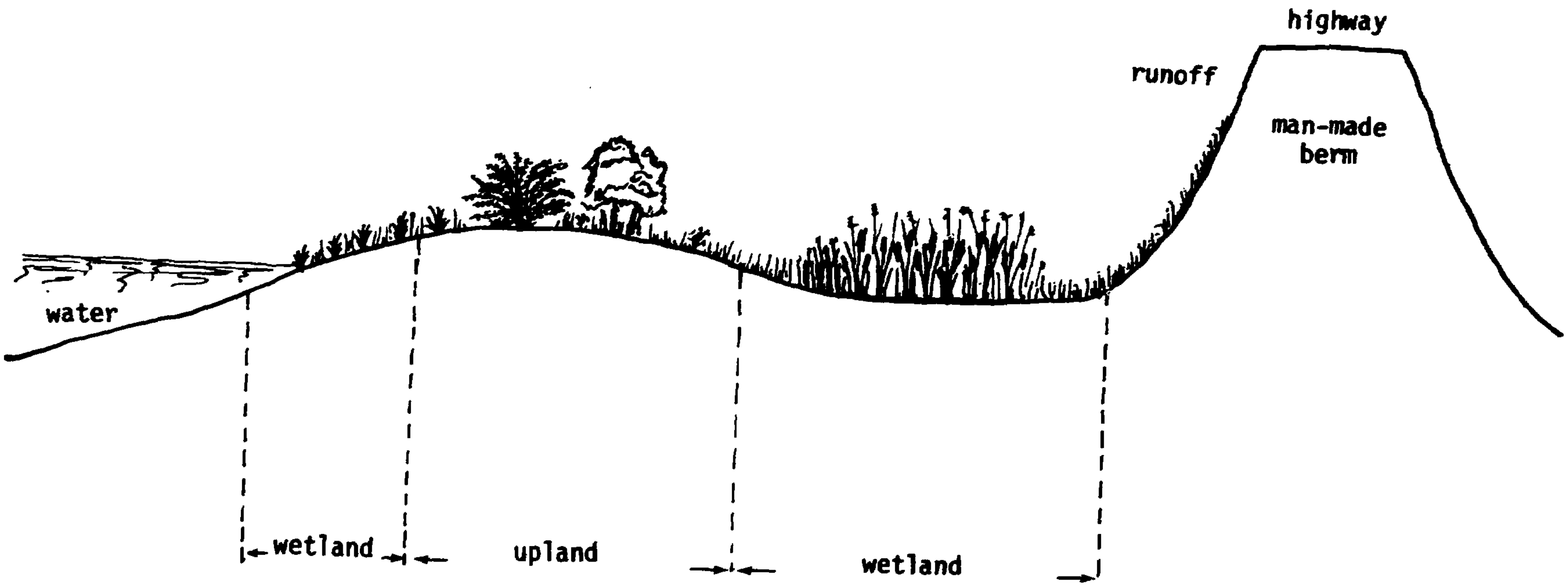


FIGURE 12 Cross section of hypothetical man-made berm

Conversely, new wetlands created by fills of similar groundlevel alterations were mapped as wetlands provided they are functionally related to navigable waters. According to refinements in field interpretation (see page 21, paragraphs 3 and 4) other wetlands in "close proximity to navigable waters" have also been indicated on the aerial photographs.

2) Culverts and Tidegates

53. There are numerous culverts and tidegates connecting Snohomish Estuary wetland areas with navigable waters. Tidegates, which are culverts intended to permit only one way flow (drainage) of water are often non-functional and in disrepair. These structures can often be located from aerial photographs and verified through field investigation. In some cases, their presence can be used to explain the existence of tidal wetlands within diked areas.

54. On Smith Island, numerous wetlands are found to be long, narrow areas flanking drainage ditches and roadways. Some of these have a connection with tidal water through tide gates, and water levels are directly influenced by tidal action. These tidally influenced wetlands are mapped as adjacent wetlands.

3) Drainage Ditches

55. Traditionally, drainage ditches have been an effective means of converting wetlands to uplands. This is particularly true in high marsh areas where inundation is infrequent.

56. Priest Point is an example of this conversion. Here homes were built along the entire length of the spit, and a drainage ditch was constructed along the back line of the lots. With this ditch the yards were drained sufficiently to allow lawns or small gardens to be planted. However, if these yard areas went untended, the high marsh vegetation prevalent across the ditch would probably resume dominance.

