INVENTORY OF WETLAND RESOURCES AND EVALUATION OF WETLAND MANAGEMENT IN WESTERN WASHINGTON

Prepared for

WASHINGTON STATE DEPARTMENT OF ECOLOGY

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JOHN SPELLMAN
Governor

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Dear Reader:

The Shoreline Management Act, begun as an initiative of the people of Washington, became law in 1971. It found that shorelines, including wetlands, are among the most valuable and fragile of the state's natural resources. The Act directed state and local governments to develop programs for shoreline management and protection. The 1976 federal Coastal Zone Management Act contained similar directives and provided funds to coastal states to implement management programs.

The attached report examines the success of the Shoreline Act over the last dozen years in protecting wetland resources in the 15 counties that constitute Washington's coastal zone. This report is one part of an overall evaluation of the state's shoreline/coastal zone management program. Other aspects of the program evaluation are public perception, coastal access, and master program analysis. For additional information, contact Don Peterson, Supervisor, Shorelands Planning, at (206) 459-6282.

Sincerely,

Bill

William Obert
Shorelands Planner

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EXECUTIVE SUMMARY

The purpose of this study was threefold:

- To develop a comprehensive inventory of wetlands and determine the trends in wetlands development during the last 100 years in western Washington;
- to evaluate the effectiveness of the Shoreline Management Act (SMA) in protecting the wetlands of western Washington; and
- to identify improvements to SMA or other programs which might increase the effectiveness of wetlands protection efforts.

Existing information in the form of maps, reports, and inventories were used to prepare the inventory and analyze the trends in wetland losses. A questionnaire and interviews with local shoreline planners were the principal information sources used to evaluate the Shoreline Management Act.

The inventory covers approximately 46% of the 12,000,000 acres in the 15 coastal counties of western Washington. Almost 235,000 acres of wetland habitats were identified in that area, of which about 67,000 acres are vegetated wetlands (marshes and swamps); the remainder are open water, unvegetated shore, or aquatic bed habitats. About one-third of the vegetated wetlands of western Washington are estuarine marshes. Another one-third are forested and shrub swamps. Emergent estuarine wetlands tend to be much larger than palustrine emergent wetlands. There are a greater number of palustrine wetlands, however. As a result, the total area of palustrine wetlands is much greater than estuarine wetlands in western Washington.

The jurisdiction of both federal (Section 404) and state (SMA) regulations governing development activities in wetlands is determined by mean annual flows; thus, the size of the watershed supporting a wetland area often determines whether it is protected. Using runoff calculations, it is possible to estimate which wetlands would be regulated under which programs. In King County, for example, 500 distinct wetlands encompassing over 6,600 acres are not protected by either the SMA or Corps 404 jurisdiction. This comprises 76% of the total palustrine wetlands in King County. If this trend holds for all counties, large areas of wetlands are presently unprotected.

The trends analysis indicates several types of development activities have been responsible for decreases in wetlands in western Washington. The rich organic soils of palustrine and tidal freshwater wetlands made them prime areas for conversion to agricultural uses at the time of early settlement. In a few areas (notably, the Duwamish and Puyallup estuaries) the demand for industrial development led to conversion of estuarine wetlands to port facilities. The Puget Sound bays showed dramatic losses between 1900 and 1940. In the Snohomish Estuary, as much as 150 acres per year were converted to agricultural uses; in Commencement Bay, an average of 75 acres per year were filled. The trend of wetland loss has slowed substantially since 1940 in most areas; however, the wetlands of Commencement Bay and the

Duwamish Estuary have been virtually eliminated. The coastal bays, Willapa and Grays Harbor, showed more dramatic changes in wetlands since 1931 with little loss prior to that time. The coastal systems show both increases and losses of wetlands over time, as a result of dredging or filling activities and natural changes altering these areas. Many lake shore wetlands have been dredged or filled as part of residential development around the lakes.

Interviews with over 30 shoreline planners indicated a general satisfaction with Shoreline Master Programs with respect to protection of coastal wetlands. Many of them, however, were interested in expanding the jurisdiction, recognizing that many wetlands were not protected. Other concerns which were raised included difficulties with the definition of "associated wetlands" and coordination problems with state and federal agencies. The planners offered numerous suggestions about improvements they would like in the shoreline management process.

I. INTRODUCTION

The perception of wetland values has changed considerably in recent years. At the turn of the century, wetlands were termed "wastelands" and the Swamp Acts were passed by Congress to assist local jurisdictions in reclaiming these areas for productive uses. Dredging and filling for port facilities and diking for agricultural purposes were the most common forms of reclamation. During the 1950's and 1960's, the physical and biological functions of wetlands began to be recognized. Wildlife habitat, floodwater storage and high biomass production were some of the first values to be identified.

With this change in perception, wetland areas have become the center of numerous conflicts between economic development and habitat preservation interests. Furthermore, the value of wetlands to these interests has changed as a result of the changing needs and values of society. In response to these conflicts and changing values, new policies and laws were established by the federal, state, and local agencies to identify and consider the public interest and resolve conflicts between the interest groups. The intent was to ensure responsible management, to encourage the beneficial use, protection, and development of natural resources, and to achieve a balance between wetland preservation and the need for economic development.

The Washington State Shoreline Management Act (SMA) was one of the first of these regulations to specifically identify wetlands as areas requiring special attention and protection. The guidelines for development of master programs under SMA (WAC 173-16) describe important wetland functions and recognize the fragile nature of these ecosystems. Many local jurisdictions gave special attention to wetlands while developing their Shoreline Master Programs. This attention was reflected in conservancy and natural environment designations and severe restriction of activities in wetland areas.

Purpose

It has now been over 10 years since SMA was enacted. In addition, a number of other federal, state, and local regulations have been established which may influence development activities in wetlands. In that time, implementation procedures have been developed and refined, regulatory personnel have been trained, and in some cases legal issues have been contested and refined. The regulatory structure has resulted in a level of wetlands management and protection that did not previously exist. At the same time, conflicts regarding the role and interplay between federal, state, and local levels of government have resulted from the differing points of view held by each.

Although the difficulties of the regulatory processes and the conflicts between agencies have frequently been discussed, there has been little analysis of the effectiveness and success of programs established to protect wetlands. Furthermore, little is known of wetland losses either before or since the establishment of these regulations.

The purpose of this report is threefold:

- Determine the present extent of wetlands within the Washington coastal area and the historic trends in wetland losses.
- Evaluate the effectiveness of SMA and other wetland protection programs.
- Identify improvements to SMA or other programs which might increase the effectiveness of wetlands protection efforts.

Authority

This study was supported by the Washington State Department of Ecology (WDE) with funds provided by the Office of Ocean and Coastal Resource Management (OCRM). OCRM was established by the Coastal Zone Management Act (CZMA) of 1972 to assist the states in preparing and implementing programs to regulate development activities in the Coastal Zone. An important aspect of implementation is evaluation to determine the effectiveness of those programs. This study is one of several being conducted by WDE to assess the results of over 10 years of regulation under the Shoreline Management Act.

II. STUDY AREA

The 15 coastal counties of western Washington were selected as the study area for this project. The major reasons for selecting this area were:

- These counties comprise Washington's coastal zone
- Development pressure
- Predominance of wetlands
- Availability of data

The Coastal Zone Management Act (CZMA) was enacted to assist states in regulating development activities in their coastal zone. Traditionally the coastal zone has been defined as the marine shoreline. Under SMA, however, the shorelines of most rivers and lakes were included within the jurisdiction. Thus, virtually all the counties of Washington have developed shoreline master programs. Nonetheless, the emphasis of SMA, as fostered by OCRM has been on the coastal counties. It should also be noted that over 60% of Washington's population is located in the coastal counties. As a result, this is where development activities are concentrated.

Preliminary evidence indicates that the majority of Washington's wetlands are located in western Washington. The estuaries of Puget Sound and the Coast are recognized as major wetland areas. Numerous lakes also support nearshore wetland areas. Finally, the substantially greater rainfall in western Washington suggests there is more water available to create wetlands.

The existence of substantial information on wetlands in western Washington is the final reason for limiting the study to this area. Numerous site-specific studies exist, WDE has completed an atlas of the coastal shoreline, and U.S. Fish and Wildlife Service (USFWS) is conducting its National Wetland Inventory (NWI) in this area. Thus, there is a diverse collection of data on which to base an analysis of the presence and loss of wetlands.

III. METHODOLOGY

A. INVENTORY

Introduction

The objective of this portion of the study is to provide a comprehensive and consistent inventory of wetlands habitats, and to determine their extent and distribution in the 15 coastal counties. This involved consolidation of a number of different inventory documents into a single wetland data base. Data on the wetlands of coastal Washington vary considerably with location; there is no single complete inventory of the region. Existing studies vary in detail, complexity, area of coverage, accuracy, and other factors. The purpose of this inventory was to standardize the information to one classification system and to resolve the difficulties of overlapping data and gaps between studies.

Desired Information

The objective was to develop a wetlands inventory useful to resource managers and local governments. To do this, it is important to choose measurable parameters from the data available, which provide the most valuable information. This allows comparison of one wetland to another and one area to another. The following factors were considered:

- Wetlands size, type, and distribution. This is information common to most inventories and is of greatest interest in providing a general overview of wetlands. It is necessary to determine if size is a criteria for identifying a wetland as unique. Is anything larger than 10 acres or 100 acres unique? It is also important to determine which types of wetlands are common and which types need more protection (e.g., emergent vs. forest swamps). It is also important to ascertain where most of Washington's wetlands are found. Are they concentrated in lowland areas or along coastlines?

- Areal extent of wetlands. Numerous inventories give acreage figures making it necessary to determine which information is of greatest value in a regional inventory, without excessive duplication of existing information.

- Watershed size. This is valuable information since is correlates with the annual flow of a stream. Mean annual flows determine the jurisdiction of both federal and state wetlands regulations.

Overlaps and Gaps

Many studies overlapped in coverage, especially between site specific studies and regional studies. If the figures were just combined and summed, there would be double counts and inflated numbers. Thus, in the case of overlap, it is important to determine which study to use and which to ignore. This inventory was limited to existing reports or mapping projects, leaving gaps in coverage. There are large areas where no wetland surveys have been completed.

Factors to Consider

In determining what sources were the most accurate and comprehensive the important factors to consider were:

- scale
- accuracy - degree of field investigation
- type of information - size, type, distribution
- age of inventory

In most studies wetlands were identified by aerial photograph interpretation. The amount of detail available is dependent on the scale (e.g., using 1:24,000 vs. 1:50,000 photos). Several studies field checked their data with following up on-site visits, increasing their accuracy. The more detailed the information in a report, the more valuable it was to this inventory. Studies where type and size of each wetland had already been calculated were of greatest value. Older inventories will be less accurate due to some wetlands being changed or filled.

Data Manipulation

This inventory was collected from the following sources:

(1) Wetland inventory projects completed for specific locations. These had first priority, since they were generally completed at a large scale and have been extensively field checked (see Appendix A - County inventories for specific sites).

(2) County wide inventories completed in King and Skagit counties. These inventories provided size, distribution and, in King County, watershed size of wetlands for a large area.

(3) Washington Coastal Zone Atlas (CZA) - Department of Ecology. Information was available for 12 counties, where land use coverage extends from a point approximately 30 feet below mean sea level shoreward to the beach and inland for 2,000 feet. CZA data has been field checked and has a computerized summary of areal extent.

(4) National Wetlands Inventory Maps (NWI) - U.S. Fish and Wildlife Service. NWI mapping is available for much of Puget Sound and other areas. There was very little field verification, however, and no wetland acreages were calculated.

It should also be noted that the classification systems used to describe wetland types may vary. The U.S. Fish and Wildlife Service (USFWS) developed an early classification as a part of Circular 39 (Shaw and Fredine, 1956), the first nationwide inventory of wetlands. In 1976 the U.S,. Geological Survey (USGS) developed a landcover classification system for use in aerial photograph interpretation (Anderson, et al, 1976). This was adapted by the Washington Department of Game (WDG) for the Snohomish Estuary (Burrell, 1978, the Coastal Zone Atlas, and other inventories). A similar adaption of the USGS system has been used by SHAPIRO in its numerous inventories. This study defined wetland types in accordance with the Classification of Wetlands and Deep Water Habitats of the United States

(Cowardin, et al., 1979). It is a hierarchical system with major categories for headings (e.g., estuarine, lacustrine, and palustrine) and extensive subheadings down to specific substrates and life forms. Wetlands are classified by plants (hydrophytes), soils (hydric soils), and frequency of flooding. This classification was developed as part of the National Wetlands Inventory. The NWI system was selected because it is becoming a nationwide standard and has the greatest land coverage.

Data Presentation

The numerous existing inventories offer a wide range of information, and yet, still may lack important information. Furthermore, they do not provide comprehensive coverage for the area of interest to this study. The available information was consolidated to create a single comprehensive wetland inventory which is consistent for the 15 coastal counties. Not all the information of interest was available for every county. Each county was completed, however, to the extent possible given the available data.

Data chosen for inclusion in this comprehensive inventory were selected to fulfill important management considerations. These data are:

- Wetland Type
- Total Area
- Size Distribution
- Watershed Size

Table 1 illustrates how the data are presented. Appendix A is the completed inventory for 15 coastal counties. The reasons for including each data type are discussed below.

Wetland type is based on the U.S. Fish and Wildlife Service classification (Cowardin et al., 1979) developed for NWI. As noted previously, this classification is becoming the standard for wetlands throughout the country. It is possible to convert other classification systems to the NWI classification. That conversion has already been developed for the Circular 39 and SHAPIRO classification systems. The CZA land cover/use types were converted to the NWI categories as shown in Table 2.

The categories of size distribution suggested are based on wetland evaluation methodologies developed by King County and the Corps (Reppert, et al., 1979). In King County, one of several necessary criteria for an "outstanding" wetland is an areal extent greater than 10 acres. The Corps notes that wetlands greater than 100 acres have a "high" water purification value. Thus, these two size categories are probably important in determining wetland values.

Watershed size is an important factor determining the mean annual flow of a stream. Mean annual flow is the factor determining jurisdiction under a variety of wetlands regulations. Using the simplified runoff calculation identified in Section 404 Regulations (33 CFR 323.2h), the Corps has determined that in Western Washington a 2,000 acre watershed develops a mean annual flow of about 5 cfs. This is the maximum flow for the "headwaters" of a stream as defined in Corps regulations. Wetland fill activities in headwaters areas are covered under a nationwide permit and do not require an

Table 1

SUMMARY OF WETLANDS INVENTORIES FOR _____ COUNTY

Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]							
Emergent							
Scrub/Shrub							
Forested							
Subtidal							
Aquatic Bed							
Lacustrine							
Open Water							
Aquatic Bed							
Emergent							
Palustrine							
Open Water							
Aquatic Bed							
Emergent							
Scrub/Shrub							
Forested							
Total							

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

Table 2

COASTAL ZONE ATLAS LAND COVER/USE TYPES
CORRELATED TO NATIONAL WETLANDS INVENTORY MAPS CATEGORIES
(Classification system is from Cowardin, et al., 1979)

National Wetland Inventory Wetland Legend	Coastal Zone Atlas Land Cover/Land Use
ESTUARINE	
Intertidal	
flat	beach substrate - 63
beach/bar	beach substrate - 63
rocky shore	beach substrate - 63
emergent	salt marsh - 623 salt meadow - 625 brackish marsh - 626
scrub/shrub	bog - 624
forested	brackish swamp - 612
Subtidal	
aquatic bed	seagrass - 627 kelp community - 628 other algal community - 629
PALUSTRINE	
Emergent	inland freshwater marsh - 621 coastal freshwater marsh - 622
Forested	freshwater swamp - 611 bog - 624

individual Corps 404 permit. Fill activities in all other wetlands do require a 404 Permit. Using the same calculation, an 8,000 acre watershed would develop a mean annual flow of 20 cfs, the lower limit of jurisdiction under SMA.

B. TRENDS

Introduction

The purpose of this task is to analyze the changes in wetlands in selected areas of the 15 coastal counties of Washington State. The extent of wetlands is altered by both natural and human imposed processes. Commencement Bay represents an area of massive alteration to the wetlands due to human intervention. On the other hand, much of the historical intertidal areas may change to marshland or open water over time depending on the natural changes in hydrology of a region. By studying historical developments such as dredging, diking, filling, recreational or industrial activities and correlating them with the wetland changes, one can better estimate the impacts of further development in a region.

In order to determine trends in wetland conversion, it is necessary to know the extent of wetlands not only in the present, but also at several times in the past. Although these data are fairly comprehensive for the present, they are extremely limited for the past. Historic data can be developed from interpretation of historic maps and aerial photographs; however, these sources are limited and the process is extremely time-consuming. Furthermore, with the increasing concern about and knowledge of wetlands, many areas identified as wetlands today may not have even been recognized historically. [This was noted in Skagit County (Raedeke et al., 1976) and the Snohomish Estuary (SHAPIRO/Driscoll, 1978). It can also be seen by comparing the results of the first U.S. Fish and Wildlife Service wetland inventory (USFWS, 1954) with those of NWI.]

Few analyses such as these have been conducted to date in the State of Washington. Bortleson, et al. (1980) determined the changes in wetland extent between the 19th century and the present for 11 Puget Sound deltas. That work did not identify trends, however, since no data were developed for interim years. A recent study of the geology of Commencement Bay (Hart-Crowser, 1981) presented a series of maps comparing the extent of wetlands in the Puyallup Estuary for 1880, 1924, 1949, and 1978. No areal extent or trend data were developed, however. The only published information on trends in wetland losses is that prepared for the Snohomish Estuary (SHAPIRO/Driscoll, 1978). In an unpublished study, however, SHAPIRO (1982) developed preliminary trends of wetland losses in Lake Washington, Commencement Bay, and Grays Harbor. This work involved a review of existing literature and planimetry of historic maps and photographs. A substantial discussion of the trends in wetlands development was also prepared as part of this work.

Data Analysis

The changes in wetlands of western Washington were analyzed by comparing the acreage of marsh on maps published in three years for the same location.

For Tacoma and Chehalis Regions. First, the acreage of marsh was measured on the 30 minute USGS topographic map dated in early 1900's. Second, the wetlands which showed up on the 30 minute map were measured on the 15 minute USGS maps (circa 1930's). The third step in the process was to calculate acreage of marsh from the 7.5 minute USGS quads (circa 1970's). In taking the measurements from the 15 and 7.5 minute maps, it was recognized that small (< one acre) wetland parcels may not have appeared on the 30 minute maps for one of two reasons--(1) the marshes have been created since the early 1900's when the 30 minute map was published, or (2) the wetland may have existed in 1900; however, the size of the wetland was sufficiently small so that it did not appear on the small scale 30 minute map. This second reason was assumed to be the case for tiny wetlands (< one acre); therefore, they were excluded from the trend analysis to prevent bias and unreal impression of overall increase in wetlands since 1900. Each of the marsh areas measured was compared on all three maps before using them as acreage figures in the trend analysis. In several instances an extensive marsh area appeared on the 7.5 minute quad, which had not appeared on the other maps. In these cases, the acreage was assumed to be newly created marsh and the number was left in the analysis.

For Grays Harbor and Willapa Bay. Navigation charts for selected years since early 1900's were compared for both Willapa Bay and Grays Harbor estuaries and acreage a marsh were calculated for both locations. The intertidal and open water areas were also calculated for Grays Harbor in order to better determine the extent and cause of changes made in that estuary. Human activities such as dikings, filling, and dreding were determined.

The maps were closely examined to determine the cause for the changes in wetlands. Marsh area lost due to diking was calculated for both bays. Other sources were consulted to confirm the time and extent of dreding, filling and dredge disposal activity in the estuaries. A record of the type of activity and the wetland change was made where possible; some of the damages could not be accounted for and were included only in the marsh totals.

Chehalis and Tacoma Region

Three 30-minute maps of inland areas were chosen for analysis of wetland trends since 1900. The NW quarter of the Chehalis Quad was compared with the Tenino 15 minute map and the four 7.5 minute quads: Maytown, East Olympia, Tenino SW, and Bucoda. NE quarter of Chehalis 30 minute map was compared with Yelm 15 minute map and the four 7.5 minute quads Weir Prairie, McKenna, Lake Lawrence, and Vail. SW 1/4 Tacoma 30 minute map was compared with the Tacoma South 15 minute map and the four 7.5 minute quads: Spanaway, Tacoma, South, Frederickson, and Puyallup. SE 1/4 Tacoma 30 minute map was compared with the Lake Tapps 15 minuute map and the four 7.5 minute quads: Sumner, Buckley, Orting, and Wilkeson. For the Tacoma region, a 1981 acreage figure was obtained by comparing the USGS 7.5 minute quads with the National Wetlands Inventory (NWI) maps for the same quad. No NWI coverage was available for the Chehalis region.

C. EVALUATION OF PROGRAMS AFFECTING WETLANDS

In order to assess the effectiveness of SMA and the Shoreline Master Programs in regulating development in wetlands, interviews were conducted with about 30 shoreline planners from the 15 coastal counties. The interviews were conducted as a four-step process:

- Presentation of study to the Puget Sound Coastal Zone Planners Group
- Description of the study and interview process to each participant individually
- Distribution of questionnaires
- Telephone interviews

Soon after the project began, a presentation was made to the Puget Sound Coastal Zone Planners Group to describe the purpose and approach of the study. The presentation included a discussion of the interview process and presentation of a draft questionnaire for review and comment. Revisions were made to the questionnaire based on comments received.

Following the development of the final questionnaire, each recipient was telephoned to describe the study and request assistance with the questionnaire. Due to the length of the questionnaire, no request was made for written responses. Each respondent was requested to only make notes for responses; the consultant team would then conduct the interview by telephone. It was hoped this method would reduce the time required of the repondents and also allow the interview to concentrate on issues of importance to each jurisdiction.

Questionnaires were mailed to each respondent immediately after the first telephone contact. The interviews lasted about one hour, although a few actually required two hours to complete. All of the respondents were extremely open and supportive of the work. The discussion of results is a summary of the responses received.

D. OTHER APPROACHES TO WETLANDS PROTECTION

Leaders of local conservation groups and botanical societies were contacted by phone to obtain information about programs which help to protect wetlands. Existing literature was consulted for the discussion of land acquisition, property tax schemes, mapping and inventory efforts, and tax incentive programs.