57. Drained areas have not been designated as adjacent wetlands unless wetland vegetation is present. However, siltation or blockage of drainage channels may at some future time cause reversion to wetland conditions.

4) Multiple Dikes

58. In many places throughout the estuary there is evidence of one or more older dikes seaward of the present dike. These may be anywhere from five to 500 meters in length. They are usually lower than the present dike and have been breached in several places. In some cases older dikes may not be exposed at high tide. There is usually water between these older dikes and the present dike.

59. The crests of these older dikes are sometimes covered by upland plant species such as alder (*Alnus rubra*) or blackberry (*Rubus* spp.). The slopes may be covered by sedges (*Carex* spp.), cattails (*Typha* spp.) or swamp shrubs, thus creating a narrow, but long island of upland vegetation surrounded by wetland species. This upland community is often too narrow to map at a scale of 1:12,000 or even 1:6000.

60. In other areas, older dike crests may be covered with upland vegetation and the slopes, although intertidal, may be unvegetated. If the upland vegetation is mostly shrubs it may come in contact with the vegetation on the primary dike. This gives the impression of a much wider dike crest, especially from the air or at high tide.

61. In mapping these areas, it was decided to map the boundary only along the present dike. This was done for several reasons. First, many of the older dikes appear to be eroding away, thus a line established along the present dike will still be accurate even after the older dike has disappeared. Second, the crest elevation of some of the old dikes suggest they are merely "de facto"

uplands. In others words, if the present upland vegetation were removed, wetland species would replace it. Thus some of these areas would normally support wetlands species. Finally, these old dikes usually constitute no more than minor hummocks with respect to overall topography of the area.

5) Permeable Dikes

62. During the course of the study, several permeable dikes were identified. In some areas, such as the south shore of Steamboat Slough near its confluence with the main channel (Site 13), this condition appears to have resulted from poor quality repairs or inadequate maintenance. At these points the leaking water enters a drainage ditch and eventually flows to a pump station(s).

63. Of particular interest was a permeable dike along the east side of Ebey Slough, south of Highway 2 (Site 14). The dike surrounds a parcel of approximately five acres which had apparently been intended for upland use. The dike has been leaking for some time, and the entire parcel is presently a fresh-water wetland. Evidence of tidally influenced flow through the dike was observed, suggesting the area is a tidal wetland dominated by large, discreet communities of burweed (Sparganium), Cattail (Typha), rush (Juncus), and bentgrass (Agrostis).

IV. RECOMMENDATIONS

1. The results noted above show the Snohomish Estuary to be different in several physical and ecological aspects from many other estuaries which have been studied. Whether these differences are unique to the Snohomish or are characteristic of Puget Sound estuaries in general cannot be determined based on current research. The differences are due in part to high fresh-water flows which minimize saline intrusion into the estuary while responding to tidal fluctuations. The resulting communities and zonations are in some manner a response to these physical conditions. Future research aimed at both applications of Section 404 authorities and better definition of the biological basis for regulatory decisions is desirable.

2. Specifically, further study should be directed towards:

- a methodically designed photographic documentation of the Snohomish Basin plant communities, carried out to supplement non-growth season photographs of this study. Such a documentation would serve as a reference framework to assist Regulatory Functions personnel.

- quantitave data gathered on the relationship of the marsh-upland boundary to tidal datums and to tidal innundation, similar to east coast studies (Boon, Boulé and Silberhorn 1977).

- more ecological information collected on inundation tolerance of northwest plant species. This is a necessary component of more accurately implementing existing Corps' permit regulations. Particular stress should be placed on the complex issue of swamp species.

- research on relative productivities of fresh-water versus marine wetlands in order to place brackish-fresh-water wetlands into perspective with productivity information in the literature.

BIBLIOGRAPHY

Boon, J.D. III, M.E. Boulé, and G.M. Silberhorn, 1977. Delineation of Tidal Wetlands Boundaries in Lower Chesapeake Bay and Its Tributaries. Virginia Institute of Marine Science. Gloucester Point, Virginia.

Burrell, G. 1978. Habitat Classification System for the Snohomish Estuary Study (Draft Rept.). Washington Department of Game, Seattle, Washington.

Clark, J. 1974. Coastal Ecosystems: Ecological Considerations for Management of the Coastal Zone. The Conservation Foundation. Washington, D.C.

Cowardin, L.M., V.C. Carter, F.C. Golet and E.T. LaRoe. 1976. Interim Classification of Wetlands, and Aquatic Habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services. Washington, D.C.