IV. RESULTS

A. WETLAND INVENTORY

Wetland Type Descriptions

There are numerous definitions of "wetlands" with no one ecologically sound and correct definition. The reason for this is the wide diversity of wetlands and the varied needs for defining them for evaluation and management. For the purpose of this inventory, wetlands are defined from Cowardin, et al., 1979, as follows:

> "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."

This inventory was completed at the highest level of the classification hierarchy, inventorying wetlands in broad systems and classes. The three major systems inventoried were estuarine, lacustrine, and palustrine. Riverine systems were not included because the area could not be accurately measured and the values would be misleading. In addition, very few riverine vegetated wetlands have been identified in the study area.

(1) Estuarine: This system consists of deep water tidal habitats and adjacent tidal wetlands which are strongly influenced by the ocean waters. The salinity of estuarine waters varies in response to freshwater land runoff, tides, evaporation, precipitation or wind. The estuarine system extends upstream and landward to where ocean-derived salinity measures less than 0.5 $^{0}/_{oo}$ (parts per thousand). Estuaries are highly productive ecosystems and support extremely diverse life forms.

(2) Lacustrine: Permanent standing water systems, either fresh or salt water, which exceed 20 acres or, if under 20 acres, 6.6 feet depth at deepest topographic depression. The vegetation present depends on substrate and depth and consists of floating-leaved aquatics, submerged aquatics, and macroalgae. They are important for fish, waterfowl, shorebirds, aquatic mammals, and amphibians.

(3) Palustrine: This system includes all persistent wetlands adjacent to lakes, streams, bays, and estuaries with salinities of less than 0.5 $^{0}/_{oo}$. They are typically called marshes, freshwater swamps, bogs, and ponds. They are vegetated by trees, shrubs, persistent emergents, and emergent mosses and lichens. These wetlands provide excellent nesting, feeding, and resting habitat for a variety of wildlife.

Each class describes the general appearance of the habitat in terms of either the dominant life form of the vegetation or the physiography and composition of the substrate. The classes used are described as follows:

(1) Aquatic Bed - This habitat type is dominated by plants that grow principally on or below the surface of the water. These include kelp beds, seagrass beds, aquatic mosses, and other algal associations.

(2) Emergent - These wetlands are dominated by emergent herbaceous angiosperms. Most species are perennial plants. Common plants of this habitat type include sedges, rushes, grasses, salt grasses, pickleweeds, and cattails. These wetlands are commonly called marshes, wet meadows, and sloughs.

(3) Scrub/Shrub - This habitat is dominated by shrubs or small trees less than 20 feet tall. They may represent a successional stage leading to forested wetland. They are commonly called shrub swamps or bogs. Common plant species are willows, alder, red osier dogwood, and spiraea.

(4) Forested - These are forests which are saturated or inundated sometime during the year. The tree species commonly found include alder, willow, black cottonwood and Sitka spruce. The woody vegetation is usually very dense and greater than 20 feet tall.

If vegetation cover is less than 30% of the substrate, the physiography and composition of the substrate are the principal characteristics used to describe the habitat. These are described below:

(1) Open water - This habitat type includes a wide variety of water bodies (i.e., streams, lakes, bays) where the bottom characteristics are unknown. Phytoplankton is the primary producer of the open water habitat.

(2) Flat - This substrate is usually mud, although silt/sand or cobble/gravel may be intermixed. They are irregularly shaped, nearly level unconsolidated sediments sheltered from strong currents and wave action. This habitat is highly productive for benthic invertebrates.

(3) Rocky shore - The bottom is 75% of more bedrock, stones, or boulders. Rocky shore habitats are exposed to continuous erosion by wind and waves, but are usually stable enough for sessile or sedentary invertebrates and some attached algae.

(4) Beach bar - This substrate consists of unvegetated and sloping land forms determined by waves and currents. It is composed mostly of unconsolidated sands and/or cobble/gravel and is located in the intertidal zone.

The terms Flat, Rocky Shore, and Beach Bar have been reclassified with the term unconsolidated shore in the current NWI classification system.

Table 3

TOTAL ACREAGE COVERED BY INVENTORY

County	Approximate Area Covered by Inventory (Acres)			Total County Area (Acres)	Percent of County Covered
	NWI	CZA	Other		
Clallam		31,400		1,121,600	3%
Grays Harbor	111,000		63,400	1,222,300	14%
Island	135,400	74,000		135,400	100%
Jefferson	291,000	50,000	1,300	1,555,300	30%
King	1,500	5,900	640,000	1,363,800	47%
Kitsap	251,000	66,500		251,300	100%
Mason	111,000	55,700		615,900	27%
Pacific	52,000		95,400	581,200	25%
Pierce*	458,000	52,700		1,072,600	48%
San Juan	90,000	67,900		114,800	100%
Skagit		52,800	1,110,100	1,110,100	100%
Snohomish*	392,000	26,700	159,000	1,342,800	43%
Thurston*	114,000	29,800		456,900	31%
Wahkiakum*			3,700	116,800	3%
Whatcom*	308,000	26,600		1,360,800	25%
TOTALS	2,314,900	540,000	2,796,700	12,421,600	45%

Total inventoried acres = 5,651,100
This is an estimate with some overlapping between NWI and CZA coverage.

*Additional NWI map coverage has been completed for these counties; however, it was not available at the time of this report.

Inventory Results

This section will discuss the areal extent of wetlands in 15 coastal counties. The wetland inventory covered about 45% of the total area of these counties (see Table 3). Island, King, Kitsap, San Juan, and Skagit County inventories have complete county coverage. The following counties have excellent coastal coverage and less than 30% inland coverage: Clallam, Grays Harbor, Jefferson, Mason, Pacific, Thurston, and Whatcom. Appendix A indicates the portion of each county covered by this inventory. Figure A-1, Appendix, indicates the extent of existing NWI coverage, and NWI coverage included in this inventory by 7.5 minute quads. Not all completed mapping was available at the time of this report.

Approximately 246,000 acres of wetlands were identified in this inventory (see Table 4). This represents the total wetland area in western Washington as determined from the numerous available sources.

Data on the distribution of wetlands, in the form of maps and inventories, are most comprehensive and detailed for the tidal shorelines of counties around Puget Sound and the inland waters; here the National Wetland Inventory (NWI), Coastal Zone Atlas and local shoreline inventories provide considerable overlapping coverage. For non-tidal wetlands, NWI and inventories of King and Skagit Counties provide the most comprehensive data.

Table 4 is the sum total of all the individual county summaries. [Note that the size distribution acreage figures do not always equal the total acreage for each wetland type (see Table 4 and county summaries). This is due to the limitations of available data. The area of individual palustrine and lacustrine wetlands was measured directly and recorded by size class for each NWI quad. These figures were then summed to obtain the total area. Estuarine wetlands area, however, was obtained from the Coastal Zone Atlas (CZA) computer summaries that do not indicate wetland size.] See Appendix A for individual county inventories. Table 5 is a summary of all estuarine, lacustrine, and palustrine wetlands by county.

There are about 166,000 acres of estuarine type wetlands in the study area. This is 70% of the total wetlands identified. Unvegetated beach substrate and subtidal aquatic beds account for 86% of this estuarine total. A total of about 17,500 acres of lacustrine wetlands were inventoried. This represents 8% of the total inventory; over 96% of this area is open water habitat. The approximately 51,200 acres of palustrine wetlands represent 22% of the total. A majority (85%) of the palustrine type are vegetated wetlands (emergent, scrub/shrub, and forested).

Estuarine wetlands are found in every county along the shoreline. Pacific and Grays Harbor County account for 42% of the acreage, because these areas are huge enclosed bays highly influenced by the ocean. Puget Sound estuaries are formed from riverine delta systems, with the larger rivers producing the large estuaries (e.g., Snohomish River--13,855 acres of estuarine wetlands in Snohomish County). Other areas with a large distribution of estuarine habitat are counties with irregular coastlines, producing many small bays and inlets. Island, San Juan, and Kitsap Counties are examples of these.

Table 4

SUMMARY OF WETLANDS INVENTORIES FOR 15 COUNTIES

Wetland Type	Total Area (Acres)	Size Distribution (acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate*	80,529	--	--	--			
Emergent	23,743	854	3421	12,820			
Scrub/Shrub	67	37	29	--			
Forested	3,038	16	--	528			
Subtidal							
Aquatic Bed	70,399	--	--	--			
Unconsolidated	12	--	--	--			
Lacustrine							
Open Water	16,678	23	4339	5942			
Aquatic Bed	351	4	347	--			
Emergent	145	--	145	--			
Unconsolidated	275	--	275	--			
Palustrine							
Open Water	6718	3049	2102	115			
Aquatic Bed	722	268	454	--			
Emergent	17,612	6356	6508	1716			
Scrub/Shrub	15,756	3866	9158	1850			
Forested	10,298	1870	5908	1084			
Unconsolidated	77	30	47	--			

Total: 246,420

Sources: See individual counties

*beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

Table 5

SUMMARY OF WETLANDS INVENTORIES FOR 15 COUNTIES

County	Estuarine (Acres)	Lacustrine (Acres)	Palustrine (Acres)	Total Wetlands (Acres)
Clallam	4,667	0	207	4,874
Grays Harbor	31,702	439	2,831	34,972
Island	15,607	86	2,026	17,719
Jefferson	9,541	411	1,851	11,803
King	5,856	1,716	11,685	19,257
Kitsap	13,614	1,154	2,971	17,739
Mason	6,392	1,075	1,630	9,097
Pacific	38,108	60	2,747	40,915
Pierce	6,497	2,903	4,777	14,177
San Juan	6,655	112	807	7,574
Skagit	12,080	6,343	4,776	23,199
Snohomish	13,855	141	6,116	20,112
Thurston	4,077	1,236	1,191	6,504
Wahkiakum	3,730	0	0	3,730
Whatcom	5,407	1,773	7,568	14,748
	177,788	17,449	51,183	246,420

Lacustrine wetlands are essentially open water lakes, with a minimal amount of vegetated wetlands adjacent to them. Most lakes are over 20 acres in size. Counties with the highest lacustrine figures reflect the counties with the most complete inland coverage instead of the counties with the most lakes. Skagit with 6,343 acres and Pierce with 2,903 acres are counties with large-size lakes and reservoirs, and enough inland coverage to have them inventoried.

Palustrine wetlands are distributed next to lakes, ponds, streams, bays, and estuaries. It is important to note that county totals are more representative of how complete the inventory coverage is in that county than the total amount of palustrine wetlands. For example, King County has the largest amount of palustrine wetlands, 11,685 acres, collected from a recent county-wide field checked inventory.

Factors to consider which determine the distribution of palustrine wetlands is the physical topography and amounts of lakes, ponds, and streams. Counties with lots of palustrine wetlands tend to have large areas of relatively flat low elevation lands. King County is a good example of this. Large lakes such as Lake Washington in King County have extensive areas of palustrine wetlands associated with them.

Vegetated Wetlands Inventoried

Emergent, scrub/shrub, and forested types are considered vegetated wetlands. Table 6 presents a summary of type and size distribution of these wetlands. Very little lacustrine vegetated wetlands exist because only non-persistent plants are classified. The amount of emergent vegetation is similar in estuarine and palustrine wetlands. What is important to acknowledge is the differences in size distribution. Most estuarine wetlands (75%) are over 100 acres in size, while palustrine wetlands are usually either under 10 acres (43%) or between 10 and 100 acres (45%). A total of 635 acres of estuarine scrub/shrub or forested vegetation types were inventoried while palustrine scrub/shrub and forested wetlands account for 52,108 acres. Only 12% of these palustrine wetlands are above 100 acres in size, with a majority falling in the 10 to 100 acres (62% to 67%) size.

Wetland Regulations

It is important to determine what percentage of wetlands, and what types, are protected by jurisdiction either by U.S. Corps of Engineers 404 permit or the Shoreline Management Act (SMA). All estuarine wetlands are under both SMA and Corps 404 permit jurisdiction. Lacustrine wetlands containing lakes larger than 20 acres are protected by the SMA. Watershed size is a factor used to determine if palustrine wetlands and lacustrine waters under 20 acres are under jurisdiction by the following criteria:

- A 2,000 acre watershed produces a mean annual flow of about 5 cfs--Corps 404 permit minimum.
- An 8,000 acre watershed produces a mean annual flow of about 20 cfs--SMA minimum.

Table 6

VEGETATED WETLANDS INVENTORIED

	Total Area (Acres)	Size Distribution (Acres) <10	10-100	>100
Emergent				
Estuarine	22,483	854 (5%)	3,421 (20%)	12,820 (75%)
Palustrine	17,612	6,356 (43%)	6,508 (45%)	1,716 (12%)
Lacustrine	145	-0-	145 (100%)	-0-
Scrub/Shrub				
Estuarine	67	37 (56%)	29 (44%)	-0-
Palustrine	15,756	3,866 (26%)	9,158 (62%)	1,850 (12%)
Forested				
Estuarine	568	16 (6%)	-0-	528 (94%)
Palustrine	10,298	1,870 (21%)	5,908 (67%)	1,084 (12%)
TOTAL (acres)	66,929	12,999	25,169	17,998

Total acres of wetlands inventories: 246,420

Vegetated wetlands represent 27% of the wetlands inventoried

Analysis was limited to data from King County. Palustrine vegetated wetlands were found in the following watershed sizes:

- 8 wetlands (318 acres) are under SMA jurisdiction
- 30 wetlands (1,818 acres) are under Corps 404 jurisdiction
- 500 wetlands (6,655 acres) are not under the jurisdiction of SMA or Section 404

Seventy-six percent (76%) of the palustrine vegetated wetlands acreage in King County are unprotected by SMA and Section 404. If this is the trend for all 15 counties, large amounts of wetlands are under no jurisdiction. Information on watershed size for additional counties is needed to document this.

B. TRENDS

Introduction

The classic and often repeated view of the Pacific Northwest is mountainous, steep terrain densely covered by evergreen forests of fir, hemlock, and cedar--all of this clothed by gray skies and incessant rainfall. While the view is essentially accurate for western Washington, it should be noted that east of the Cascade Mountains, the northwest is more often characterized by sagebrush and grasslands; cold, dry winters and hot, dry summers.

Ocean and stream resources (fisheries) and timber have historically been the economic base of the Pacific Northwest. In addition, the maritime climate supports farming and dairy activities, which have contributed to the economy since the state was formed in 1889. Historically, the major industry has been logging and lumbering. Puget Sound is a natural harbor to which shipping and trade, both domestic and foreign, became important in the mid-nineteenth century.

Prior to the completion of the railroad, access to western Washington was difficult except by sea. Early trade existed between San Francisco and Puget Sound; lumber was shipped to San Francisco in exchange for various industrial and domestic goods to supply the growing population of Washington. Although fishing was important to the people of the state, the primary bargaining resource was Washington's lumber and wood products. Several factors contributed to the development of western Washington as a major shipping and trade center. The sailing distance to the Orient and Russia is less than from any other port on the Pacific coast; completion of the railroad to western Washington established Seattle and Tacoma as gateways to the Orient. By 1921, more than 50% of all commerce from the Pacific coast passed through Washington, and the Port of Seattle had the largest commercial pier in the world (Meeker, 1921).

The major manufacturing industries during the pre-World War II and war years were lumber and wood products, food processing, especially canning of fish and produce, and the airplane and associated products. With the growth

of the airplane industry, the region became increasingly dependent on military spending. The economy boomed during wartime and waned when military aircraft were not needed. Meanwhile, the forest products industry became more diversified; pulp and paper, finished wood products and wood research expanded the economic base.

The trend in the past two decades has been toward development of "footloose" industries related in some fashion to the booming aircraft industry, specifically Boeing Company. Such industries include airplane and missile production, electronics, central offices, aluminum, steel and machinery. Recreation and the production of recreation products has also become important to the economy.

Western Washington has been selected as the area for this study both for its consistency of regulatory activity at federal and state level, and its diversity of wetland types and development pressures. Throughout the study area, the same regulations are implemented at the federal and state levels and, for the most part, the same personalities are responsible for implementing them. Differences in regulation and personalities exist primarily at the local level.

In contrast, there are significant differences in wetland systems and the development pressures associated with them. (Figure 1 depicts the regions of western Washington and identifies the study areas.) The northwest corner of Washington is a maze of islands and interconnecting fjord-like waterways. The entire area is often referred to as the Puget Sound region. Tidal wetlands are limited to river mouths where extensive intertidal lands and substantial freshwater runoff combine to characterize the ecosystem (Boule', 1981). (Although only the southern portion of the area can be accurately called Puget Sound, the term will be used here for purposes of simplicity.)

Along the Washington coast, the Pacific Ocean dominates the wetlands, although freshwater runoff is still a major component. Here, tidal wetlands are found in large embayments with extensive intertidal flats. Although freshwater runoff is substantial here also, the wetlands are much more saline than those of the Puget Sound area.

Non-tidal inland wetlands are also common in the region. Many are forested or shrub swamps in saturated (not inundated) soils and often are unrecognized as wetland habitats by untrained observers. Perhaps the most well known of inland wetlands, however, are those found on the shores of the innumerable lakes of western Washington. Often these are small embayments or narrow shoreline areas dominated by cattails, tules, or water lilies.

Just as the types of wetland ecosystems vary in the region, the development pressures also vary. In much of the Puget Sound region, early development of estuarine wetlands was oriented toward creating agricultural lands. The rich peaty soils were often the only flat ground available for tilling. In addition, wetlands lacked the rocks and clay of adjacent upland areas. Furthermore, their close proximity to waterways, the major travel corridors of the time, made them prime areas for development. Early construction of dikes and drainage ditches created vast acreages of farmland

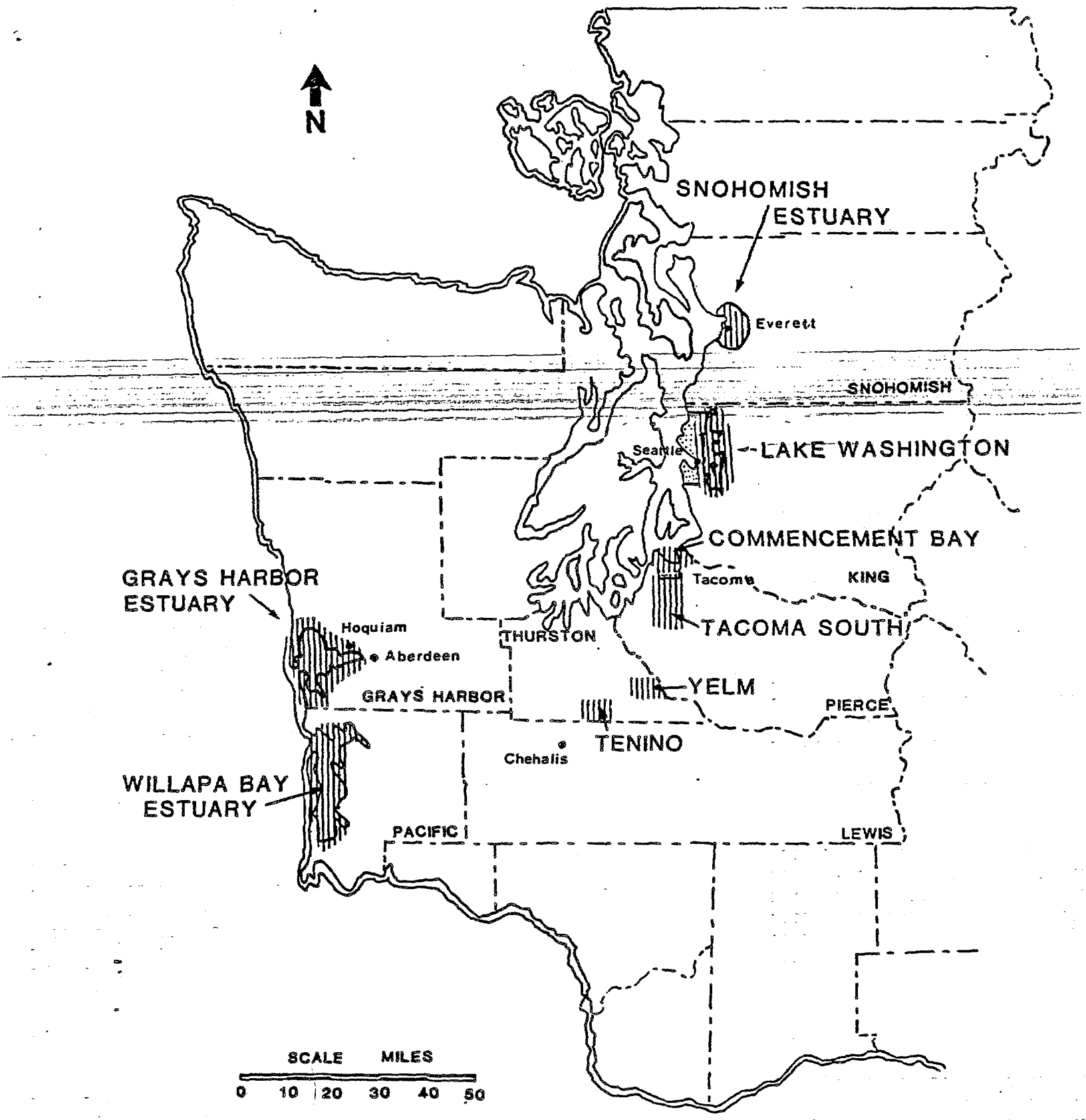

Figure 1. Western Washington. Location of the eight study areas.

from the marshes and swamps of the numerous estuaries. In much of the Puget Sound region, this agricultural activity continues today.

In a few areas, early industrial and port development precluded major agricultural activities. In Seattle and Tacoma, river mouth areas were dredged to provide navigation channels and filled to create locations for wharves, warehouses and industries. In these areas, early agriculture was established farther upriver, but still close to the urban centers which spawned the industrial activities.

Along the coast, the timber industry dominated early economic activities and still does today. Cutting, milling, and shipping lumber are the major industries. Neither agriculture nor urban development are as important. The export of lumber requires navigation channels. In these shallow bays regular dredging is necessary to maintain the channels. Historically, dredge material was disposed of in any place that was "out of the way." Often this was nearby intertidal flats or marshes, unvegetated and vegetated wetlands. Frequently, it was close to port facilities, thus creating more flatland for port expansion. In recent years, however, the dredging projects of the Corps of Engineers have been oriented toward upland or deep water disposal.

In contrast to tidal wetlands, lakeshore wetlands of western Washington have been developed almost exclusively for residential purposes. Initially, these were summer homes, but with urban growth, many of the lakes have been incorporated into nearby cities. As this happens, summer home development expands to lakes further from urban centers. Residential development may include: bulkhead construction and filling to establish a yard; clearing and minor filling with sand to create a beach; minor dredging for boat access; or simply continual mowing to create a lawn. In each case the alterations may be minor, but the cumulative effect is elimination of wetlands along most, if not all, of the lake shore.

In each of the wetlands systems described, the economic and physical factors leading to development of the wetlands are very different, both in goal and scale. Many of the individual factors are not unique to western Washington. The combination of factors is unique, however, and should be considered in any comparison of wetland development on a nation-wide basis. Important factors include:

- Relative youth of settlement in the Pacific Northwest;
- Rugged terrain which limited overland travel and available agricultural land;
- Early dominance of fishing and timber industries;
- Boom conditions created by the Alaska gold rush, proximity to Pacific Rim countries, and railroal terminals, and associated demand for port facilities; and
- Economic dependence on the aerospace industry since World War II and rapid population growth over the last two decades.

Site-Specific Studies

Snohomish Estuary

The Snohomish is the third largest river entering the Puget Sound region (behind the Fraser River in British Columbia and the Skagit River). The estuary is located about 35 miles north of Seattle (see Figure 1) and consists of four anastomosing channels (or sloughs) separating six major islands. The City of Everett, at the river's mouth, is the northern limit of western Washington's major urban area, which includes Seattle, Tacoma, and Olympia to the south.

The 10,000 acre estuarine system is a classic example of the agriculture-dominated scenario discussed in the previous section. Earliest settlement began around 1880 with diking of small portions of wetland on several islands. During the next 60 years, diking activities slowly converted most of five islands, almost 9,000 acres of wetland, into farmland. As is apparent from Figure B-1, almost all wetland conversion prior to World War II can be attributed to agricultural expansion; essentially no filling occurred during this period.

Prior to the war, the mills and port facilities at Everett were limited mostly to upland areas where piers could be extended out to deep water. Industrial and port expansion began just before the war and continues to the present time. Much of this expansion has entailed the filling of intertidal flats and marshes to provide the space required by modern manufacturing and shipping facilities. Furthermore, as a result of the development of large scale earth-moving machinery, fill became much more cost effective than piers and piling as a means of constructing near-shore foundations. Figure B-1 shows the wetland loss associated with this slow but steady expansion of industrial activity since 1940. Although the area involved is much smaller than that used previously for agriculture, two aspects of the industrial development of wetlands have major impacts. First, filling is a much more permanent elimination of wetland habitat; diking impacts can be readily reversed by breaching the dike. Second, the result of industrial development was the filling of some of the last wetlands of the estuary.

Since about 1965, there has been a slow, steady filling of wetlands on one island in the estuary with urban waste. The site was closed about 1979 after almost 200 acres had been filled. This was the major fill activity within the estuary at that time. During the same period, most industrial activities and the associated fills occurred on the shores of Port Gardner, not in the estuary. Most of these fills were in unvegetated flats, although a few vegetated wetland areas were also filled. These fills totaled approximately 60 acres between 1970 and 1980. Other than the solid waste disposal site, wetland fill activities within the estuary between 1970 and 1980 were generally small in scale, scattered, and infrequent. Less than 70 acres of vegetated wetlands within the estuary were filled during the decade; two woodwaste and dredge material disposal sites account for almost 50 acres.

One other interesting phenomenon is apparent in Figure B-1. Wetland area actually increased in the Snohomish estuary between 1947 and 1970. This was caused by several dikes being breached during floods and not being repaired. As a result, agricultural lands reverted to wetland habitats.

This suggests that agricultural use of the land at that time was not sufficiently productive, economically, to justify repairing the dikes. This occurred at the same time that industrial activities were beginning to fill other wetland areas.

As is apparent, most of the wetland losses in the Snohomish area can be attributed to early agricultural development in the region. The tidal freshwater conditions of the region's estuaries meant that there were no concentrations of salt in the soils; thus, diking and draining converted wetlands to farmlands. At the time, of course, there were no regulations to limit development of wetland areas. Furthermore, there was a strong ethic throughout the country to control and develop the land. Clearly, the conversion of wetland (wastelands) to productive agricultural lands fulfilled that ethic.

Tacoma

The wetlands in the SW quarters of the Tacoma 30 minute quadrangle are scattered palustrine emergent marshes associated with the Puyallup River, Muck Creek, and Spanaway Lake. In 1900 there were 2,760 acres; in 1944, 1,050 acres; and by 1956, only 838 acres remained of the original 2,760. According to the NWI inventory, 784 acres of marsh remained in this region. The above changes are reflected in Figure B-2, Tacoma South. Urbanization and diking of agricultural land appears to be the primary reason for wetland loss. Seventy percent of the loss occurred between 1900 and 1950. Since then the changes have been small and related to development in outlying areas. The NWI maps show 192 acres of new wetland which did not appear on the 1956 quad. The presence of these new wetlands cannot be explained conclusively from the maps alone, but they may be a result of hydrological changes following construction or suburban development, or they may simply have been missed in 1956.

The SE quarter of Tacoma or Lake Tapps region (Figure B-3) had only 373 acres of wetland in 1900, excluding the open water of Lake Tapps. The White, Puyallup, and Carbon Rivers enclose the major wetlands of the region, including Morgan Lake, Orting Lake, and Rhode Lake. No wetlands were indicated in the SE quarter of the 1900 Tacoma quad; however, numerous sizable wetlands appeared in this same place on the later maps indicating that they were either omitted in the earlier mapping or newly created, perhaps by road construction diking.

Commencement Bay

The estuary at the mouth of the Puyallup River provides an example of early industrial development in Puget Sound region tidal wetlands. The Port of Tacoma on Commencement Bay, like the Port of Seattle 30 miles to the north, developed as a commercial center soon after settlement began. The deep waters of the bay immediately adjacent to broad expanses of tidal unvegetated flats and vegetated wetlands represented prime conditions for port facilities.

Pierce County, including the City of Tacoma, had a population of about 3,300 in 1880. The transcontinental railroad was completed to Tacoma in 1887; by 1890 the county population was over 50,000. Completion of the

railroad to Tacoma was a major impetus for the growth of the Port of Tacoma. Lumber, coke and fish were major commodities for export. Construction of a copper smelter on the shore of Commencement Bay in the early 20th Century was a precursor of the numerous chemical processing plants present at the Port today. By World War I, Tacoma was a major industrial community in western Washington with a substantial port facility.

Waterways were dredged through the flats and marshes and the dredged material discharged onto adjacent wetland areas, creating both protected moorages and abundant flat upland areas from vegetated and unvegetated wetlands. Dredge and fill activities began at the river mouth and expanded upriver as more facilities were developed. Figure B-4 shows the continual conversion of unvegetated flats and vegetated wetlands to port facilities from 1880 to the present. Of about 1,700 acres of intertidal flats in 1880, 1,500 had been dredged or filled by 1920. Between 1880 and 1940, about 1,900 acres of vegetated wetlands were filled. By 1980, only 216 acres of wetlands existed in the estuary (Shapiro and Associates, 1981b); 95 acres of these were isolated depressions in fill material which were maintained by upland runoff and 97 acres were unvegetated flats. Only 14 of the original 1900 acres of marsh in the estuary remain today.

Lake Washington

Forming the eastern boundary of the city of Seattle, the 35-square mile Lake Washington is the largest lake in the state. Urban development, primarily residential, completely surrounds the lake, with only a few enclaves of park or undeveloped land remaining. The recent history of urban development around the lake parallels that of many lakes in western Washington.

Early settlement of the lake began with homesteads and small farms all along the shore. Often marshes and swamps were converted to orchards or other agriculture (Hockett, 1976). Coal mining in areas to the south and east in the 1870's led to hopes for factories and industrial activities around the lake. Before this could occur, the era of coal-fired boilers ended, and with it the dreams for industrial development. Establishment of regular ferry service across the lake by 1913 was the impetus for urbanization of the east shore.

Approximately 2,300 acres of wetlands are depicted on a 1902 map of the lake. In 1916 the lake was lowered approximately 8 feet as part of a major public works project, which connected the lake to Puget Sound via the Chittenden Locks. A 1936 map indicates there were about 1,400 acres of wetlands around the lake, concentrated in about 10 major areas (Ellman and Schuett-Hames, 1978). Since 1936, about 500 acres have been filled, primarily for urban residential or commercial activities. Figure B-5 shows the decline in wetlands around the lake since 1916.

It should be noted that while early development of wetland areas on the lake involved complete use of the land, recent developments have been more limited. Since implementation of the Shoreline Management Act, most development activities have included permanent dedication of a portion of the wetlands for preservation of the habitats.

Chehalis

Being the outwash plain of the Vashon glacier, much of the Chehalis quad topography is comprised of prairie lowlands, lakes, and river corridors surrounded by low hills. This portion of Thurston County has traditionally been used for agricultural purposes, large tracts are set aside for growing crops or pasturing livestock. More recently, new residential areas and the growth of the town centers have had more effect on the wetland habitats. The Tenino quad contained 4,480 acres of wetland in 1900, 2,300 acres in 1944 and 2085 in 1956 (see Figure B-6). The Yelm quad showed a similar trend with 2,680 acres measured in 1900 and a low of 1,093 acres in 1956 (see Figure B-7). The losses in some cases were due to placement of fill during road construction, other areas have been eliminated by residential development, and still others seem to have been altered by natural changes in the high water table of the outwash plain. No NWI coverage was available to measure the 1981 value of wetlands in the area. (These maps have been ordered from the U.S. Fish and Wildlife Service and the current wetland value for both Tenino and Yelm quads could be calculated to determine the trend since 1956.)

Grays Harbor

One of two large embayments on the Washington coast, this area has a history of wetland development very different from that just described for the estuaries of the Puget Sound region. Grays Harbor has never been a major urban center. It is, however, the economic center of a major timber harvesting area. Since its first settlement, it has existed almost exclusively as a logging and lumber export area.

The Chehalis River forms two main channels through Grays Harbor and sections the estuary into the north and south bays. The North Bay is fed by Hoquiam River, Grass Creek, Chenois Creek, Humptulips River, John and Campbell Sloughs, Point Brown, and Ocean Shores Spit form the western boundary of the North Bay. South Bay is the main body of water in the southern half of the estuary. It is fed by Johns River, Elk River, and Beardslee Slough. Point Chehalis and Westport are located on the southern spit forming the western boundary of South Bay.

Lumber export requires modern accessible port facilities to remain a viable industry. In Grays Harbor, almost continual dredging is required to maintain the north and south Chehalis navigation channel through the shallow bay. The dredging activities have required the discharge of immense quantities of material. In early years this was deposited close to the channel; later confined "spoil areas" were constructed on nearby tidal flats or marshes. Today, most of the material is disposed of on upland sites or in deep water offshore.

Numerous changes, both natural and human, have occurred in the Grays Harbor Estuary since 1900 (Figure B-8). The greatest area of marsh existed in the estuary around 1960 having increased from 3,580 in 1916 to 4,690 by that time. This increase reflected a major conversion of upland to marshland on the Ocean Shores peninsula between 1916 and 1960. Another significant gain between 1931 and 1960 was the conversion of intertidal mudflat to marsh by dredge disposal west of the Hoquiam River and northeast of

Bowerman Field (Corps of Engineers, 1975). Upland, marsh, and intertidal areas were all used for dredged material disposal prior to 1960; therefore, the change in marsh area reflects a conversion of intertidal to marsh as well as some loss of marsh to form upland habitat.

Some losses in the extent of wetlands can be identified. Approximately 500 acres of flats were converted to uplands prior to 1916. Between 1916 and 1942, all dredged material was deposited in deep water within the harbor. Between 1940 and 1975, about 3,800 acres of intertidal area were used for dredge material disposal. The Corps reverted to deep water or upland disposal in about 1976. Although there have been no wetland losses due to dredged material disposal since 1976, approximately 500 acres of fill are proposed as part of the Grays Harbor Estuary Management Plan. About 90 acres of this is vegetated wetlands, the remainder is intertidal flats.

Between 1960 and 1967, approximately 900 acres of swamp habitat was eliminated due to filling or diking. Most of this change can be attributed to the construction of the railroad track along the South Channel. Approximately 1,400 acres of marsh were converted to upland on the Ocean Shores spit presumably by diking and filling between 1967 and 1973. This major loss was offset by a conversion of 640 acres intertidal flat to marsh near Point Brown (440 acres) and north of Bowerman Airport (200 acres). The most recent (1981) navigation chart shows approximately 2,200 acres of wetland remaining in the Grays Harbor Estuary. Several areas of marsh have diminished or been eliminated while others have been created to equal a net loss of 1,560 acres of marsh since 1967. The large marsh (265 acres) on the east side of the Ocean Shores spit was reduced to 185 acres by 1981. Several of the small brackish marshes along Beardslee Slough off of South Bay were eliminated apparently because of diking or road construction. Other changes occurred in two major dredged material disposal sites along the North Channel: Point New and Bowerman Field. The net effect was a loss of 160 acres of salt marsh between 1973 and 1981. Approximately 175 acres of marsh were created in several intertidal areas near Point Brown southeast of Westport and in the Whitcomb Flats. ALthough numerous human activities have greatly altered the shorelines of Grays Harbor, the overall change in intertidal flats has been negligible as has the change in open water (Figure B-8). Total acreage of the estuary was increased by about 700 acres since 1900 because of the jetty construction which placed the boundary of the mouth of the harbor about 3,000 yards west of the earlier locations (Figure B-8). The values represented on the graph for open water and total estuary acreage are estimates based on measurements of the major channels and waterways of the harbor. They are placed in the figure to show the comparative changes in intertidal and marsh areas in relation to the total estuary over time and they should not be used as inventory values.

The long history of dredged material disposal has created several large tracts of upland suitable for development of port facilities. It also appears to have contributed to an attitude that filling wetlands with dredged material to create upland sites for port development is a reasonable and acceptable approach. In recent years, the conflict between the economic and environmental concerns relating to this attitude has become a major controversy in the region. The Grays Harbor Estuary Management Plan is an attempt to reconcile those differences.

Willapa Bay

This large embayment is located at the mouth of the Willapa River on the coast of Pacific County. Extending over 20 miles south of the mouth, the bay is fed by the Palix, Naselle, and Nemah River systems as well. The west boundary of the bay is the North Beach Peninsula, a long spit where the towns of Ocean Park, Oysterville, Oceanside, Long Beach are located. Long Island is a large land mass in the center of Willapa Bay now preserved as the Willapa National Wildlife Rrefuge and containing the Diamond Point Research Natural Area. Over 50% of the bays are wetland habitats: intertidal mudflats, salt marshes, brackish marshes, and freshwater marshes (Table B-2).

Early settlers of the Willapa Estuary found the tideland grasses to provide good spring and summer pasturage. Low dikes were erected by hand to hold off the summer high tides and to protect farm buildings. Higher dikes were constructed by some land owners but the diking district provided the basis for high dikes in most areas. The diking districts were granted the right to widen, straighten, and improve rivers, water courses, or streams within the boundaries of the district; the right to acquire the state's rights to wetlands and tidelands within the district boundaries; and the right to contract work and to issue bonds to cover costs of construction and acquisition of land. Five diking districts were formed along the borders of Willapa Bay between 1912 and 1920. The major efforts of these diking districts was to create and protect agricultural land; some 3,500 acres of wetland was diked to form pasture. Roads constructed around the permimeter of the bay effectively blocked off wetland from tidal exchange during the early part of the century.

The early use of the estuary was generally as a transportation system and many of the towns and industries were extended over the bay on pilings. As industry and population increased, some wetlands were filled to provide more area and to provide support for structures previously on pilings. Shotwell (1977) reports that approximately 650 acres of wetlands were filled and used for urban and industrial facilities.

Much of the fill material was dredged from the tributaries of Willapa Bay. Other dredging was done to clear and deepen major navigation channels within the bay.

The general trend of wetlands according to the NOAA navigation charts is a slight increase between 1905 and 1933 then a gradual decline until the present time (Figure B-10). The overall loss of wetlands was about 2,770 acres or about 36% of the original marsh area. Like Grays Harbor, much of the net loss of marshland can be attributed to human activities of diking, dredge material or fill disposal or urban development. Table 7 illustrates some of the changes within the estuary and the approximate year of the activity. Diking has been a major influence since the establishment of five diking districts to promote agricultural development in Pacific County (Shotwell, 1977). The bulk of the lost wetland is the portion that has been converted to diked pastureland. Roads, towns, and industries have all been constructed within the wetlands of Willapa Bay, both intertidal flats and salt marshes. Pilings, fill, and dredged material were all used to stabilize the ground for construction at these sites.

Table 7

SOME CHANGES IN WETLANDS IN WILLAPA BAY ESTUARY
1905-1974

	1905	1912	1933	1955	1974
Total Marsh Area	7,780	7,720	7,760	5,990	5,020
Net Conversions					
Marsh to Intertidal	--	--	--	(-)1,594	423
Marsh to Upland	--	59	--	1,326	206
Marsh to Fill	--	20	--	510	--
Marsh to Diked	--	--	--	1,474	285

Summary and Comparison of Similar Wetland Regions

Prior to 1944, a substantial amount of wetlands were eliminated in the Tacoma and Chehalis regions. An average of 52 acres per year was lost from the Tenino area (Figure B-6) while 36 acres per year were eliminated in the Yelm area (Figure B-7). The rate of loss was much lower (only 4 acres per year) in the Lake Tapps quad from 1900 to 1968 (Figure B-3). Between 1944 and 1953, the rate of loss averaged 33 acres per year in both Tenino and Yelm quads while the Tacoma South area lost a mean of 22 acres per year (Figures B-2, B-3, B-7, B-8). Since 1953, the trend of massive wetlands destruction has slowed to less than 4 acres per year in Tacoma South while Lake Tapps has averaged less than one acre loss per year since 1968 (Figures B-2, B-3). The figures for a current inventory of Yelm or Tenino are not available.

The coastal bays examined for trends showed more dramatic changes in wetlands since 1931 than prior to that time. Although there was a loss in the origiinal marsh area, the net marsh area increased in Grays Harbor between 1916 and 1960 due primarily to the conversion of some upland and intertidal areas to new marshland (some wetland losses were also occurring during this period). This trend ended in 1960 and by 1973 over 2,000 additional acres of marsh had been eliminated from Grays Harbor. There has been little net loss of wetlands in Grays Harbor since 1973 (Figure B-9). The rate of loss was much more consistent in Willapa Bay averaging 45 acres per year since 1933.

The Puget Sound bay showed dramatic losses between 1900 and 1940 where an average of 75 and 150 acres per year were eliminated from Commencement Bay and Snohomish Estuary, respectively. The losses in Commencement Bay continued to occur between 1944 until the wetlands were virtually eliminated by 1980 (Figure B-4). Some of the Snohomish Estuary wetlands were reclaimed between 1940 and 1960 so that the remaining acreage in 1970 is equivalent to that found prior to 1940 (Figure B-1).

C. EVALUATION OF PROGRAMS AFFECTING WETLANDS

As noted earlier, regulation of development activities along shorelines, in wetlands, and in other sensitive areas became an issue of major concern nationwide during the late 1960's and early 1970's. Although the level of concern may have diminished some since that time, the environmental regulations which emerged remain and continue to be enforced. The purpose of this section is to describe those regulations, the concerns and justifications which led to enacting them, the methods to implement them, the difficulties which have arisen, and the resulting effectiveness of them.

Concerns, Reasons, and Benefits

Most respondents indicated that the concern for wetlands protection was both real and justified, although it appeared to be more adamantly expressed in urban rather than rural counties. In rural counties, the concern was sometimes more strongly expressed by local planning staffs than it was by local residents. This obviously may lead to conflicts between the staff and the residents or the elected officials responsible for decision-making.

Within urban areas, it was noted that there were very few remaining wetlands. Generally, those remaining were considered important to protect. "It's nice to have natural areas within the city; the public likes to have these visible." Despite this interest, however, conflicts do arise where wetlands are located in areas slated for major development activities. If these are small isolated areas surrounded by major existing development (e.g., Commencement Bay, the Duwamish River), their importance and value may be questioned. If they are large areas long identified for development (e.g., Bowerman Basin in Grays Harbor), the importance of economic growth may be stressed. Elsewhere (Yarrow Bay in Kirkland, Maltby Swamp in Everett), the demand by the public for protection of wetlands often is overwhelming.

In rural areas, the opinions of the general public may be very different. Wetland areas, especially floodplain marshes, offer rich soils for agricultural activities if they are drained and properly managed. Farming interests often see wetlands protection as an intrusion on their rights to farm, especially since they still must pay taxes on the land. One respondant suggested that wetland values should be measured according to human food production. Logging interests see wetlands as areas of decreased productivity and sometimes obstacles to the easiest logging practices. (Private forest land grading by DNR has presumably tempered the tax issue by reducing the assessed value of these less productive lands.)

In contrast, some rural fishing interests have begun to recognize the value of wetlands to fishery resources. This is particularly true in Wahkiakum and Pacific Counties. It has led to some interesting conflicts. The contrast and humor of "redneck fishermen arguing with redneck farmers" about wetlands protection was noted.

In Island County, where all potable water is drawn from wells, groundwater recharge has become an issue of concern. Although still difficult to prove, this has been stated as a major issue of concern in wetland protection. (This concern may also be valid in San Juan County, although it was

not mentioned.) In several areas, flood water storage and flood damage protection were also noted as major benefits associated with wetlands.

The conflict between the protection and development interests in rural counties is also an important element. The protection interests feel the "locals" don't really understand the importance and values of wetlands. Rural development interests complain they are being dominated by urban expatriots with other sources of income and no understanding of traditional lifestyles.

It appears then that the major recognized benefits from wetlands protection vary between urban and rural counties. In urban areas, the recreational and aesthetic benefits are noted; these benefits are also recognized in rural San Juan County. In rural areas, the more frequently recognized benefits are contributions to fisheries (and waterfowl) resources and flood damage protection. In both areas, however, interference with economic development is often cited as a detriment of wetlands protection.