__________. 1977. Classification of Wetlands and Deepwater Habitats of the United States. (An operational draft.) U.S. Fish and and Wildlife Service. Washington, D.C.

Doumlele, D.G. 1976. Primary Production and Plant Community Structure in a Tidal Fresh Water Marsh. Unpub. M.S. Thesis, College of William and Mary. Williamsburg, Virgina.

Eilers, H.P. 1975. Plants, Communities, Net Production and Tide Levels: The Ecological Biogeography of Nehalem Salt Marshes, Tillamook County, Oregon. Unpublished Ph.D. Dissertation, Oregon State University. Corvallis, Oregon.

Freibertshauser, M.A. and A.C. Duxbury. 1972. A Water Budget Study of Puget Sound and its Subregions. Limnology and Oceanography. 5(17): 237-247.

Franklin, J.E. and C.T. Dyrness. 1973. Natural Vegetation of Washington and Oregon. U.S. Forest Service. Portland, Oregon.

Giles, R.J. Jr. (ed.). 1971. Wildlife Mangement Techniques. The Wildlife Society. Washington, D.C.

Hicks, S.D. 1972. On the Classification and Trends of Long Period Sea Level Series. Shore and Beach. April, 72:20-23

Hinde, H.P. 1954. The Vertical Distributions of Salt Marsh Phanerograms in Relation to the Tide Levels. Ecol. Mono. 24:209-225.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press. Seattle, Washington.

Jefferson, Carol. 1975. Plant Communities and Succession in Oregon Coastal Salt Marshes. Ph.D. Thesis, Oregon State University. Corvallis, Oregon.

McIntire, W.G., M.J. Hershman, R.D. Adams, K.D. Midbox, and B.B. Barrett. 1975. A Rationale for Determining Louisiana's Coastal Zone. Report No. 1, Coastal Management Series. Louisiana State University. Baton Rouge, Louisiana.

National Oceanic and Atmospheric Administration, National Ocean Survey. 1975. The Relationship Between the Upper Limit on Coastal Marshes and Tidal Datums. U.S. EPA. Rockville, Maryland.

Northwest Environmental Consultants. 1976. Coastal Wetlands Project, Final Report. Washington Department of Ecology. Olympia, Washington.

______________________. 1977. Aquatic Lands Definition Study. Washington Department of Ecology. Olympia, Washington.

Odum, E.P. 1969. The Strategy of Ecosystem Development. Science: 164: 262-270.

______________________. 1971. Fundamentals of Ecology. Third Ed., W.B. Saunders Co. Phildelphia, Pennsylvania.

Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. U.S. Fish and Wildlife Service. Circ. 39. Washington, D.C.

Shea, G.B. 1977. Tidal Current and Flushing Study for Port Ludlow Bay, Washington. Northwest Environmental Consultants. Bainbridge Island, Washington.

Sudworth, G.B. 1967. Forest Trees of the Pacific Slope. Dover Publ., Inc. New York, New York.

Tanner, W.F. 1968. "Levee-Natural": in The Encyclopedia of Geomorphology, R.W. Fairbridge, Ed.). Reinhold, Inc. New York, New York.

Yocum, C. and V. Brown. 1971. Cascades Wildlife. Naturegraph Publishing Co. Healdsburg, California.

Appendix A Literature Review

APPENDIX A. LITERATURE REVIEW

A. CLASSIFICATION OF WETLANDS

1. In the past three decades, wetlands have become both scientifically and publically recognized as environmentally important ecosystems (Odum 1969, Teal 1962, Odum 1971). Their values range over several categories, including high biological productivity (Teal 1962), habitat for a diversity of wildlife (Giles 1971), buffering shoreline areas against erosive forces, and other benefits (Clark 1974). In this context it has become important to classify wetlands so they can be studied in a logical manner.

2. Wetlands have been traditionally classified by such terms as marsh, swamp, bog, etc., by Circular 39 (Shaw and Fredine 1956). Although usage of such terms is now beginning to change based on emerging classifications systems, these terms are currently the most useful and widely understood. All fall under the Corps authorities as normally supporting vegetation adapted to hydric (saturated) soils.

3. The U.S. Fish and Wildlife Service (Cowardin et al. 1977), has recently developed a classification system for wetlands based on:

- Changes from hydrophytic to mesophytic or xerophytic vegetative types
- Changes from hydric to non-hydric soils
- Changes from normally flooded to normally non-flooded land

Based on this classification system, which includes marine, estuarine, and riverine systems, the Fish and Wildlife Service is now engaged in a nation-wide mapping effort intended to identify wetlands for resource management purposes. It is anticipated that this study will introduce a new set of standard terminology to replace existing terms such as swamps and bogs. This terminology, however, has not yet been published in final form.

4. Jefferson (1975) has identified and categorized wetland types in Oregon. In addition, she classifed marsh zones and successional stages. Her designation of high and low marsh zones coupled with analysis of mature vs. immature marsh made possible a functional differentiation of marsh areas within a similar environment. Jefferson's study, together with more detailed work by Eilers (1975), has to date served as a basis for most marsh identification and categorization in the Pacific Northwest.

5. Northwest Environmental Consultants (NEC 1976) in a study for the Washington State Department of Ecology has reported on marsh types in the State of Washington and proposed a tentative list of wetland indicator species for saline, brackish and fresh water marsh areas subject to tidal influence. The study also identified management areas and species for both Puget Sound and Pacific coastal marshes.

6. These studies can be used by government agencies to broadly define wetland areas, and estimate the quantity and types of wetlands within a given jurisdictional area. Enforcement of statutes or issuance of permits, however, requires a more specific delineation of wetland boundaries.

B. DELINEATION OF BOUNDARIES

7. A complete delineation of wetland boundaries involves setting limits both landward and seaward of each known wetland area. Since Corps of Engineers jurisdiction includes all waters of the United States, it is the wetland-upland boundary that is of major concern in this study. This boundary marks the landward limit of the jurisdiction and authority of the Corps of Engineers under Section 404.

8. The wetland-upland boundary has been referred to as "upper limit of marsh" (ULM), or as "lower limit of uplands" (LLU) (NOS 1975,

NEC 1977). While the two terms seem to be conceptually identical, there is a functional difference which is critical to an understanding of the reasons wetland vegetation exists where it does. Wetland vegetation consists of terrestrial species which are poor competitors with upland plants. Over evolutionary time, these plants have survived in marginal areas with saturated soils, where they have adapted to the existing conditions in these habitats. Therefore, wetlands plants can often still grow in upland areas but are primarily limited to wetlands as a result of competition from upland plants. Upland plants, on the other hand, usually cannot survive or do not survive well in saturated soil conditions. Thus, the best conceptual term to use would be LLU, lower limit of uplands. According to Corps' permit regulations, adjacent wetlands jurisdiction is based on prevalence of aquatic vegetation requiring saturated soil. This places the wetlands - upland jurisdictional boundary somewhere between ULM and LLU.

9. There have been few studies nation-wide on exact delination of wetland boundaries and only four complete studies to date in the Pacific Northwest that relate to the subject. These studies, in contrast to most other wetland research, focused on the relationships between vegetative transition and elevations with respect to tidal influence. Below are discussed two applicable studies from California and Louisianna, followed by the four northwest studies.

10. Early research on the West coast was carried out by Hinde (1954) in San Francisco Bay. He identified three communities and their relative height with respect to the tide. Although he did not discuss the concept of marsh-upland transition zone, he did note species in the high elevations of the marsh, including the tops of levees.

11. In an attempt to identify the shoreward limits of its coastal zone, the state of Louisiana has compared the wetland/upland vegetation

boundary with other biological and physical parameters (McIntire et al. 1975). This delineaticn showed close correlation with topographic contours, geologic contact and soil variations.

12. Eilers (1975) has extensively analyzed marshes in Nehalem Bay, Oregon with respect to elevational and inundation characteristics. He found soil salinity to be a poor indicator of wetlands due to difficulties in measurement and the relation of this parameter to a variety of confounding influences. There was, however, a strong correltation between tidal elevations and the ranges of particular plant species and communities. It was therefore possible to identify three marsh zones (intertidal, transitional and extratidal marsh) and four geographic zones based on steepness of gradient. Eilers found that plant community locations could be predicted based on known elevational factors. He also noted that each plant community possessed a specific signature, determinable from aerial photographs. This fact has proved extremely useful in more recent studies, especially those involving large areas.

13. In a pilot study initiated by EPA to aid in delineation of Corps jurisdictional boundaries, NOAA (1975) determined the relationship between the upper limit of the marsh and tidal datums in several locations around the nation. The Columbian Region survey was performed on the north shore of Ebey Slough, and indicated that the ULM was 1.2 feet above MHHW. In this study the marsh transition was described as extending from 0.06 to 1.70 feet above MHHW.