An interesting aside was noted with regard to a few county Public Works Departments. These agencies are generally not recognized as leading proponents of wetlands protection. Nonetheless, in a few counties they have begun to discourage wetland development in response to the physical problems of settlement and flooding. Some highway engineers, for example, are expressing a preference for roadways on pilings, or even around wetland areas in order to avoid frequent and costly maintenance. Although this is not a prevalent attitude statewide, it does appear to be growing.

There was little concensus with respect to the cause of these concerns. Some were willing to attribute them to SMA, as the first of several regulations. Others felt that Section 404 of the Clean Water Act or the State Environmental Policy Act (SEPA) were more important. Still other respondents suggested that these regulations were more an effect of an overriding general awareness, rather than a cause.

Regulatory Approaches

Shoreline Master Programs

Although there are no programs set up specifically for wetland protection, Shoreline Master Programs are the most common means of regulating development in wetland areas. In many jurisdictions, they are the only local regulation. Generally, these programs "parrot" the SMA Guidelines (WAC 173-16). At the time they were written, few of the jurisdictions felt they had sufficient expertise to expand or modify the guidelines. In addition, in some areas, land use regulation was not well received, and even less so if required by the state. Furthermore, many jurisdictions lacked the technical expertise to evaluate shoreline habitats or identify their significance.

As a result, many shoreline inventories and Shoreline Master Programs (SMP) are considered weak and lacking in specificity. At the same time, however, local planners and the concerned general public, have become better trained in technical areas. Consequently, in many jurisdictions, staff

interpretations, requirements for further information from project proponents, and other regulations, such as SEPA or flood control ordinances, have all been used to strengthen the provisions of the programs.

As written, most SMP's are based on performance standards, rather than strict regulations. Furthermore, many programs use the conditional "should" rather than the absolute "shall." Thus, programs state "projects in the vicinity of marshes, swamps, or bogs should be constructed to minimize impacts on the recognized values of those habitats." Regulations of this type obviously offer considerable flexibility in interpretation and implementation and, as a result, considerable variation in effectiveness.

Other Local Regulations

Many of the local governments in Western Washington have enacted or proposed other ordinances which may effectively protect wetlands from development, even if this was not their principal intent. Among these are grading ordinances, erosion and sedimentation control ordinances, flood damage protection ordinances, and sensitive areas ordinances. In a few cases, comprehensive plans and zoning ordinances have also included provisions for wetlands protection. Of particular interest is that often these types of ordinances apply to areas too small to fall under the jurisdiction of SMA. Table 8 indicates which types of ordinances are used by which jurisdictions. The State Environmental Policy Act (SEPA) also offers a mechanism for local jurisdictions and staff and federal agencies to review developments in wetland areas.

Grading and clearing ordinances generally require a permit anytime a major recontouring of the land surface is proposed. Used alone, or in combination with other regulations, they allow the local jurisdiction to limit potential erosion, sedimentation, or flooding impacts as a result of development activities. Grading restrictions can be used to protect wetland areas from dredging or filling and in some cases may result in the establishment of a buffer zone around wetland areas.

Erosion and sedimentation control ordinances are intended to protect downstream property owners from the effects of watershed development. Here again, although the ordinances are not intended for wetland protection, they often prevent or limit a major secondary impact of development, that is, filling of wetlands from sediment-laden waters. It should be noted, however, that implementation of related surface water management ordinances can actually result in the damage or destruction of wetland areas through creation of sedimentation or detention facilities. This apparently has become less of a problem in recent years as wetland values have become more common knowledge.

Floodplain protection ordinances generally preclude development within the floodway (main channel) and severely limit development within the floodplain of any river or stream. Often, these ordinances are encouraged or required by flood insurance regulations under the Federal Emergency Management Act (FEMA). The limitations to fill activities associated with flood protection ordinances can function as an effective tool to protect wetlands habitats.

Table 8

PLANS, ORDINANCES, AND REGULATIONS USED TO CONTROL DEVELOPMENT IN WETLANDS

	SMP	Comp. Plan	Zoning	Grading Ordinance	Drainage Ordinance	Special Sensitive Areas Ordinance	Purchase or Ownership Wetland Property	Floodplain Management
Clallam County	X							X
Grays Harbor County	X							
Aberdeen	X							X
Hoquiam	X							
Island County	X		X	X		X*		
Coupeville	X		X*					
Jefferson County	X							
King County	X			X		X		
Seattle	X			X	X			
Kitsap County	X	X						
Bremerton	X						X	
Port Orchard	X							
Poulsbo	X		X					
Winslow	X							
Mason County	X							

Table 8 (continued)

	SMP	Comp. Plan	Zoning	Grading Ordinance	Drainage Ordinance	Special Sensitive Areas Ordinance	Purchase or Ownership Wetland Property	Floodplain Management
Pacific County	X	X	X					
Pierce County	X			X	X	X		
Tacoma	X							
San Juan County	X							
Snohomish County	X	X			X	X*		
Edmonds	X		X				X	
Everett	X							
Thurston County	X	X	X	X				X
Olympia	X							
Whatcom County	X							
Bellingham	X			X				X
Blaine	X							
Wahkiakum County	X							

*Currently proposed or considered

Sensitive areas ordinances are perhaps the most direct and specific mechanisms for protecting wetlands habitats. At present, only King County has such an ordinance, although one has been proposed in Island County and are being considered in Snohomish County. These ordinances identify areas extremely sensitive to the impacts of development activities and recommend preservation, buffer zones, and other means to protect them. In addition to wetlands and other unique wildlife habitat areas, steep slopes and previously mined areas are also recommended for protection from development.

Comprehensive plans and zoning ordinances are increasingly being used to identify and protect wetland habitats. Where wetlands are clearly identified within a jurisdiction, these regulations offer a convenient mechanism for protecting them. In addition, since this type of land use planning is reasonably well accepted (with a few notable exceptions), it eliminates the need for implementation of special regulations which might not be as well received.

State Regulations

Two major state regulations can be used to regulate development activities in wetlands: Hydraulic Project Approval (HPA), and Floodplain Management. As noted above, the State Environmental Policy Act also provides state agencies with the opportunity to review locally regulated project proposals, including those which might be located in wetland areas.

The HPA is implemented by the Departments of Fisheries and Game, and is intended to protect fisheries resources. Any activity which would occur within the "state's waters" requires approval from both departments. Wetland habitat types are generally found in or immediately adjacent to the "state's waters" and are considered important components of fisheries habitat. As a result, wetlands are often considered in HPA decisions.

The state also exercises some jurisdiction over activities in wetlands through flood control management. The state flood control management program prohibits construction in the floodway and limits construction in the floodplain. Flood control management regulations are intended to limit increases in either upstream or downsteam flood elevations due to construction in the floodplain, and to provide protection from flooding for structures within the floodplain. Fills are allowable if they achieve both purposes. Thus, protection of wetlands under these regulations is limited. Any construction activities in the floodplain require a permit from the state if the city or county does not have an acceptable flood control ordinance. Most cities and counties in western Washington do have acceptable ordinances.

Federal Regulations

The two key federal programs which regulate development activities in wetlands are federal consistency under the Coastal Zone Management Act (CZMA) and the Section 10/Section 404 Programs of the Corps of Engineers. As specified under CZMA, federal permit issuances and federal development activities must be consistent with an approved state coastal zone management program. Thus, no federal permits (including Section 10/404, Coast Guard bridge permits, etc.) can be issued if a substantial development permit has

been denied by the state or local government. Furthermore, any development activity on federal lands, such as military bases, must be consistent with the requirements of SMA.

Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act are administered in combination by the Corps of Engineers. Section 10 regulates all activities within navigable waters (navigable waters include all tidal areas to mean high water and all traditionally navigable water bodies). Although originally intended to provide for navigational safety, the Corps' review of Section 10 permits includes other elements of the public interest, including environmental considerations.

Section 404 regulates only fill activities, but extends the jurisdiction to all waters of the United States. Waters of the U.S. have been defined to include adjacent wetlands; thus, jurisdiction of Section 404 extends well beyond that of Section 10. Public interest review under both Section 10 and Section 404 provides for review and comment on all proposed projects by all interested federal, state, and local agencies, as well as the general public. It should be noted, however, that the definitions of wetlands under SMA and Section 404 differ substantially leading to confusion and regulatory conflict. This is discussed in more detail later.

Importance of Regulations

Perception of the significance of any and all of the above regulations varies considerably from one jurisdiction to another, and even from one individual to another within the same jurisdiction. For local regulations, this is based in part on whatever ordinances may exist. For state and federal regulations, the perceptions vary dramatically. Many of the difficulties in coordination and jurisdiction will be discussed later. Of principal concern here is which regulations are thought by local government regulatory staff to be effective in regulating wetland development.

For most jurisdictions, the SMP is the primary, and often only, regulation available to regulate wetland development at the local level. This was in some cases felt to be inadequate, but it is all they have. Where support from the general public or the elected officials is limited or non-existent, local staff members have very negative attitudes about the effectiveness of their programs.

The use of other local regulations to implement wetlands protection varies considerably. In some areas, grading ordinances or sensitive areas ordinances offer staff planners a means to regulate development activities where the SMP has no jurisdiction. Elsewhere, comprehensive plans or zoning ordinances offer opportunities not only to manage development activities, but also to provide long-range planning and predictability in decision-making. In many jurisdictions, however, there is no effective mechanism for protecting the variety of wetlands outside the jurisdiction of SMA. This may be a matter of some concern to local planning staffs interested in protecting wetland areas.

The HPA program is generally recognized as important but of little value to local regulators. In general, coordination is considered poor, with local governments often not knowing an HPA has been requested. In

addition, there is no mechanism for local input into the HPA process. Finally, the jurisdictional limits of HPA are considered to offer little in the form of wetlands protection.

The Corps' Section 10/404 Program receives perhaps the most diverse judgments. Some local jurisdictions see the Corps as a valuable "club" to discourage development in wetland areas, especially those not regulated by SMA. The Corps is also seen to offer a diversity of technical expertise not available anywhere else. In contrast, other local planners view the Corps as a "dinosaur," and describe coordination as "dancing with an elephant." They feel coordination is poor, are unaware that the Corps offers any expertise, and wonder why they don't enforce the 404 regulations. These perceptions seem to cross both geographic and urban/rural boundaries, making it difficult to ascertain the reasons for such differences of opinion.

Implementation

Standards and Criteria

While every jurisdiction interviewed has a Shoreline Master Program (SMP), very few of the plans have specific policies regarding wetland development or protection. In most cases, wetland areas (or at least those recognized as significant when the program was adopted) are placed in the Natural or Conservancy environmental designations. Development in wetlands is then regulated by the general guidelines established for that particular environmental designation. Most SMP's restrict dredging and filling within the natural environment designation but there are generally no specific criteria or standards with regard to development or protection of wetland areas. At the same time, single-family homes, parks, or other "low intensity" uses are often permitted. The designation provides a general guideline for uses which can and cannot occur within the environmental designation but does not specify how this development should occur (i.e., height, bulk, construction techniques, etc.). Some SMP's also describe setback requirements from lakes and streams which may or may not also serve to protect some wetland areas depending on their size and location.

Regulations

Implementation of wetland protection occurs for the most part on a case-by-case basis through the permitting process when a development is proposed in a wetland area. There are several local permitting processes which might be used to implement wetland protection, including the Substantial Development Permit and building, grading, and drainage permits. If the development proposed is in a wetland area, the local agency would use the SMP to determine if the general use proposed is permitted and then may use several other means to regulate setbacks, bulk, height, etc. Several jurisdictions have general development criteria for wetland areas within their comprehensive or subarea plans, but, again, these criteria tend to be general in nature relating to uses and general environmental qualities recommended for the wetland areas.

The zoning code, for areas presently zoned in each county, is the only regulation which provides specific setback, height, and bulk guidelines used by all jurisdictions. Again, specific development criteria within the

zoning code will vary from jurisdiction to jurisdiction and are subject to staff interpretation. In many cases, the zoning was adopted prior to the local SMP and, therefore, the zoning is not always consistent with the general intent of the SMP. If the zoning has been implemented after adoption of the local SMP, then the jurisdiction usually placed a low density residential or agricultural zoning designation in the wetland areas.

No zoning codes, however, specify standards or criteria for development within wetland areas. The setbacks, height, and bulk regulations applicable to the structures allowed within a particular zone would be applied to the wetland area as well. Some jurisdictions have encouraged PUD's as a way of protecting wetland areas while allowing dense development in less sensitive areas of a site. Some PUD guidelines specifically mention sensitive areas which should be left as open space, including wetland areas, although, again, most PUD guidelines do not contain specific criteria for development within a wetland area.

Another process identified as a means of regulating wetland development was the SEPA process. Several jurisdictions specifically mentioned SEPA as a means of implementing wetland protection through imposition of special conditions as mitigating measures. The criteria developed as mitigating measures would vary on a case-by-case basis, depending on the type of development proposed and the wetlands affected. It should be noted, however, that several other jurisdictions specifically mentioned that SEPA was not used to place conditions on a project but used only to disclose impacts to decision makers.

Several jurisdictions implement wetland protection through purchase of the properties. Once the properties are in city and/or county ownership, development restrictions are easily implemented. Wetlands in public ownership were either left as permanent open space, developed for park and/or recreational purposes, or incorporated into the drainage plan for the particular jurisdiction.

Some jurisdictions which lack specific criteria or standards, rely on the Army Corps of Engineers, Departments of Fisheries and Game, or WDE to place restrictions on a development during their review of the Substantial Development Permit application or through the 404 or Hydraulic Project Approval process. Reviews by federal and state agencies, however, were never mentioned as the only means of regulating wetland development but were seen as an aid, particularly if the local SMP is not specific to wetland protection, thus leaving the jurisdiction with little means for achieving such protection.

Personnel and Budget

In most jurisdictions expenditures for shoreline and wetland management are measured as a proportion of the salary of the staff assigned to the shorelines program. Direct CZM grants or other funds spent on special studies related to shorelines or wetlands may also be considered.

In general, the larger urban jurisdictions tend to have one or two shoreline planners. These planners generally are responsible for substantial development permits and other permits and planning in the shoreline areas.

They are involved in wetland protection and/or development, if the areas are included in their SMP or if the area is identified during the permit process as a wet area. Smaller rural areas may only have one planner who also serves as inspector, engineer, and administrator. In most cases, the shoreline planner has a background in planning and a general knowledge of wetland issues. However, most do not have specific backgrounds in biology or natural systems which would make them technical experts in shorelines or wetland development or protection. Wetland cases usually comprise only a small portion (5-10%) of the shoreline management work for which they are responsible.

Most jurisdictions received some CZM funding during 1983 and reported that the amount of funding and number of personnel had both been reduced over that of the past five years. Most jurisdictions felt a reduction in CZM funds in 1984 would not significantly change their regulation of wetland or shoreline development primarily because current funding is minimal. There were only one or two smaller jurisdictions who felt that the reduction in funding would reduce their ability to regulate development in shorelines and/or wetlands because of either a forced reduction in staff hours and/or a change in emphasis to other local concerns. The latter was expressed by several smaller jurisdictions who felt that if federal funding was eliminated and local tax dollars had to be increased, then the local populations would want their dollars spent on more tangible public works projects rather than on shoreline and wetland development regulations and enforcement. Several jurisdictions felt that the funds were very helpful in the past to allow special studies to assist in identification of wetlands or for development of shoreline inventories or other studies related to coastal zone management. Several jurisdictions expressed a concern that their ability to fund future special studies would be eliminated or severely restricted due to the elimination of CZM monies.

No jurisdictions interviewed had allocated specific funds from their operating budget for wetland development or protection programs, nor were any able to identify specific funds set aside for wetlands programs.

In summary, many SMP's do not provide specific policies or regulations concerning regulation of wetland areas. Wetlands which were recognized as significant at the time of program development were designated as natural or conservancy and are thus regulated by the general guidelines affecting development in those environments. A wide range of other regulations can be, and generally are, used by local jurisdictions to limit development in wetlands. These include grading and drainage ordinances which can be used to restrict development. The SEPA process can also be used through identification of impacts and requirement for mitigating measures. In some cases, however, SEPA is used only to disclose potential impacts. Zoning codes have also been used to limit development in wetland areas. When combined with PUD's this can be an effective method of limiting development within wetlands, but sometimes at the expense of increased surrounding density. In general, funding for staff was not identified as a key issue except in small rural jurisdictions, where a loss of CZM funds could result in a reduction of staff.

Implementation Problems

Questionnaire respondents were asked to identify and rank the main problems in controlling the use of wetlands. There were several main problems which appeared to be consistent among all jurisdictions, including monitoring and enforcement, lack of expertise, funding, lack of data, lack of coordination, lack of private sector cooperation, and political influences on local permitting decisions.

Monitoring and Enforcement

The problem mentioned by more jurisdictions in controlling the use of wetlands was monitoring and enforcement of the existing regulations. More counties cited this as a main problem than either urban or rural cities or towns. Even though many of the small cities and towns have limited staff (often only one planner) monitoring does not tend to be a problem since the jurisdictional boundaries are small. The rural counties which have limited staff and large jurisdictional boundaries cited monitoring as a major problem whereas the counties with more staff and more urbanization tended to cite lack of coordination and private sector cooperation as major problems.

Most of the jurisdictions who cited enforcement and monitoring as a major problem also cited funding as another key problem. Indeed, many respondents felt that with increased funding, more staff could be assigned to monitoring and enforcement. Others felt that increased funding would allow them to spend more time on critical projects and/or to have special studies conducted to upgrade their current wetland inventories. As might be expected, several of the jurisdictions who expressed the desire for greater funding for specialized studies also mentioned lack of data as a key problem in controlling the use of wetlands.

Two common problems cited most often among smaller rural towns was lack of expertise and political pressures in development decisions. The jurisdictions who expressed a problem with lack of expertise were ones with a small staff, often only one planner. These jurisdictions cited DOE as their key resource for experts in wetland identification and problem solving. Several of the small rural towns also felt that wetland protection gives way to political influences far too easily and that often local commissioners or council persons do not back staff recommendations regarding wetland protections if political pressures favor development in wetlands.

Definitions

The various wetland definitions created problems for many jurisdictions. Only where there was no incentive to implement SMA, or where there was substantial local wetland expertise were the definitions not considered a problem. The problems included trying to resolve overlapping and conflicting jurisdictional boundaries, and trying to explain the differences (and their significance) to both proponents and elected decision makers. Comments ranged from noting that the various definitions "have created a monster" to "no problem, we can use the USFWS definition." Some repondents complained that the SMA definition lacked specificity and was difficult to measure precisely; one felt it might be a problem if it were more specific since now "they can stretch it as far as they want."

Another concern which was raised was the lack of accuracy in WDE's associated wetland mapping. It was felt that major areas were sometimes missed and that the mapping lacked the precision necessary to make it useful. Furthermore, there was some concern expressed about getting the associated wetland boundary changed when adequate data were provided to support the change.

Coordination

Coordination was not seen as a major problem among small rural or urban jurisdictions. Most smaller jurisdictions stated that they had little or no coordination with the Army Corps of Engineers, primarily because either their shorelines were already developed or the Corps has not had jurisdiction over the type of projects proposed. Most small towns expressed positive experiences regarding coordination with the Department of Ecology and minimal contact with the Departments of Fisheries and Game.

Among county planners, there was significant difference of opinion concerning coordination issues at both state and federal levels. The Departments of Fisheries and Game (WDF and WDG) were generally recognized to have the best available technical expertise concerning wetland issues. When an HPA was also required on a project, they were willing to lend their assistance. However, for projects in outlying areas or not requiring an HPA, it is often difficult to get WDG or WDF personnel to view the site or comment on the project. Furthermore, they often don't agree. "Three different agencies look at the same spot with three different interpretations. They never show up together and leave staff feeling embarrassed."

WDE also received mixed reviews. Some felt the Department offered important administrative assistance, or occasionally technical expertise. Other comments were made about frustration, lack of coordination, and bureaucratic paper shuffling. (It was noted, however, that red tape can have the advantage of delaying bad projects.) WDE was also noted as providing a layer of regulation not subject to local political pressures.

As with WDE, the Corps received mixed reviews for its coordination and interaction. Some jurisdictions felt the Corps kept them apprised of many projects through the Section 404 public notice. The Corps was also felt to offer regulation in areas not subject to SMA. Others countered that the "obtuse federal bureaucracy" was difficult to penetrate and not of any assistance if a project did not fall within a narrow set of standards.

Overlaps and Gaps

Just as there were counties who expressed a problem with coordination and too much duplication in the process, others felt the duplication in the permitting process was good and that it provided a safeguard against developments that might otherwise slip through the cracks due to an oversight at the local level or local political pressures. Most of the jurisdictions who experienced coordination problems also felt the permitting process was too duplicative and felt it should be streamlined; none, however, had specific recommendations regarding streamlining.

It was also stated that wetland concerns were different at different levels of government and, therefore, justified different levels of regulation. At the local level, flood protection and drainage issues might be most important. At the federal level, however, protection of major stops along a "flyway" might be a much more significant issue.

Gaps in coverage include geographic areas as well as types of activities. Geographic areas which are not be covered by SMA include wetlands adjacent to lakes less than 20 acres in size and wet areas in excess of 200 feet from a shoreline. [Many local shoreline planners had originally felt their SMP's provided protection for most of the wetlands in their jurisdiction. They were surprised to learn the extent of wetlands when the USFWS NWI mapping was prepared.] Although the Corps' Section 404 program extends to wetlands adjacent to streams with flows of as little as 5 cfs, there are still numerous wetlands which are not protected by regulations. (See, for example, the discussion in Inventory Results regarding wetlands regulated in King County.)

Activities not regulated in some jurisdictions which may indirectly or directly affect wetlands include dredging, logging activities, grading and draining, and in some cases filling in small wetlands not under Corps jurisdiction. Several respondents expressed concern about inadequate regulation of logging activities and indirect impacts to wetlands areas. Some felt the Forest Practices Act did not offer adequate protection, or else it was inadequately enforced. Impacts included direct habitat destruction or indirect impacts due to road construction and sedimentation. Offsite sedimentation was also identified as an often unregulated impact associated with a variety of development activities. "The state is making a mistake by regulating the estuary, but not controlling upstream influences.

Federal Consistency

Generally, federal consistency was not recognized as a significant issue. In Grays Harbor, however, it is an issue of significant concern. Some feel it is one-sided and should work in both directions (i.e., not only should federal agencies be restricted from issuing permits over local SMA limitations, but also they should be required to issue permits where local government has authorized projects). Although this is not an issue which can be handled at the state level, it is one which should be stated.

Results and Effectiveness

Estimates of SMP effectiveness in protecting wetlands varied considerably as did the criteria for determining wetland losses. Evaluations ranged from "D" to "very effective." General criticisms included "too awkward" and "too late to stop residential development." The following sections discuss some of the factors identified as measures of the success of SMA and the associated SMP's.

Types of Wetland Losses

Several respondents noted that fills in estuarine or coastal wetlands were no longer occurring as a result of SMA regulations. Others felt this was more a function of public awareness rather than any specific regulations

("standards and regulations did not save the wetlands, public process did"). There was general agreement that the level of awareness and to some degree the difficulty in getting permits all contribute to diminishing losses. Evidence of this is "the existence of places where people would fill if they could. There was even mention of the reversion of marginal wet agricultural lands to wetlands because it was no longer economically feasible to protect or reclaim them.

In contrast were responses which recognized the incremental or minor wetland losses and the effects of indirect impacts (e.g., changes in drainage patterns due to construction in another region of the watershed). These were attributed to activities occurring outside the jurisdiction of SMA. Often these activities go unregulated due to the lack of ordinances to control them.

Changes in Trends of Wetland Losses

Generally, it was assumed that the trend of wetland losses had diminished, but there was little evidence to support that feeling. Some felt that there was a decrease in wetland losses within the jurisdiction of SMA, but perhaps an increase outside the jurisdiction. One local planner suggested that SMA had contributed to slowing wetland losses," but it is not a leader in the field." There was even the suggestion that the attitude has become "fill it while you can before the regulations get tougher"; as a result areas have been filled which would not have been before.

Permit Conditions

Another important measure of program effectiveness is the development of permit conditions to minimize the impacts of development activities in or adjacent to wetland areas. Setbacks or buffer zones are the most common conditions required. These are generally considered successful in protecting wetlands ("if the work hasn't been completed before they apply" or "if the person applying isn't political"). Erosion and drainage controls (including catch basins and oil-water separators) were also noted by some as successful. Other conditions which were mentioned include requirements for providing public access, revegetation and limits on construction time to protect any nearby fish spawning.

In general coastal planners are convinced there has been some reduction in wetlancreased destruction of "upland" (palustrine) wetlands not under the jurisdiction of SMA. Permit conditions were seen as a means of protecting or minimizing impacts to wetland areas. Buffer zones, sedimentation controls and revegetation were a few of the conditions mentioned.

Suggestions

Many coastal planners offered suggestions for improvements to various aspects of the Shoreline Management Process. Some were as basic as a"streamline the process" while others provided much more detail. These suggestions are listed below. (Since the suggestions were phrased in many

different ways, the location of a suggestion on the list only approximately represents how often it was mentioned.)

- Change "associated wetlands" definition to parallel Corps 404 or USFWS definition, or develop specific criteria for definition.
- SMP's should be more specific, improve regulations and guidelines.
- Streamline the process, shorten required time frame for permits.
- Improve coordination with WDE, WDF, WDG.
- Should develop an inventory and policy for sensitive lands (especially those outside of present SMA jurisdiction) or, extend SMA jurisdiction to include other wetland areas, smaller creeks, etc.
- Improve monitoring and enforcement capabilities.
- Improve coordination with Corps.
- WDE should work more ctively to reduce political influences on decision making and assure adequate expertise.
- Expand jurisdiction to include dune lands, dune marshes, and natural spits.
- Improve accuracy of DOE associated wetland maps.
- WDG should be more involved in wetlands regulation (since they have the technical expertise).
- Local governments need good grading and erosion control ordinances.
- Strengthen and enforce Forest Practices Act.
- Create a technical group at state level to provide support and expertise to local governments.
- Develop specific requirements for mitigation.
- Allow public interest groups to file suits and claim damages.
- Raise the $1,000 minimum on permit requirement.
- Enact Grays Harbor Estuary Management Plan.
- Make federal (Section 404, CZM) and state (SMA) regulations more readable.
- Allow administrative variances.
- Develop basinwide land use regulations controlling drainage, grading, and filling.

From the responses, it was apparent that increased specificity in the definition and in SMP guidelines and regulations are considered important to most county shoreline planners. The need for a streamlined process was also considered important. These suggestions imply the SMA regulations are considered too vague and, therefore, difficult to implement. These difficulties may also be reflected in the desire for increased coordination with state and federal agencies. These agencies are considered important sources of technical expertise which can aid local decision making.

It is also interesting to note that there was substantial encouragement for expanded jurisdiction to dune lands, isolated wetlands, and other areas. There were also several requests for improved monitoring and enforcement capabilities and for more active DOE participation to reduce political influence on decision making. These suggestions were recognized as requiring more funds. They also indicate a recognition of the difficulties in regulating wetland development and a desire to improve the effectiveness of that regulation.

D. OTHER APPROACHES TO WETLANDS PROTECTION

Protection of wetlands can also occur through efforts undertaken by citizens and organizations in both public and private sectors. These efforts may range from public education and rehabilitation programs to inventories, mapping, wetland purchases, and taxing programs. Government programs are supplemented by the nonregulatory techniques to increase their effectiveness and to achieve objectives unobtainable through regulations. Concerned individuals and conservation groups have developed these approaches in some cases as a result of the inadequacy or lack of existing wetlands regulations. Implementation of protective measures presents a variety of difficulties and limitations, but the individuals involved have overcome many of these obstacles with creative solutions.

Identification and mapping of wetlands is a key step toward achieving wetlands protection, as accurate maps provide helpful tools for other approaches. Several mapping approaches exist. For all of the lower 48 states, the U.S. Fish and Wildlife Service has prepared the National Wetlands Inventory using the classification in "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin,et al., 1979). These small-scale maps (originally 1:100,000 transferred to 1:24,000 quad maps) are useful to identify sensitive areas, but small areas of interest must be remappepd if accurate boundaries are required. Large-scale mapping provides detailed site characteristics (i.e. vegetation, wildlife, soil, water regime) which are useful in determining the relative importance of a given wetland. Numerous small wetland surveys have been made for impact assessment, planning or development programs, wildlife surveys, endangered, threatened or sensitive species surveys, or in compliance with permit regulations. These small surveys would be more useful if a consistent classification system was used to identify the habitats. Consistent definitions and classification allows sites to be ranked and provides valuable information and for land use planning, to help evaluate development permits, and to define acquisition priorities.

Detailed maps and inventories also provide valuable data for educational efforts. Public education programs include films, workshop and publications produced and presented by conservation groups, government agencies and regional botanical or wildlife societies. The Nature Conservancy, National Audubon Society and its local chapters, the Sierra Club and the National Wildlife Federation increase public awareness of wetlands. Lectures, slide shows, public school audio-visual presentations, fund raisers and workshops are important vehicles for dissemination of general and site specific wetlands information. Technical assistance and educational materials are available from many federal and state agencies to assist local groups in their presentations.

Land acquisition or acquisition of development rights and tax incentives are effective measures used in conjunction with regulations to protect wetlands. Public purchase of land is expensive but it provides good protection and permits public use. Federal and state open space, recreation and wildlife grant-in-aid programs are available to aid community groups in acquiring desirable properties. Some of the most effective land acquisition programs exist with conservation groups.

The Nature Conservancy acquires land through donations or bargain sales and uses federal tax laws to make it desirable for the landowner to sell. They insure that the land is managed in a manner acceptable to the previous owners and the State. Over 175,270 acres of land is owned or leased by Audubon Society and patrolled by Society wardens. The sanctuaries range from 10 to 26,800 acres in size and most are acquired through donations, independent purchases or joint ventures with other conservation groups. They may lease portions or all of the property to other resource agencies for management and to alleviate maintenance costs. The National Wildlife Federation, though not a large land owner, channels donations of land to private and public organizations that maintain property donations in accordance with the wishes of the donor. It is an effective program since all donations are tax deductible. Thousands of state and local citizen organizations play wetland protective roles. Ducks Unlimited has acquired over four million acres of wetlands in Canada to be protected and managed by the Canadian Fish and Wildlife Service for waterfowl. Currently, no purchase of properties in the United States is allowed except through the Duck Stamp program; however, the Department of Interior presently has a bill in Congress which would provide funds for waterfowl habitat protection nationwide.

Other options for protection indirectly related to land acquisition are deed restrictions, covenants and conservation easements. These protect wetlands by restricting their use and allowing landowners to protect their wetlands even after their death or the sale of land. Federal and state governments offer tax advantages and conservation groups coordinate these efforts to encourage use of these contract restrictions. Each of these techniques requires legal assistance, since there are no standard requirements, validity, enforceability or tax implications for all jurisdictions.

Real property taxes, estate taxes, gift taxes, and income taxes all affect the use of wetlands. Real property taxes are based on the "assessed" value of lands and structures. Development restrictions can be used to lower the assessed value of property. Landowners can enjoy the benefit of reduced property taxes assessments if they own some wetland area and that

portion of their property is taxed at a use value rather than its full market value. The State has developed three systems of differential tax assessment--pure preferential assessment, deferred taxation, and restrictive agreements. Landowners can be encouraged to protect their wetland property by taxing the property at its use value (i.e., lower undeveloped value) and not the fair market value. These landowners often subdivide and sell their property when they encounter changes in market value or development pressures. No penalties are applied for developing the land or withdrawing from the program. Deferred taxation applies when the landowner converts to a non-eligible use (i.e., residential, commercial). The owner may then be asked to pay some or all of the taxes that would have accrued during the years of preferential assessment. Restrictive agreements encompass the first two systems but also include an agreement by the owner to leave the property undeveloped for an assigned number of years. This is probably the most effective property tax approach for wetland protection; however, the taxation scheme should be supplemented with regulatory programs to insure protection of ecologically-sensitive areas.

Estate taxes, paid to the state or federal government upon an individual's death, are calculated on a progressive scale and based on the value of assets in the decedents estate. If most of the assets are land, the taxes may be extremely burdensome to the beneficiary. Therefore, tax laws provide for a deduction of the value of all gifts or donations of property, leases, options to purchases or easements to charities or government bodies. In effect, the value of the donated land or interest is deleted from the total estate value.

Gift taxes are calculated as estate taxes; they are imposed at the time of the donation and they apply only to property transferred without compensation. Gifts to certain charitable organizations and all government bodies are exempt from taxation.

Income taxes are the major source of revenue for the federal government and most state governments. As discussed in the land acquisition section, landowners may obtain tax advantages through donation of land, conservation restrictions, or easements for charitable organizations or government bodies. The owner may deduct the full value of the capital gain on the donated property provided that it does not exceed 30% of the adjusted gross income during the year of the donation. For gifts of partial interests in property, the donated interest must be granted in perpetuity or it must qualify as a conservation purpose. The objectives in preserving land for conservation purposes are to (1) preserve natural wildlife, plant or fish habitat; (2) preserve open space for the public; (3) preserve outdoor recreation areas; or (4) preserve a site of historical importance.

Wetland rehabilitation efforts are a way of protecting these fragile ecosystems and drawing attention to their ecological value and their primary role in maintaining the integrity of our environment. Communities or local wildlife or plant sometimes may initiate wetland rehabilitation efforts for damaged or destroyed areas to reestablish natural wetland vegetation and hydrologic regimes. The success rate of reestablishing wetlands is high providing the wetland area has not been totally eliminated. For example, previously diked land in Willapa Bay Estuary, reopened to tidal waters in

1980, is reestablishing as a productive part of the estuarine habitat of Washington. Some local jurisdictions require the reestablishment of wetlands acreage comparable to parcels of wetland destroyed through development. Creation of these new wetlands is possible and has been attempted by many agencies; however, the possibility of developing new wetlands should not encourage filling or elimination of existing ones.

V. RECOMMENDATIONS

The following are mechanisms which might enhance wetland protection efforts:

- Local regulations such as grading or building ordinances should be enacted or amended to address environmental concerns in addition to engineering concerns.

- Establish procedures to improve WDE, WDG, WDF coordination with local jurisdictions, including coordinated site visits and project review.

- Provide a mechanism for local input into the HPA process.

- Adopt a single wetlands classification system such as Cowardin's or that used by WDG and have it used by all resource agencies.

- Refine definitions of wetlands and associated wetlands to remove ambiguities (e.g., "wetland", retitled Shoreline Management Zone; "associated wetlands", use USFWS definition).

- Add a wetlands element to the SMP's, identifying specific mechanisms for regulating development activities in wetland areas.

- Amend SMA to include isolated wetlands, rather than only those associated only with lakes greater than 20 acres or rivers greater than 20 cfs.

- Establish mechanisms to coordinate all local permits and regulations, and state permits, which presently are used to control wetland development.

- Assist county planners in zoning decisions, encouraging open space designations for wetland areas.

- Conduct special studies to obtain data; this would assist decision making and contribute to public education. Possible studies include:

  - comprehensive wetlands identification/mapping
  - improve and update shoreline inventories
  - regional coastal zone management studies for areas of interest or concern
  - update WDE associated wetlands maps and streamline procedure for amendment
  - develop slide shows, movies, pictorial boards, and other presentations for the general public
  - develop workshops to educate local coastal planners concerning available data, general wetland ecology, etc.

- Improve enforcement and monitoring mechanisms and increase available funding. Possible actions include:

- accumulate and disseminate more data in comprehensible language
- improve data base for selected areas where high use is expected
- raise $1,000 minimum on permit requirements
- update shoreline inventories
- improve WDE associated wetlands maps
- complete NWI summaries of wetland areas for the quads not covered in this document

. Improve effectiveness of SMA wetland regulations by providing specific requirements for buffer zones, best management practices, and strict limitations on development activities.

. Clarify and strengthen regulations in SMA limiting development in wetlands areas.

. Encourage establishment of PUD's to protect small wetlands and sensitive areas -- include specific guidelines for wetland portions. Develop specific standards or criteria for development within wetland areas.

. Encourage development of sensitive area ordinances to limit development activities in wetlands areas.

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APPENDIX A

COUNTY WETLANDS INVENTORIES

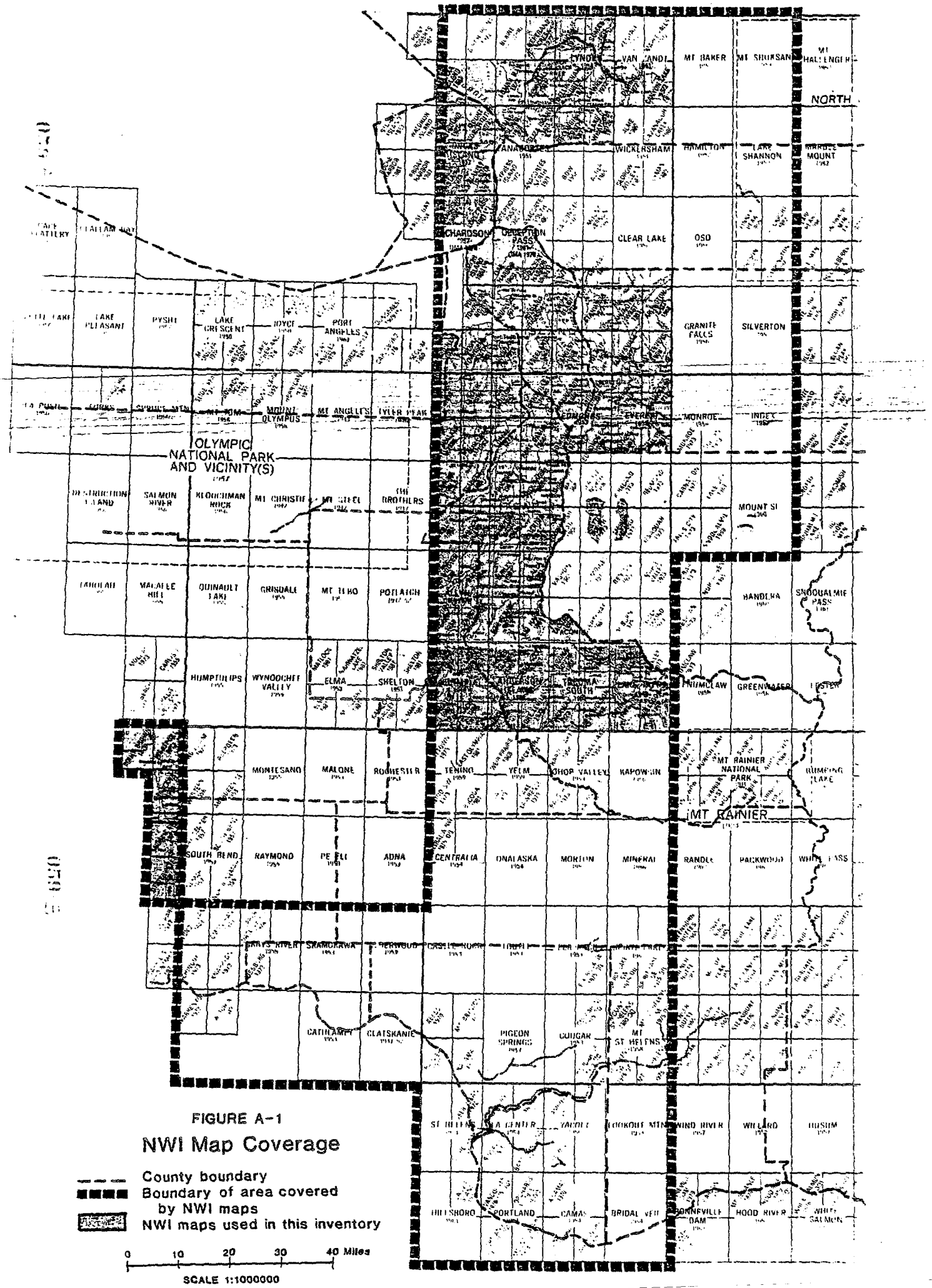


FIGURE A-1

NWI Map Coverage

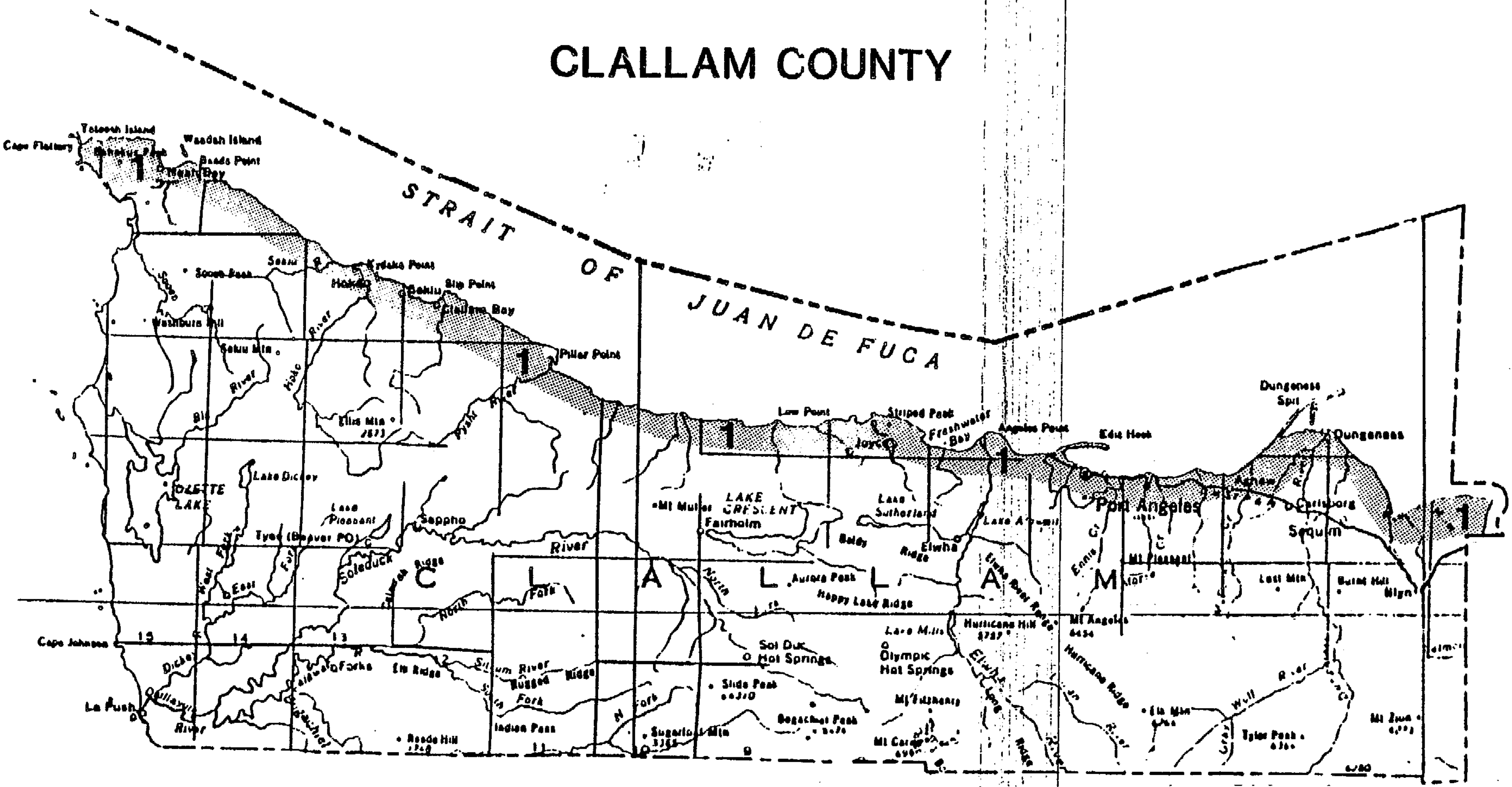
County boundary

Boundary of area covered by NWI maps

NWI maps used in this inventory

0 10 20 30 40 Miles

SCALE 1:1000000



1. Coastal Zone Atlas, 1978.

SUMMARY OF WETLANDS INVENTORIES FOR CLALLAM COUNTY

Wetland Type	Total Area (Acres)	Size Distribution (n[1]/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	2148	--	NA/465	NA/1683			
Emergent	476	--	4/164	2/312			
Scrub/Shrub	--	--	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	2043	--	6/225	NA/1818			
Lacustrine							
Open Water	--	--	--	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	113	7/79	2/78	--			
Aquatic Bed	--	--	--	--			
Emergent	94	4/19	1/75	--			
Scrub/Shrub	--	--	--	--			
Forested	--	--	--	--			