14. Until recently, only ecologists and a few others have noted the concept of such a transition zone. The transition zone concept became more important when the Corps included wetlands within their jurisdictional boundaries, as a result of Section 404 regulations. The concept of the transition zone helped localize the definition of marsh boundaries on the basis of characteristic vegetation. On the East Coast NOAA (1975) defined the ULM as "the highest elevation contiguous to the coastal marsh supporting coastal marsh vegetation." On the west coast, the

upper limit of the transitional zone was defined as "the highest elevation supporting coastal marsh vegetation," although upland flora was usually dominant in the upper part of this zone. The lower end of the transition zone was the lowest elevation supporting upland flora, although marsh vegetation was usually dominant.

15. Using these definitions as a reference, Boon *et al*. (1976) identified the "salt bush" community as the transition zone in Virginia marshes. This community is dominated by two moderate sized shrubs: marsh elder (*Iva frutescens*) and high tide bush (*Baccharis halimifolia*). Marsh elder (a salt marsh species), generally occupies the lower portion of this zone, while high tide bush (an upland species), occupies the upper portion of the zone. Application of the concept of the transition zone to this system led to the realization that a median point could be defined which might correlate 1) vegetative characteristics with tidal elevation references to 2) a local tidal datum for mean high water.

16. The median point was defined as the point at which dominance of marsh vegetation matched that of upland vegetation. It was found that in saline marshes, the median point averages 0.95 feet above mean high water, whereas in fresh marshes, the median was only 0.59 feet above mean high water. Other correlations were found with tidal inundation frequency and duration. Thus, the shrubs, marsh elder and high tide bush were a convenient and readily identifiable boundary of the marsh, since ". . . the upper limit of *Iva* (marsh elder) and/or the lower limit of *Baccharis* (high tide bush) are ordinarily found slightly below the median point of the transition zone," (Boon *et al*. 1976).

17. On the West Coast, Frenkel and Eilers (1976) identified the transition zone as "the ecotone between intertidal marsh and upland in which upland and intertidal species may both be present. . . ". Their research showed that two limits to the wetland-upland transition zone can be recognized. Of these, the upper transition limit corresponds to the ULM. It was found in this research the ULM is to

be expected in the vicinity of 2.0 feet above MHHW, but that use of tidal elevations as a complete basis for land use or jurisdictional decisions about marshes was premature. An important conclusion reached was that use of only one parameter yielded only partial understanding, and that reliance must still be placed on the evidence of plant communities and species.

18. Frenkel and Eilers identified 13 plant species common to the low and high intertidal salt marsh. In addition, they identified 18 species common the the high-low marsh transition zone. Of these, only two, rush (Juncus arcticus), and bentgrass (Agrostis alba), were listed as common the the salt marsh.

19. In a non-saline (fresh water) tidal marsh located in the Columbia Estuary, they found two types of intertidal marsh communities. These were an open herbaceous community, and a deciduous shrub and tree zone. Twentyfour species were identified as common in the open marsh, nine in the shrub marsh, and 12 in the transition zone. The most prevalent transition zone species were impatiens (Impatiens noli-tangere), sedge (Carex obnupta) and lady fern (Athyrium filix-femina).

20. Northwest Environmental Consultants (NEC 1977) tested four alternative methods of delineating the ULM: interstitial soil salinity, ground water movement, tidal elevation and floral distribution. Both ground water movement and soil salinity were found to be extremely inaccurate and highly variable. These two parameters depend on recent history of tidal influence, storm tides, rainfall and soil factors. Tidal elevation was found to be a useful, although somewhat imprecise indicator due to the slight gradient slope of marsh areas. Plant species were found to be the best indicators, if taken in the context of vegetative associations. This is in agreement with the findings of Frenkel and Eilers (1976). Use of single plant species as indicators was shown not to be a valid means of defining the ULM.

21. The NEC study identified aquatic lands as areas supporting certain flowering plants and algae common to intertidal areas. NEC noted that most species listed occurred low in the marsh, and not at the ULM. It was also noted that the marsh-upland transition zone represented an ecotone between the marsh and upland species.

22. Studies from Oregon and Washington (Frenkel and Eilers 1976, NEC 1977) provide lists of transition zone species, which are summarized in Table 1. From this table it is apparent there are several differences in terms of species identification and location.

23. Of the 66 species listed in Table 1, 27 were noted in both the Oregon and Washington studies. Of these 27, fescue (Festuca rubra), gumweed (Grindelia integrifolia), aster (Aster subspicatus) and silverweed (Potentilla pacifica) are all identified as salt marsh transition plants in Oregon and as both salt marsh and transition plants in Washington. In addition, bedstraw (Galium trifidum), wild barley (Hordeum brachyantherum) and water parsley (Oenanthe sarmentosa) are described as salt marsh transition plants in Oregon and salt marsh plants in Washington. This suggests the Oregon study used a much wider salt marsh transtion zone than the Washington study. Table 1 also shows that a greater variety of fresh water marsh species were identified in Oregon than in Washington.

24. Table 1 served as the initial basis for delineation of transition zones and wetlands boundaries in the Snohomish Estuary. During the course of the Snohomish study, it became clear that the transition concept used previously in the literature was inappropriate to the definitions upon which Corps jursidiction is based. The modifications to the transition zone concept (where that zone exists) and criteria developed for wetland boundary delineation are briefly discussed in the Excutive Summary and in greater detail in the Results and Discussion section.

TABLE 1

MARSH ZONATION SPECIES LIST

SPECIES	OREGON (Frenkel & Eilers, 1976)				WASHINGTON (NEC, 1977)					
	Salt Marsh	Transition	Fresh Marsh	Transition	Salt Marsh	Transition	Upland	Fresh Marsh	Transition	Upland
Achillea millefolium		H					X			X
Agrostis alba	H	L/H	X		X	X				
Alisma plantago-aquatica			X							
Alnus rubra				X				X		X
Angelica lucida		H								
Aster subspicatus		H		X		X	X		X	X
Athyrium filix-femina				X		X	X		X	X
Atriplex patula	H				X	X				
Bidens cernua			X							
Caltha asarifolia			X							
Carex lyngbyei	L		X		X	X				
Carex obnupta				X						
Conioselinum pacificum		L/H								
Cornus stolonifera			X	X						
Deschampsia cespitosa	L									
Distichlis spicata	L				X					

H = High Marsh
L = Low Marsh
X = Present

TABLE 1, cont.

SPECIES	OREGON (Frenkel & Eilers, 1976) Salt Marsh	Tran-sition	Fresh Marsh	Tran-sition	WASHINGTON (NEC, 1977) Salt Marsh	Tran-sition	Upland	Fresh Marsh	Tran-sition	Upland
Epilobium glandulosum			X							
Equisetum hyemale				X						
Festuca rubra		L/H				X	X		X	X
Galium trifidum		H			X					
Geum macrophyllum						X	X		X	X
Glaux maritima	L									
Glyceria grandis			X							
Grindelia integrifolia		L/H			X	X				
Habenaria dilatata			X							
Helenium autumnale			X							
Holcus lanatus				X						
Hordeum brachyantherum		L/H			X					
Hypericum formosum				X						
Impatiens noli-tangere				X						
Jaumea carnosa	L				X					
Juncus arcticus	H	X								

H = High Marsh
L = Low Marsh
X = Present

TABLE 1, cont.

SPECIES	OREGON (Frenkel & Eilers, 1976) Salt Marsh	Tran-sition	Fresh Marsh	Tran-sition	WASHINGTON ([illegible], 1977) Salt Marsh	Tran-sition	Upland	Fresh Marsh	Tran-sition	Upland
Juncus effusus					X	X				
Juncus ensifolius						X				
Lathyrus palustris						X	X		X	X
Lotus corniculatus									X	
Lycopus uniflorus			X							
Lysichitum americanum			X	X				X		
Mentha arvensis			X					X		
Mimulus dentatus			X							
Myosotis scorpioides			X							
Oenanthe sarmentosa		H			X					
Orthocarpus castillejoides	L/H									
Physocarpus capitatus			X							
Plantago maritima	L				X					
Polygonum spp.			X		X					
Potentilla pacifica		L/H			X	X		X	X	
Pyrus fusca			X				X			X

H = High Marsh
L = Low Marsh
X = Present

TABLE 1, cont.