T90

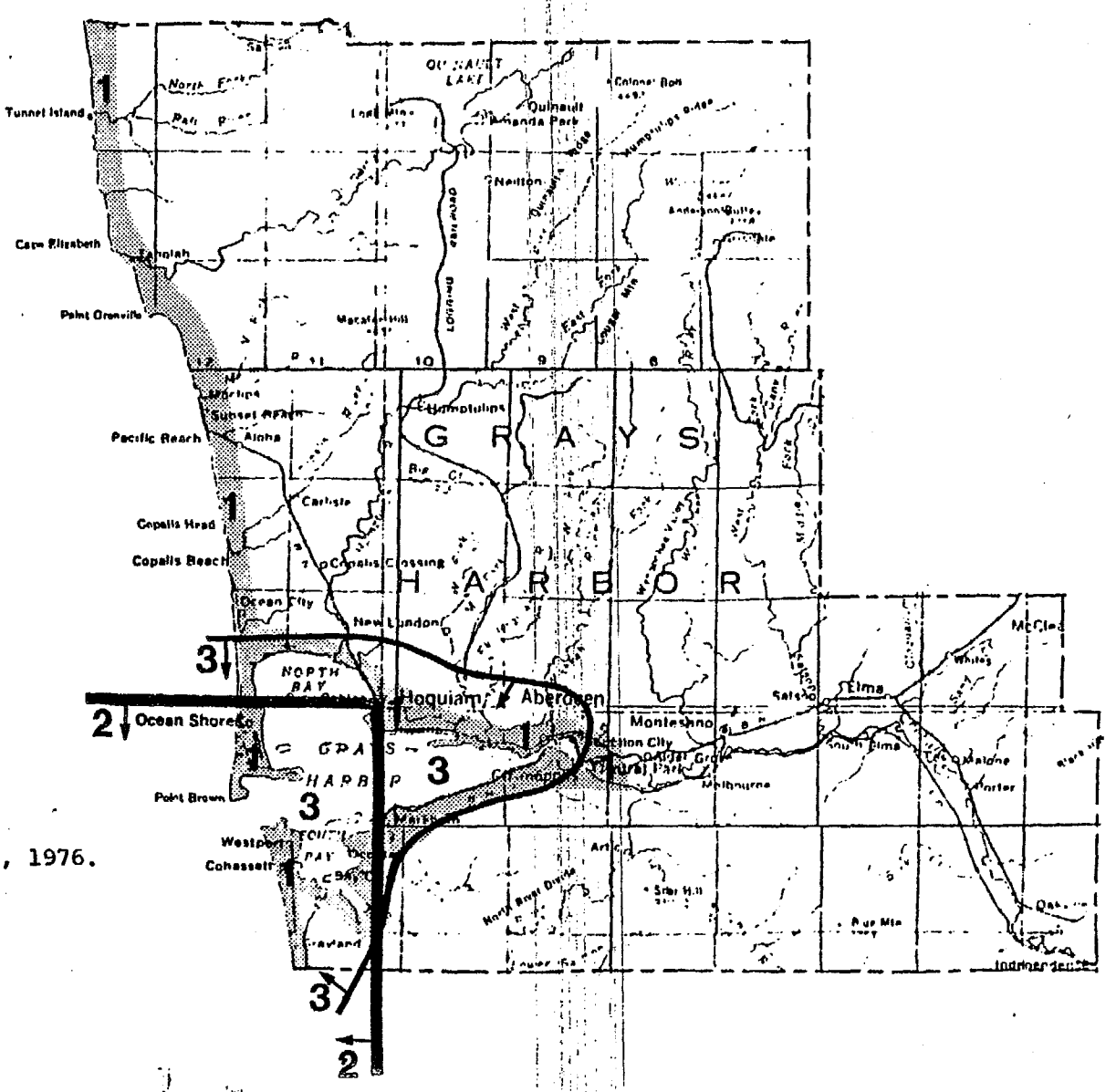
Total: 4874

Sources: Coastal Zone Atlas, 1980

[1] n=number of wetlands

[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

GRAYS HARBOR COUNTY



1. Kumze and Cornelius, 1982.

2. National Wetlands Inventory.

3. U.S. Army Corps of Engineers, 1976.

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SUMMARY OF WETLANDS INVENTORIES FOR GRAYS HARBOR COUNTY

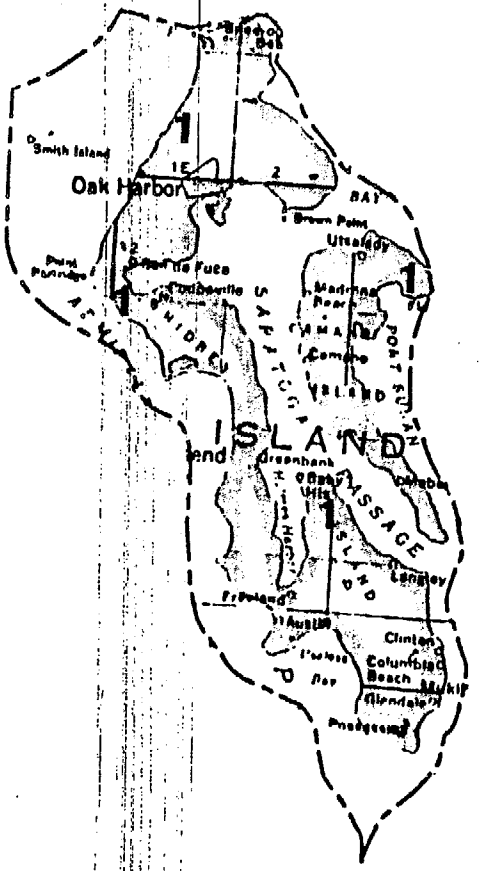
Wetland Type	Total Area (Acres)	Size Distribution (n[1]/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	13,950	--	--	--			
Emergent	2775	25/145	35/1449	6/1181			
Scrub/Shrub	29	--	2/29	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	14,948	--	--	--			
Lacustrine							
Open Water	439	--	--	1/439			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	39	13/39	--	--			
Aquatic Bed	9	2/9	--	--			
Emergent	1340	121/257	16/422	--			
Scrub/Shrub	503	21/83	13/291	1/129			
Forested	940	14/67	9/194	--			

Total: 34,972

Sources: National Wetlands Inventory
U.S. Corps of Engineers, 1976
Kunze and Cornelius, 1982

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

ISLAND COUNTY



1. Coastal Zone Atlas, 1979.
2. National Wetlands Inventory. (coverage of entire county)

SUMMARY OF WETLANDS INVENTORIES FOR ISLAND COUNTY

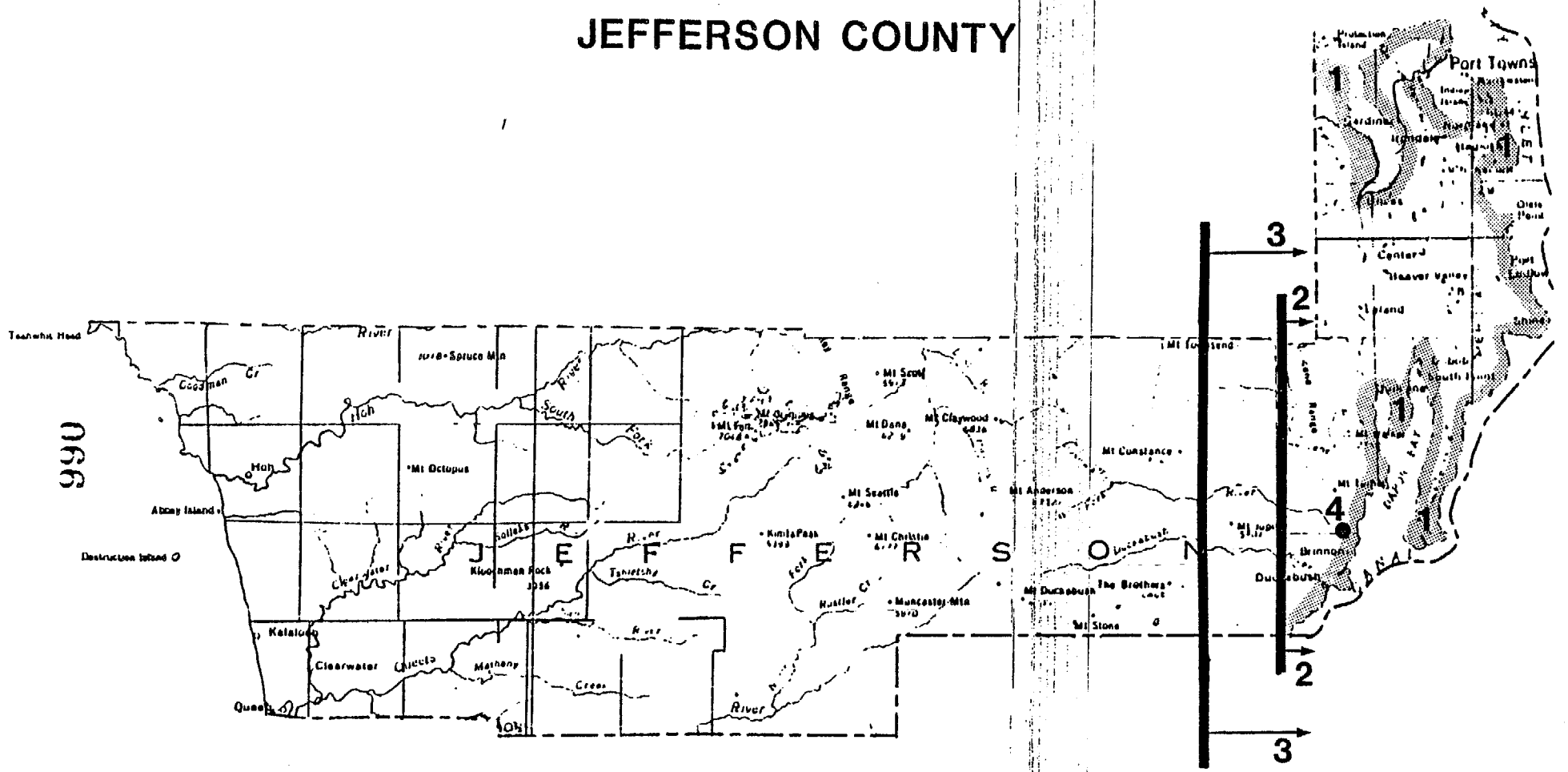
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	8370	--	--	--			
Emergent	744	NA/63	NA/369	2/312			
Scrub/Shrub	1	1/1	--	--			
Forested	18	--	1/18	--			
Subtidal							
Aquatic Bed	6474	--	--	--			
Lacustrine							
Open Water	86	--	1/86	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	99	27/85	5/56	--			
Aquatic Bed	20	1/6	1/14	--			
Emergent	1143	57/247	26/588	2/299			
Scrub/Shrub	625	27/131	23/494	--			
Forested	139	12/55	4/84	--			

Total: 17,719

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

JEFFERSON COUNTY



1. Coastal Zone Atlas, 1978.
2. National Wetlands Inventory, 1973.
3. Northwest Environmental Consultants, 1975.
4. Shapiro and Associates, Inc., 1982.

SUMMARY OF WETLANDS INVENTORIES FOR JEFFERSON COUNTY

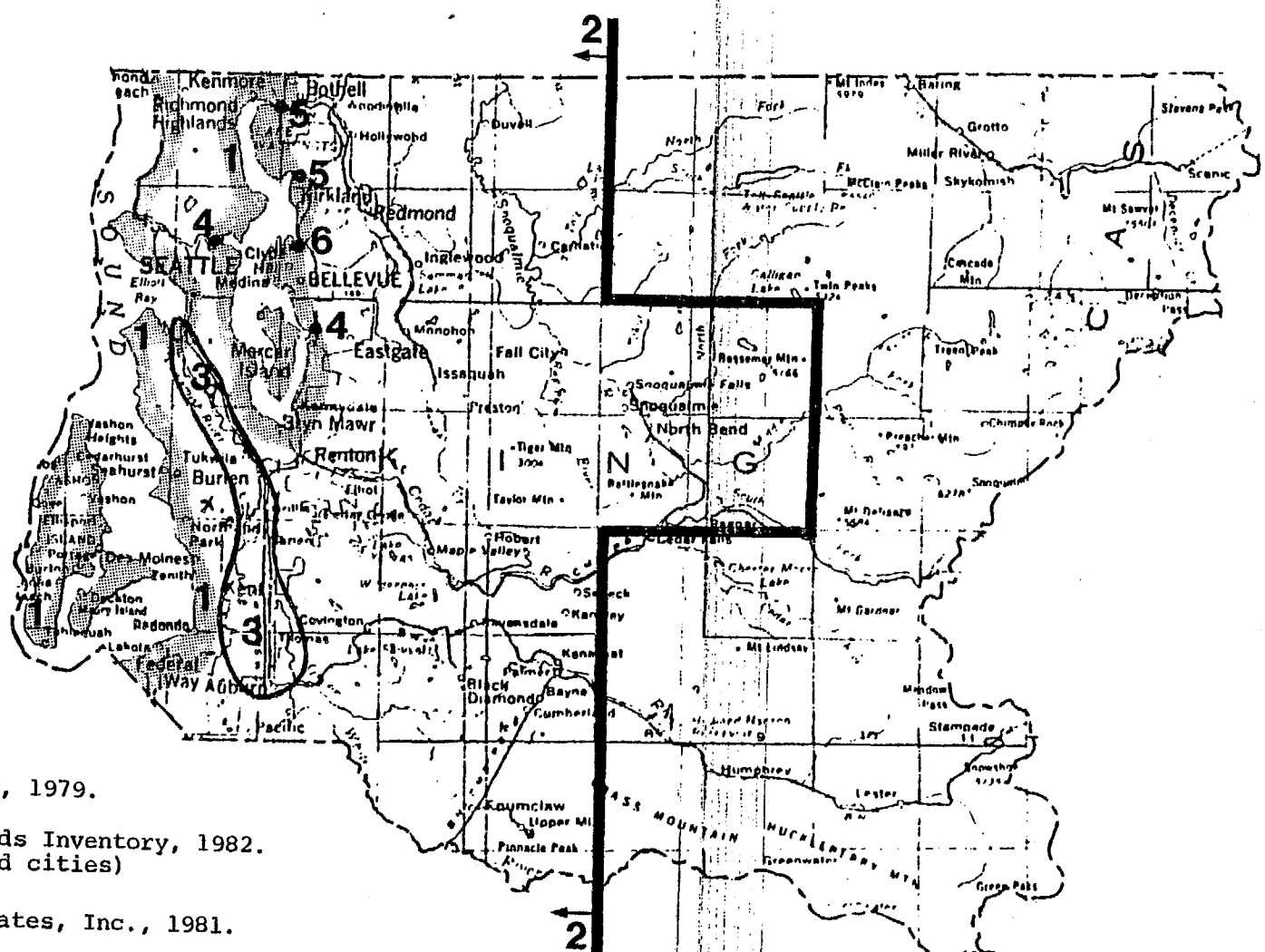
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	2253	--	--	--			
Emergent	673	NA/262	NA/272	1/139			
Scrub/Shrub	--	--	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	6615	--	--	--			
Lacustrine							
Open Water	411	--	12/411	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	211	22/88	7/123	--			
Aquatic Bed	190	2/13	6/177	--			
Emergent	640	70/272	21/368	--			
Scrub/Shrub	601	64/238	15/363	--			
Forested	209	16/82	6/127	--			

Total: 11,803

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

KING COUNTY



1. Coastal Zone Atlas, 1979.
2. King County Wetlands Inventory, 1982. (minus incorporated cities)
3. Shapiro and Associates, Inc., 1981.
4. National Wetlands Inventory.
5. Ellman, N.S. and J.P. Schuett-Hanes, 1979.
6. City of Kirkland, Yarrow Village Draft EIS Appendices, 1982.

SUMMARY OF WETLANDS INVENTORIES FOR KING COUNTY

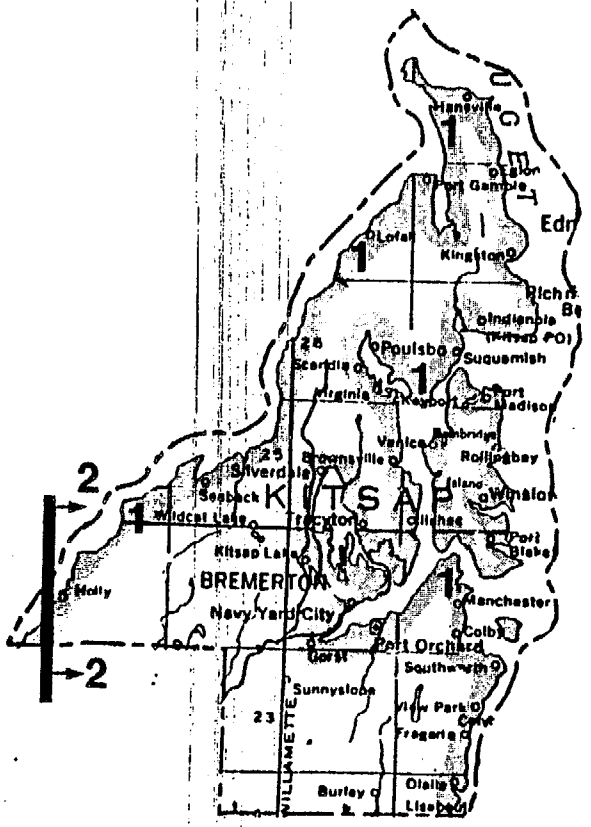
Wetland Type	Total Area (Acres)	Size Distribution (n[1]/acres) <10	10-100	>100	Watershed Size (n/acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Flat	2207	2/15	1/47	7/2145	1/253	3/306	6/1648
Rocky Shore	1445	--	--	2/1445	--	1/818	1/627
Emergent	10	--	1/10	--	1/10	--	--
Scrub/Shrub	--	--	--	--	--	--	--
Forested	--	--	--	--	--	--	--
Subtidal							
Unconsolidated	12	--	--	--	--	--	--
Aquatic Bed	2182	--	--	--	--	--	--
Lacustrine							
Open Water	1405	2/16	24/929	3/460	22/910	3/392	--
Aquatic Bed	--	--	--	--	--	--	--
Emergent	36	--	1/36	--	1/36	--	--
Unconsolidated	275	--	6/275	--	6/275	--	--
Palustrine							
Open Water	1417	99/357	45/1107	--	131/1295	2/45	2/20
Aquatic Bed	98	14/28	4/70	--	18/98	--	--
Emergent	3363	149/633	69/1917	5/771	146/1695	14/853	4/132
Scrub/Shrub	4521	194/810	99/2773	5/899	248/3391	8/684	2/110
Forested	2209	92/366	14/1681	1/185	106/1569	8/281	2/76
Unconsolidated	77	21/30	3/47	--	24/77	--	--

Total: 19,257

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980
Shapiro and Associates, Inc., 1981
Ellman and Schuett-Hanes, 1979
King County Wetlands Inventory, 1982
City of Kirkland, Yarrow Village DEIS Appendices, 1982

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

KITSAP COUNTY



1. Coastal Zone Atlas, 1979.

2. National Wetlands Inventory.

SUMMARY OF WETLANDS INVENTORIES FOR KITSAP COUNTY

Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	3944	--	--	--			
Emergent	284	NA/74	NA/178	--			
Scrub/Shrub	4	1/4	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	9382						
Lacustrine							
Open Water	1045	--	12/516	3/530			
Aquatic Bed	--	--	--	--			
Emergent	109	--	3/109	--			
Palustrine							
Open Water	416	94/269	10/147	--			
Aquatic Bed	156	32/80	4/76	--			
Emergent	1406	227/737	32/669	--			
Scrub/Shrub	812	88/324	23/488	--			
Forested	181	22/77	4/104	--			

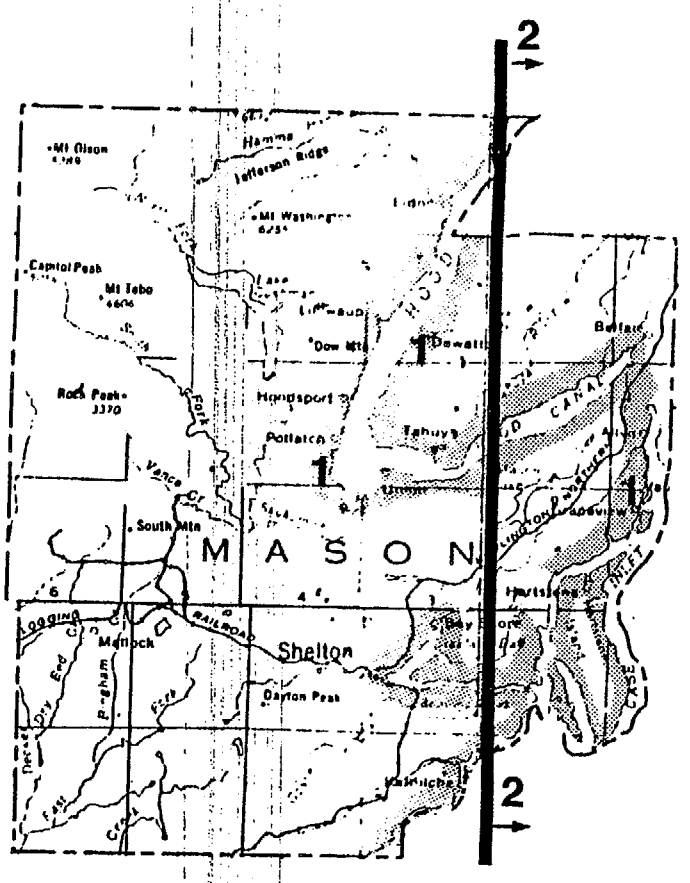
Total: 17,739

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

T20 074

MASON COUNTY



1. Coastal Zone Atlas, 1980.

2. National Wetlands Inventory.

SUMMARY OF WETLANDS INVENTORIES FOR MASON COUNTY

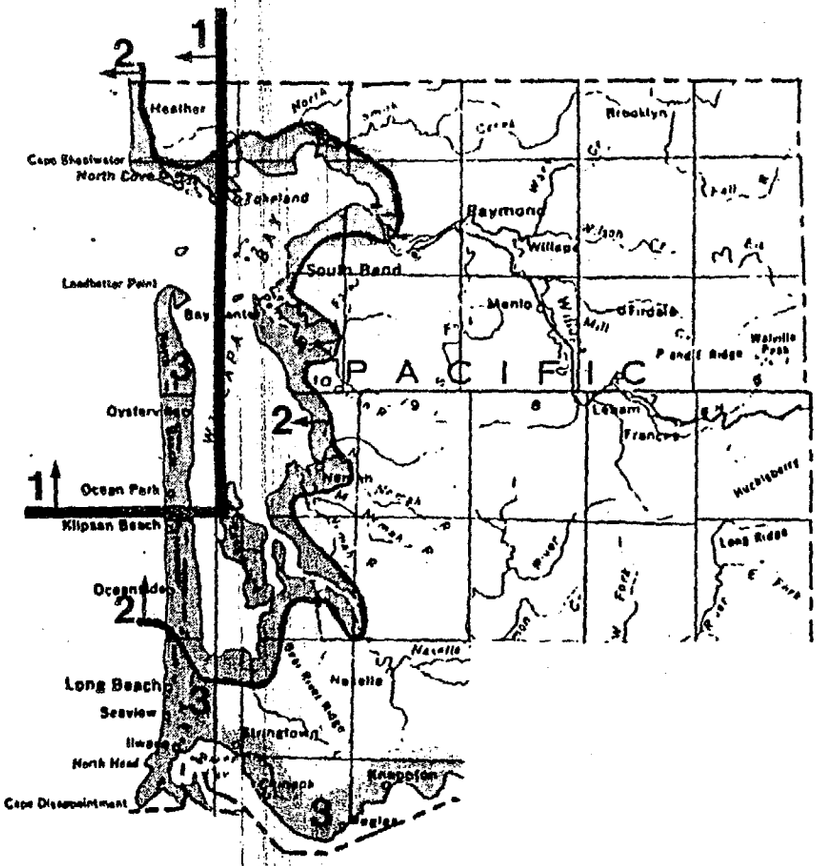
Wetland Type	Total Area (Acres)	Size Distribution (n[1]/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	3612	--	--	--			
Emergent	701	NA/91	NA/385	1/225			
Scrub/Shrub	2	1/2	--	--			
Forested	6	1/6	--	--			
Subtidal							
Aquatic Bed	2071	--	--	--			
Lacustrine							
Open Water	943	--	19/790	1/121			
Aquatic Bed	132	1/4	6/128	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	179	28/114	5/65	--			
Aquatic Bed	78	9/42	3/36	--			
Emergent	391	66/226	14/165	--			
Scrub/Shrub	705	35/153	24/552	--			
Forested	277	28/151	8/125	--			

Total: 9097

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

PACIFIC COUNTY



1. National Wetlands Inventory.
2. Northwest Environmental Consultants, 1974.
3. Kunze and Cornelius, 1982 and Washington Dept. of Game, 1982.