SPECIES	OREGON (Frenkel & Eilers, 1976) Salt Marsh	Tran-sition	Fresh Marsh	Tran-sition	WASHINGTON (NEC, 1977) Salt Marsh	Tran-sition	Upland	Fresh Marsh	Tran-sition	Upland
Ranunculus orthorhynchus			X							
Ribes inerme			X							
Rorippa islandica			X							
Rosa nutkana						X	X		X	X
Rubus spp.						X	X		X	X
Sagittaria latifolia			X							
Salicornia virginica	L				X					
Salix spp.			X			X	X		X	X
Scirpus microcarpus			X							
Senecio triangularis			X							
Sium suave			X							
Spergularia macrotheca	L						X			X
Spirea douglasii				X			X			X
Trifolium wormskjoldii		H								
Triglochin maritimum	L				X					
Typha angustifolia			X							

H = High Marsh
L = Low Marsh
X = Present

TABLE 1, cont.

SPECIES	OREGON (Frenkel & Eilers, 1976) Salt Marsh	Transition	Fresh Marsh	Transition	WASHINGTON (NEC, 1977) Salt Marsh	Transition	Upland	Fresh Marsh	Transition	Upland
Typha latifolia								X	X	
Veratrum viride			X							
Vicia gigantea				X					X	

Appendix B Corps Regulations and Definitions
(33 CFR 323.2)

APPENDIX B

CORPS REGULATIONS DEFINITIONS (33 CFR 323.2)

§ 323.2 Definitions.

For the purpose of this regulation, the following terms are defined:

(a) The term "waters of the United States" means: [1]

(1) The territorial seas with respect to the discharge of fill material. (The transportation of dredged material by vessel for the purpose of dumping in the oceans, including the territorial seas, at an ocean dump site approved under 40 CFR 228 is regulated by Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972, as amended (33 USC 1413). See 33 CFR 324. Discharges of dredged or fill material into the territorial seas are regulated by Section 404.);

(2) Coastal and inland waters, lakes, rivers, and streams that are navigable waters of the United States, including adjacent wetlands;

(3) Tributaries to navigable waters of the United States, including adjacent wetlands (manmade nontidal drainage and irrigation ditches excavated on dry land are not considered waters of the United States under this definition);

(4) Interstate waters and their tributaries, including adjacent wetlands; and

(5) All other waters of the United States not identified in paragraphs (1) - (4) above, such as isolated wetlands and lakes, intermittent streams, prairie potholes, and other waters that are not part of a tributary system to interstate waters or to navigable waters of the United States, the degradation or destruction of which could affect interstate commerce.[2]

The landward limit of jurisdiction in tidal waters, in the absence of adjacent wetlands, shall be the high tide line and the landward limit of jurisdiction in all other waters, in the absence of adjacent wetlands, shall be the ordinary high water mark.

(b) The term "navigable waters of the United States" means those waters of the United States that are subject to the ebb and flow of the tide shoreward to the mean high water mark (mean higher high water mark on the Pacific coast) and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce. (See 33 CFR 329 for a more complete definition of this term.)

(c) The term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

(d) The term "adjacent" means bordering, contiguous, or neighboring. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes and the like are "adjacent wetlands."

(e) The term "natural lake" means a standing body of open water that occurs in a natural depression fed by one or more streams and from which a stream may flow, that occurs due to the widening or natural blockage of a river or stream, or that occurs in an isolated natural depression that is not a part of a surface river or stream.

(f) The term "impoundment" means a standing body of open water created by artificially blocking or restricting the flow of a river, stream, or tidal area. As used in this regulation, the term does not include artificial lakes or ponds created by excavating and/or diking dry land to collect and retain water for such purposes as stock watering, irrigation, settling basins cooling, or rice growing.

(g) The term "ordinary high water mark" means the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

(h) The term "high tide line" means a line or mark left upon tide flats, beaches, or along shore objects that indicates the intersection of the land with the water's surface at the maximum

---

[1] **The terminology used by the FWPCA is "navigable waters" which is defined in Section 502(7) of the Act as "waters of the United States including the territorial seas." For purposes of clarity, and to avoid confusion with other Corps of Engineers regulatory programs, the term "waters of the United States" is used throughout this regulation.**