SUMMARY OF WETLANDS INVENTORIES FOR PACIFIC COUNTY

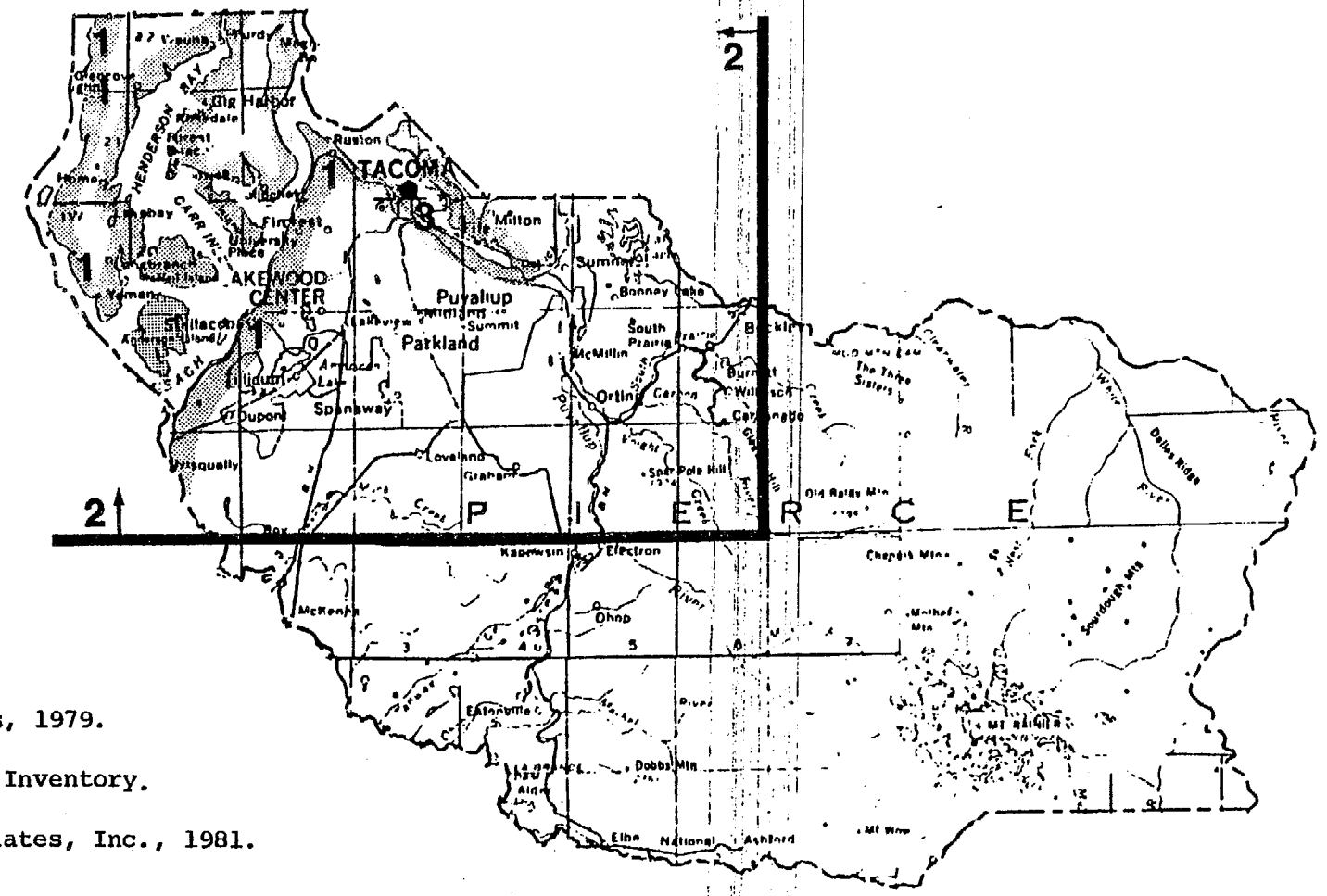
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	17,000[3]	--	--	--			
Emergent	7987	9/32	10/334	24/7621			
Scrub/Shrub	11	2/11	--	--			
Forested	10	2/10	--	--			
Subtidal							
Aquatic Bed	13,100[3]	--	--	--			
Lacustrine							
Open Water	60	--	2/60	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	102	33/72	2/30	--			
Aquatic Bed	10	--	1/10	--			
Emergent	941	54/182	10/225	2/314			
Scrub/Shrub	1319	34/125	24/755	3/439			
Forested	375	8/37	5/323	--			

Total: 40,915

Sources: National Wetlands Inventory
Washington Dept. of Game, 1982
Northwest Environmental Consultants, 1974
Kunze and Cornelius, 1982

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)
[3] figures are estimates from Washington Dept. of Game, 1982, maps prepared for DOE Coastal Zone Atlas

PIERCE COUNTY



1. Coastal Zone Atlas, 1979.
2. National Wetlands Inventory.
3. Shapiro and Associates, Inc., 1981.

SUMMARY OF WETLANDS INVENTORIES FOR PIERCE COUNTY

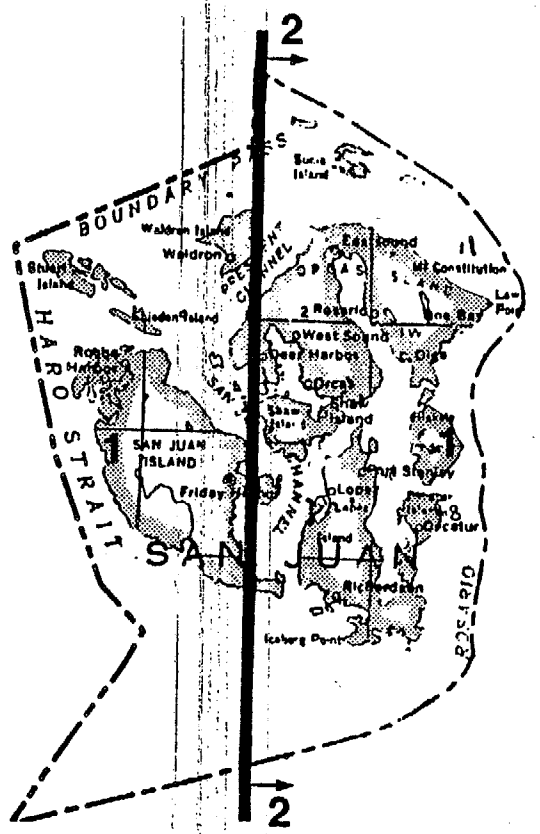
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	2993	--	--	--			
Emergent	237	NA/52	--	NA/185			
Scrub/Shrub	6	1/6	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	3261	--	--	--			
Lacustrine							
Open Water	2684	--	14/435	1/2249			
Aquatic Bed	219	--	4/219	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	411	82/302	8/109	--			
Aquatic Bed	89	7/40	4/49	--			
Emergent	1601	150/535	38/870	1/196			
Scrub/Shrub	1431	124/529	42/791	1/111			
Forested	1245	78/416	38/829	--			

Total: 14,177

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

SAN JUAN COUNTY



1. Coastal Zone Atlas, 1979.

2. National Wetlands Inventory,

SUMMARY OF WETLANDS INVENTORIES FOR SAN JUAN COUNTY

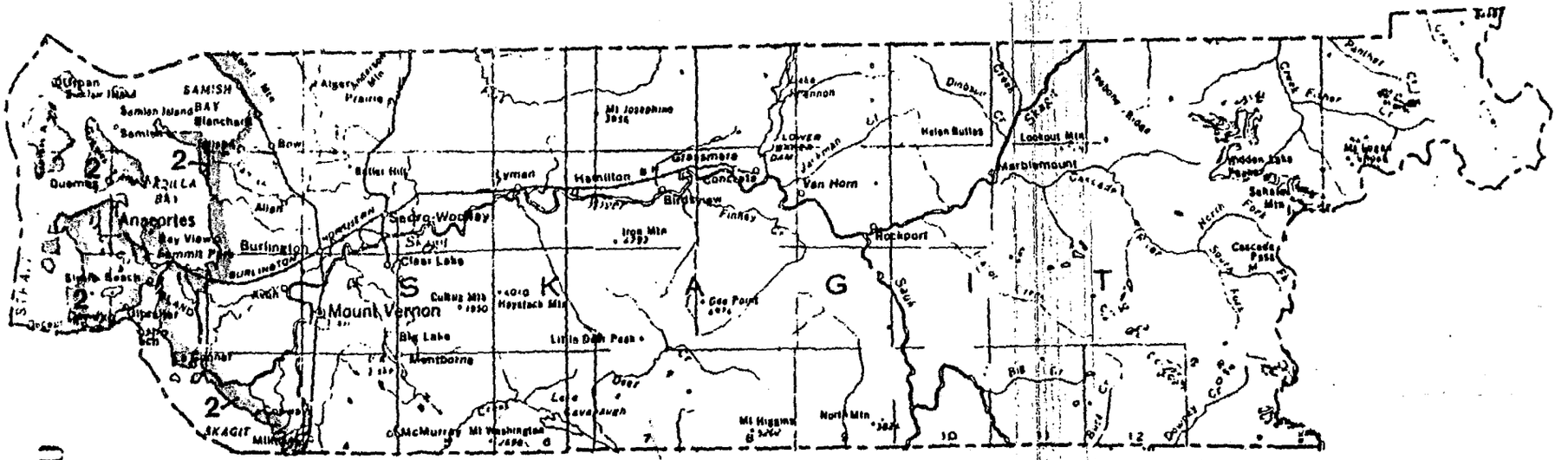
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres) <10	10-100	>100	Watershed Size (acres) <2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	2484	--	--	--			
Emergent	222	NA/62	NA/160	--			
Scrub/Shrub	13	3/13	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	3936	--	--	--			
Lacustrine							
Open Water	112	1/7	2/105	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	160	68/148	1/12	--			
Aquatic Bed	7	3/7	--	--			
Emergent	414	63/236	8/178	--			
Scrub/Shrub	124	28/112	1/12	--			
Forested	102	10/36	4/66	--			

Total: 7574

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

SKAGIT COUNTY



(180)

1. Raedeke, L.D., et al., 1976.
   (coverage of entire county)

2. Coastal Zone Atlas, 1979.

SUMMARY OF WETLANDS INVENTORIES FOR SKAGIT COUNTY

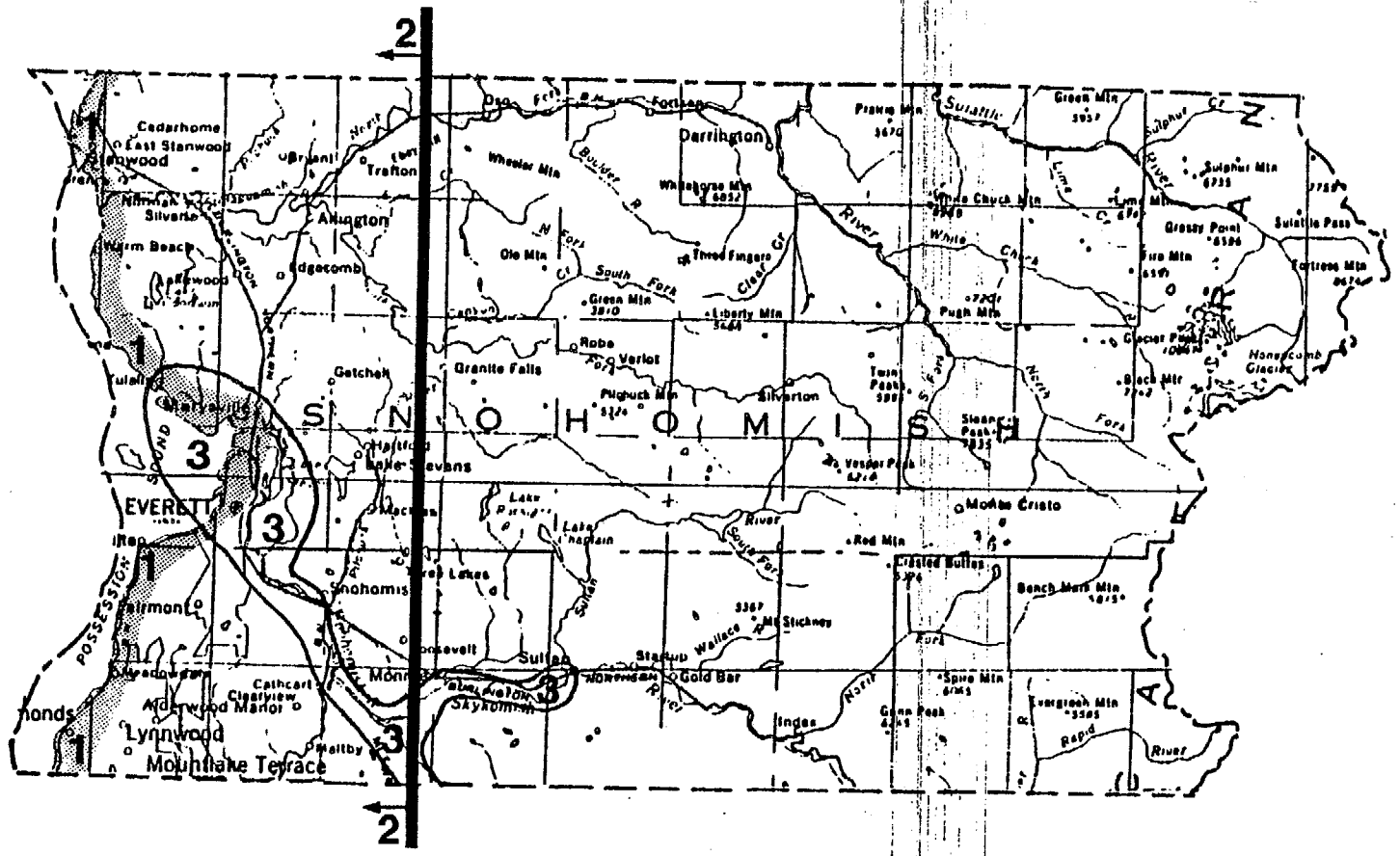
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	6645						
Emergent	4154						
Scrub/Shrub	1						
Forested	6						
Subtidal							
Aquatic Bed	1274						
Lacustrine							
Open Water	6343						
Aquatic Bed	--						
Emergent	--						
Palustrine							
Open Water	1694						
Aquatic Bed	--						
Emergent	2100						
Scrub/Shrub	862						
Forested	120						

Total: 23,199

Sources: Raedeke, L.D., et al., 1976
Coastal Zone Atlas, 1979

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

SNOHOMISH COUNTY



1. Coastal Zone Atlas, 1979.
2. National Wetlands Inventory.
3. Burrell, G., Washington Dept. of Game, 1979.

SUMMARY OF WETLANDS INVENTORIES FOR SNOHOMISH COUNTY

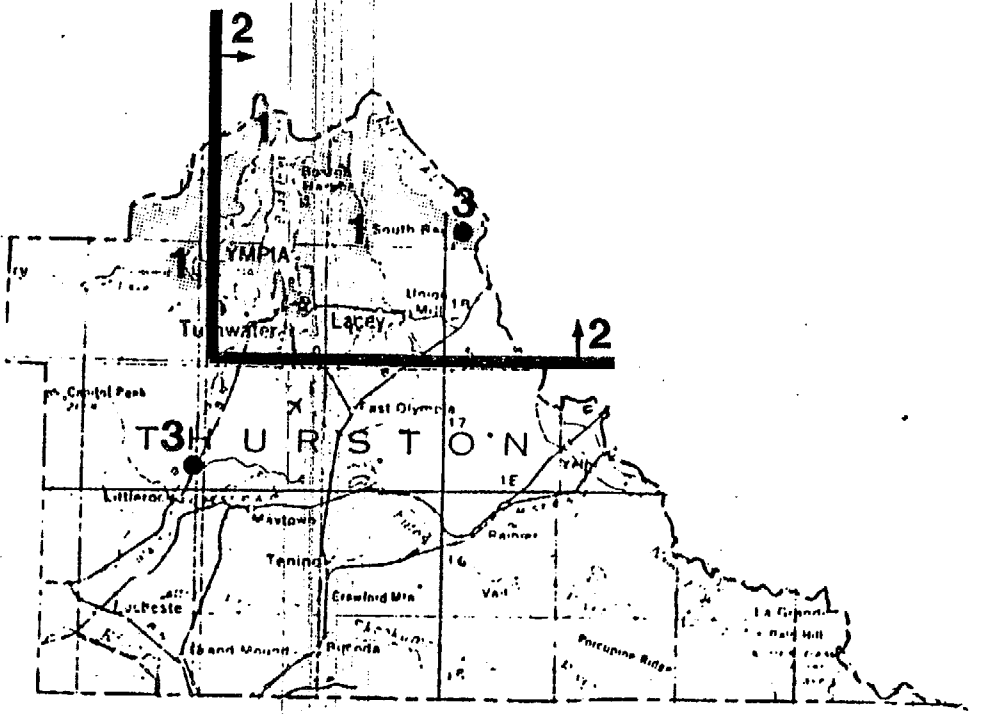
Wetland Type	Total Area (Acres)	Size Distribution (n[1]/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	7420	--	--	--			
Emergent	3744	--	1/45	NA/2494			
Scrub/Shrub	--	--	--	--			
Forested	528	--	--	--			
Subtidal							
Aquatic Bed	2163	--	--	--			
Lacustrine							
Open Water	141	--	4/141	--			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	579	79/274	16/305	--			
Aquatic Bed	30	7/30	--	--			
Emergent	983	246/537	27/446	--			
Scrub/Shrub	1690	97/387	47/1031	2/272			
Forested	2834	64/355	50/1247	3/588			

Total: 20,112

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980
Shapiro and Associates, Inc., 1981

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

THURSTON COUNTY



1. Coastal Zone Atlas, 1980.
2. National Wetlands Inventory
3. Burge, M.E., et al., 1975. (Unpublished)

SUMMARY OF WETLANDS INVENTORIES FOR THURSTON COUNTY

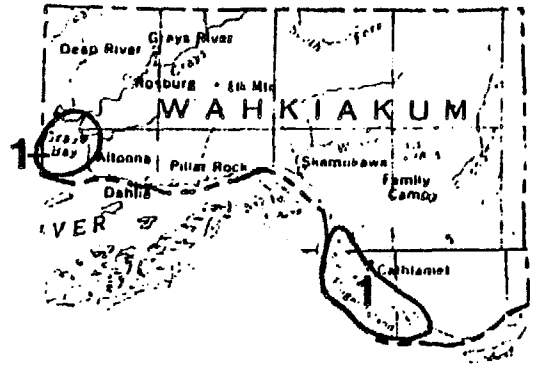
Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	2302	--	--	--			
Emergent	419	NA/54	1/14	1/351			
Scrub/Shrub	--	--	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	1356	--	--	--			
Lacustrine							
Open Water	1236	--	13/588	5/648			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	258	22/83	4/60	1/115			
Aquatic Bed	35	3/13	1/22	--			
Emergent	265	49/167	7/98	--			
Scrub/Shrub	560	37/157	19/403	--			
Forested	73	9/28	4/45	--			