[2] In defining the jurisdiction of the FWPCA as the "waters of the United States," Congress, in the legislative history to the Act, specified that the term "be given the broadest constitutional interpretation unencumbered by agency determinations which would have been made or may be made for administrative purposes." The waters listed in paragraphs (a)(1) 4 fall within this mandate as discharges into those waterbodies may seriously affect water quality, navigation, and other Federal interests; however, it is also recognized that the Federal government would have the right to regulate the waters of the United States identified in paragraph (a)(5) under this broad Congressional mandate to fulfill the objective of the Act: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). Paragraph (a)(5) incorporates all other waters of the United States that could be regulated under the Federal government's Constitutional powers to regulate and protect interstate commerce, including those for which the connection to interstate commerce may not be readily obvious or where the location or size of the waterbody generally may not require regulation through individual or general permits to achieve the objective of the Act. Discharges of dredged or fill material into waters of the United States identified in paragraphs (a)(1)-(4) will generally require individual or general permits unless those discharges occur beyond the headwaters of a river or stream or in natural lakes less than 10 acres in surface area. Discharges into these latter waters and into most of the waters identified in paragraph (a)(5) will be permitted by this regulation, subject to the provisions listed in paragraph 323.4-2(b) unless the District Engineer develops information, on a case-by-case basis, that the concerns for the aquatic environment as expressed in the EPA Guidelines (40 CFR 230) require regulation through an individual or general permit. (See 323.4-4).

height reached by a rising tide. The mark may be determined by a line of oil or scum along shore objects, a more or less continuous deposit of fine shell or debris on the foreshore or berm, other physical markings or characteristics, vegetation lines, tidal gages, or other suitable means that delineate the general height reached by a rising tide. The term includes spring high tides and other high tides that occur with periodic frequency, but does not include storm surges in which there is a departure from the normal or predicted reach of the tide due to the piling up of water against a coast by strong winds such as those accompanying a hurricane or other intense storm.

(i) The term "headwaters" means the point on a non-tidal stream above which the average annual flow is less than five cubic feet per second.[3] The District Engineer may estimate this point from available data by using the mean annual area precipitation, area drainage basin maps, and the average runoff coefficient, or by similar means.

(j) The term "primary tributaries" means the main stems of tributaries directly connecting to navigable waters of the United States up to their headwaters, and does not include any additional tributaries extending off of the main stems of these tributaries.

(k) The term "dredged material" means material that is excavated or dredged from waters of the United States.

(l) The term "discharge of dredged material" means any addition of dredged material into the waters of the United States. The term includes, without limitation, the addition of dredged material to a specified disposal site located in waters of the United States and the runoff or overflow from a contained land or water disposal area. Discharges of pollutants into waters of the United States resulting from the onshore subsequent processing of dredged material that is extracted for any commercial use (other than fill) are not included within this term and are subject to Section 402 of the Federal Water Pollution Control Act even though the extraction and deposit of such material may require a permit from the Corps of Engineers. The term does not include plowing, cultivating, seeding and harvesting for the production of food, fiber, and forest products.

(m) The term "fill material" means any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody. The term does not include any pollutant discharged into the water primarily to dispose of waste, as that activity is regulated under Section 402 of the Federal Water Pollution Control Act Amendments of 1972.

[3] For streams that are dry during long periods of the year, District Engineers, after notifying the Regional Administrator of EPA, may establish the headwater point as that point on the stream where a flow of five cubic feet per second is equaled or exceeded 50 percent of the time. The District Engineer shall notify the Regional Administrator of his determination of these headwater points.

(n) The term "discharge of fill material" means the addition of fill material into waters of the United States. The term generally includes, without limitation, the following activities: Placement of fill that is necessary to the construction of any structure in a water of the United States; the building of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection and/or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for structures such as sewage treatment facilities, intake and outfall pipes associated with power plants and subaqueous utility lines; and artificial reefs. The term does not include plowing, cultivating, seeding and harvesting for the production of food, fiber, and forest products.

(o) The term "individual permit" means a Department of the Army authorization that is issued following a case-by-case evaluation of a specific project involving the proposed discharge(s) in accordance with the procedures of this regulation and 33 CFR 325 and a determination that the proposed discharge is in the public interest pursuant to 33 CFR Part 320.

(p) The term "general permit" means a Department of the Army authorization that is issued for a category or categories of discharges of dredged or fill material that are substantially similar in nature and that cause only minimal individual and cumulative adverse environmental impact. A general permit is issued following an evaluation of the proposed category of discharges in accordance with the procedures of this regulation (§ 323.3(c)), 33 CFR Part 325, and a determination that the proposed discharges will be in the public interest pursuant to 33 CFR Part 320.

(q) The term "nationwide permit" means a Department of the Army authorization that has been issued by this regulation in § 323.4 to permit certain discharges of dredged or fill material into waters of the United States throughout the Nation.