Total: 6504

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

WAHKIAKUM COUNTY



1. Thomas, D. W., 1982 Draft.

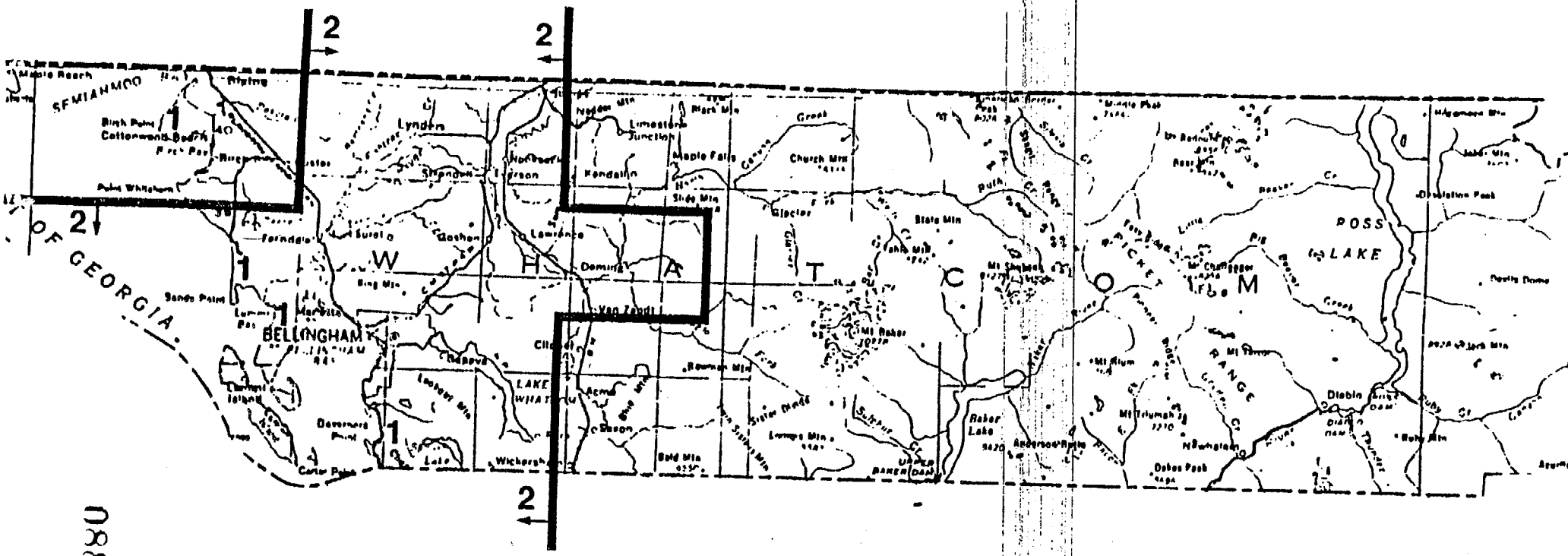
SUMMARY OF WETLANDS INVENTORIES FOR WAHKIAKUM COUNTY

Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	--						
Emergent	1260						
Scrub/Shrub	--						
Forested	2470						
Subtidal							
Aquatic Bed	--						
Lacustrine							
Open Water	--						
Aquatic Bed	--						
Emergent	--						
Palustrine							
Open Water	--						
Aquatic Bed	--						
Emergent	--						
Scrub/Shrub	--						
Forested	--						
Total							

Sources: Thomas, D.W., 1982 Draft

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

WHATCOM COUNTY



1. Coastal Zone Atlas, 1979.
2. National Wetlands Inventory.

SUMMARY OF WETLANDS INVENTORIES FOR WHATCOM COUNTY

Wetland Type	Total Area (Acres)	Size Distribution (n^1/acres)			Watershed Size (acres)		
		<10	10-100	>100	<2000	2000-8000	>8000
Estuarine,							
Intertidal							
Beach Substrate[2]	3753	--	--	--			
Emergent	60	NA/19	NA/41	--			
Scrub/Shrub	--	--	--	--			
Forested	--	--	--	--			
Subtidal							
Aquatic Bed	1594	--	--	--			
Lacustrine							
Open Water	1773	--	9/278	7/1495			
Aquatic Bed	--	--	--	--			
Emergent	--	--	--	--			
Palustrine							
Open Water	1040	58/1030	1/10	--			
Aquatic Bed	--	--	--	--			
Emergent	2931	116/2308	21/487	1/136			
Scrub/Shrub	2003	77/798	46/1205	--			
Forested	1594	35/200	41/1083	1/311			

Total: 14,748

Sources: National Wetlands Inventory
Coastal Zone Atlas, 1980

[1] n=number of wetlands
[2] beach substrate (Coastal Zone Atlas) = flat, rocky shore, beach bar (National Wetlands Inventory)

APPENDIX B

WETLAND TRENDS

Table B-1

GRAYS HARBOR, WASHINGTON
1982 ESTIMATES OF WETLAND ACREAGE

Quad and Location	Approximate Acres Emergent Marsh
Point Brown - North of submerged jetty on Point Brown "The Sink"	270
Copalis Beach - east site of Point Brown Ocean Shores Marsh Area	185
Copalis Crossing - Humptulips River Marshes	165
Copalis Crossing - Chenois Creek Marsh	70
Copalis Cross - Grass Creek Marshes	55
Westport - Point New	9
Hoquiam - Bowerman Basin - Basically developed since 1973	175
Grayland - Hunt Club/Mall and Slough Marshlands	550
Hoquiam - Johns River Marshlands	310
Grayland - Beardslee Slough (Elk River Estuary)	100
Westport - Westport Marshes	370
Grayland - Elk River Marshes, Elk River, Andrews Creek	320
Whitcomb Flats Island	40
Goose Island and Sand Island	100
Total	2,719

Source: Washington Natural Heritage Program, 1982

Table B-2

WILLAPA BAY ESTUARY AREA
1982 ESTIMATE OF WETLAND AREA

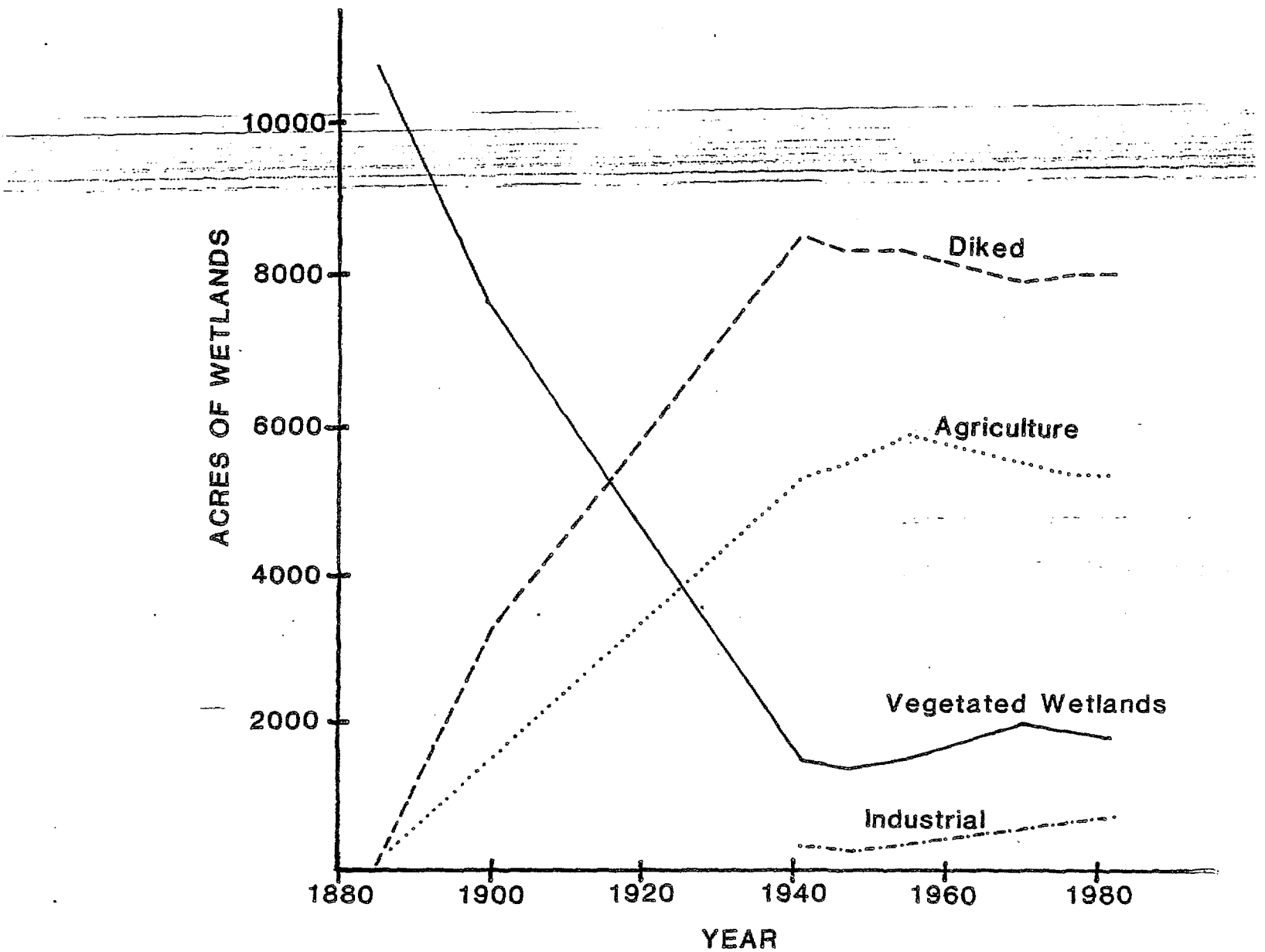
Quad/Location	Approximate Area (Acres)
North Cove - North Cove Marsh	300
Bay Center - Tokeland - Tealduck, Kindred Sloughs	170*
Cedar River/Norris	40*
Hawks Point	70*
North River/Smith Creek	300*
South Bend - II Slough/Kellogg Slough	134*
Frederickson Slough	320*
Bay Center - Hansen Creek	6*
Bruceport	25*
Bay Center - Bone River	300*
Niawiakum River	450
Nemah - Palix River	700
North Nemah River	125*
Middle and South Nemah	300
Long Island - Seal Slough	30*
Naselle River	750
Omeara Marsh	45*
Bear River	330*
Cape Disappointment - Porter Point	400
Oysterville - Goulters Slough	250*
Leadbetter Point	400*
North Cove, Oysterville - Leadbetter Point Drive System	2,800*
Ocean Park - Oceanside Dunes	180*
Long Island - South Long Island	75
Baldwin Slough	
Long Island - Lewis Slough	150*
Diamond Point RNA	upland
Long Island - Jensen Point	65*
Smokey Hollow Bog	15*
Cedar Grove	264* (upland)
Total	9,224

*Not indicated on the navigation charts as marsh and therefore not included in the estimated Willapa Bay Estuary wetland value in text.

Source: Washington Natural Heritage Program, 1982

FIGURE B-1

SNOHOMISH ESTUARY



Source : Shapiro/Driscoll, 1979

FIGURE B-2

TACOMA SOUTH

15' QUAD

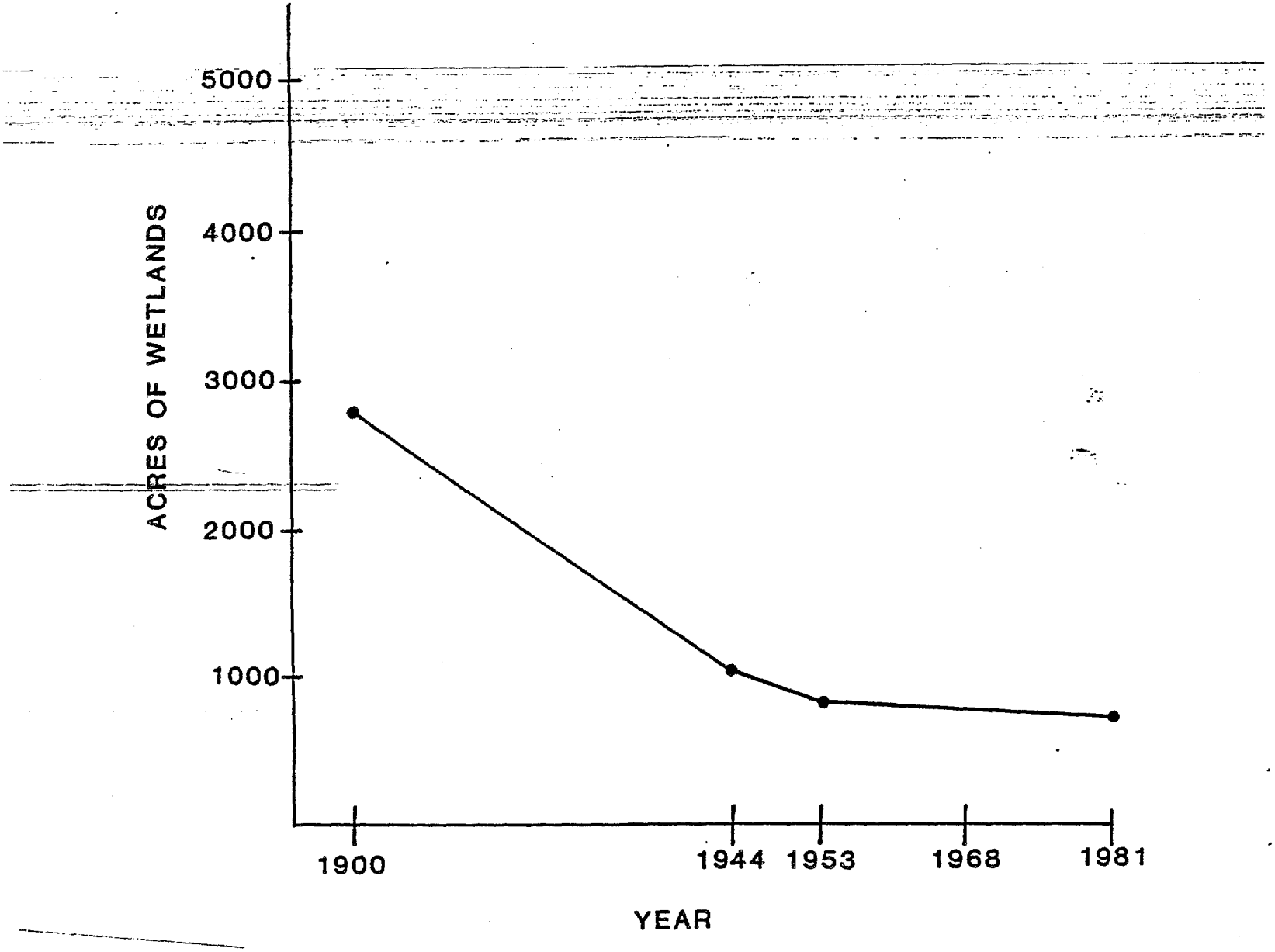


FIGURE B-3

LAKE TAPPS

15' QUAD

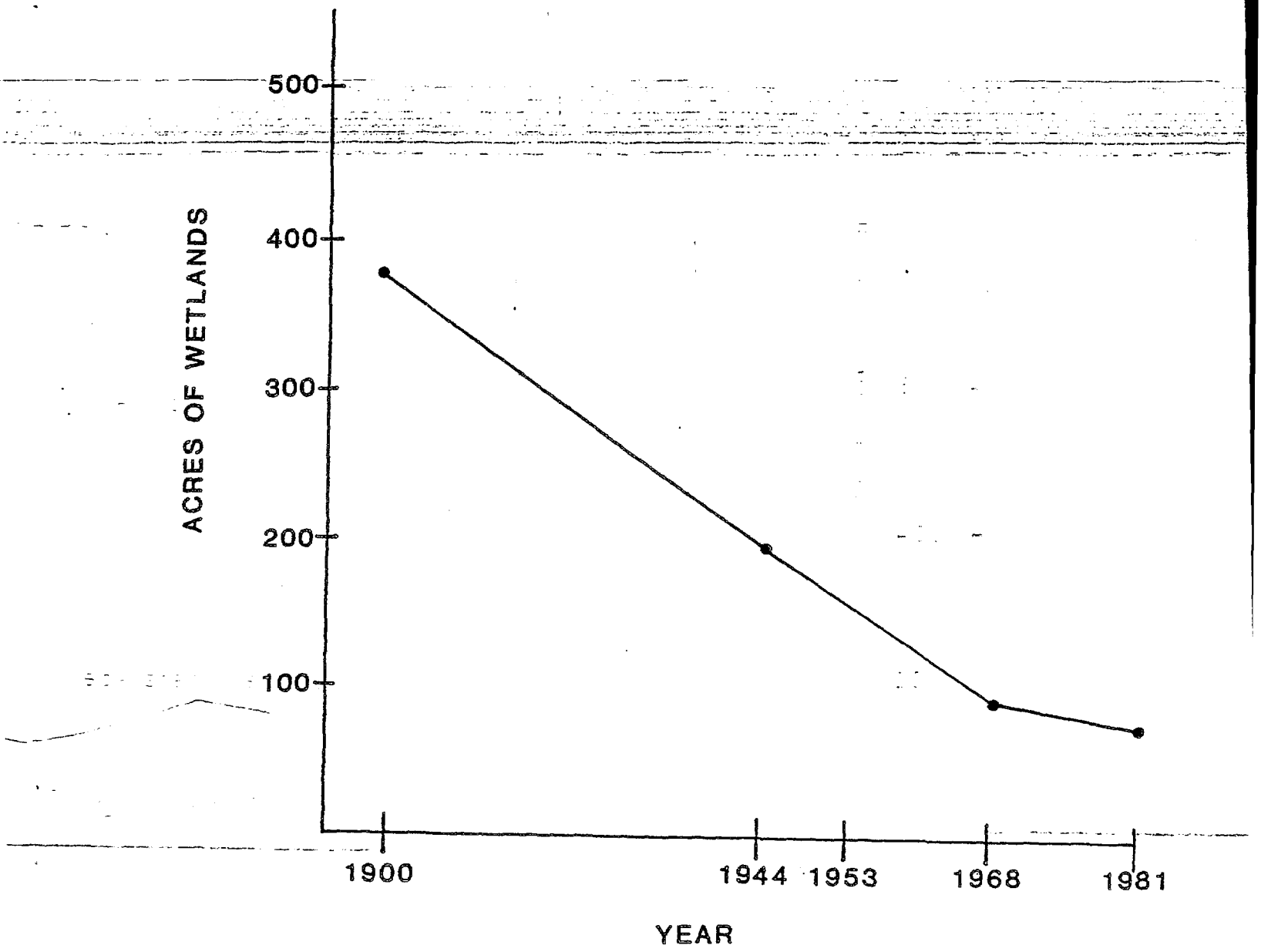
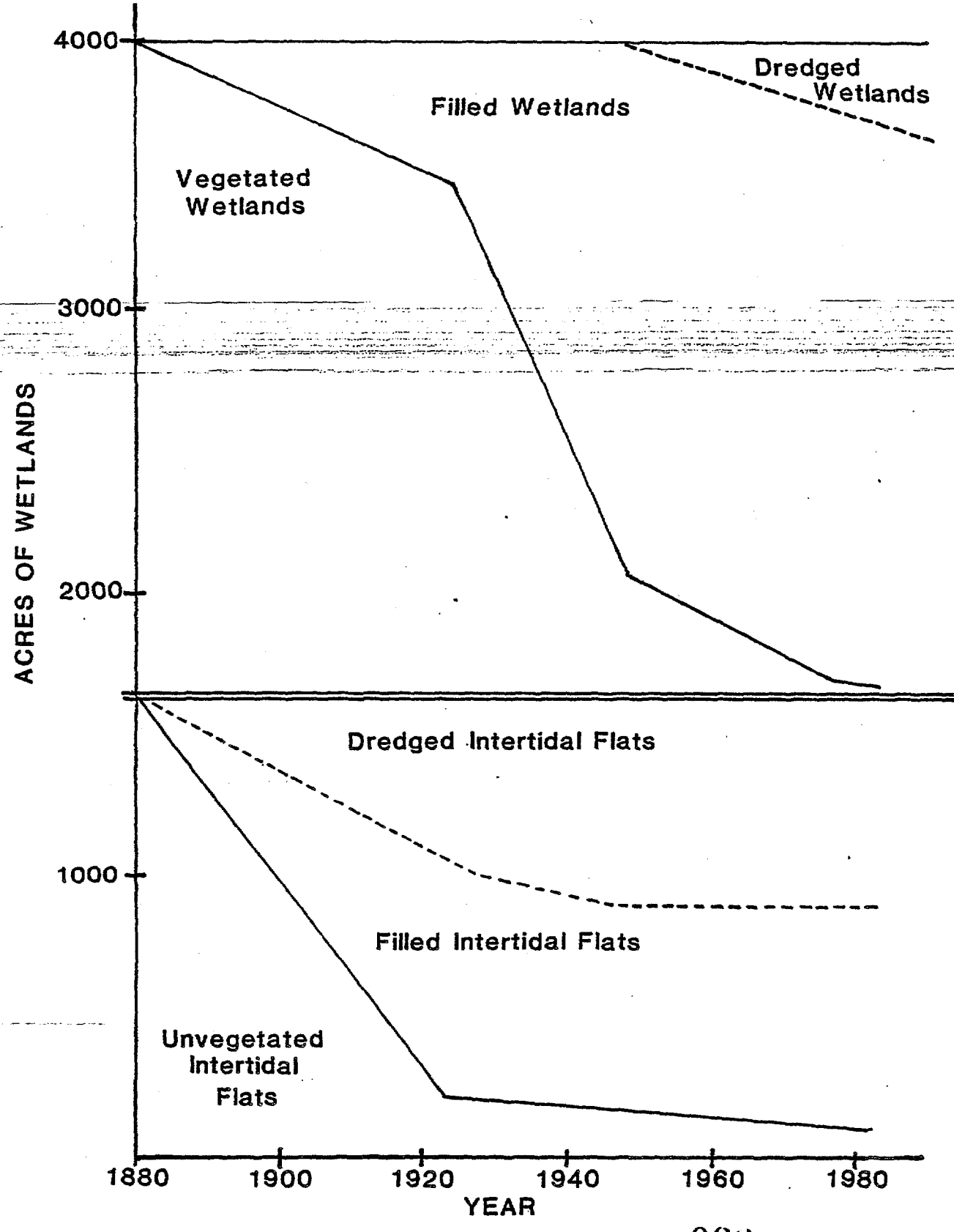


FIGURE B-4

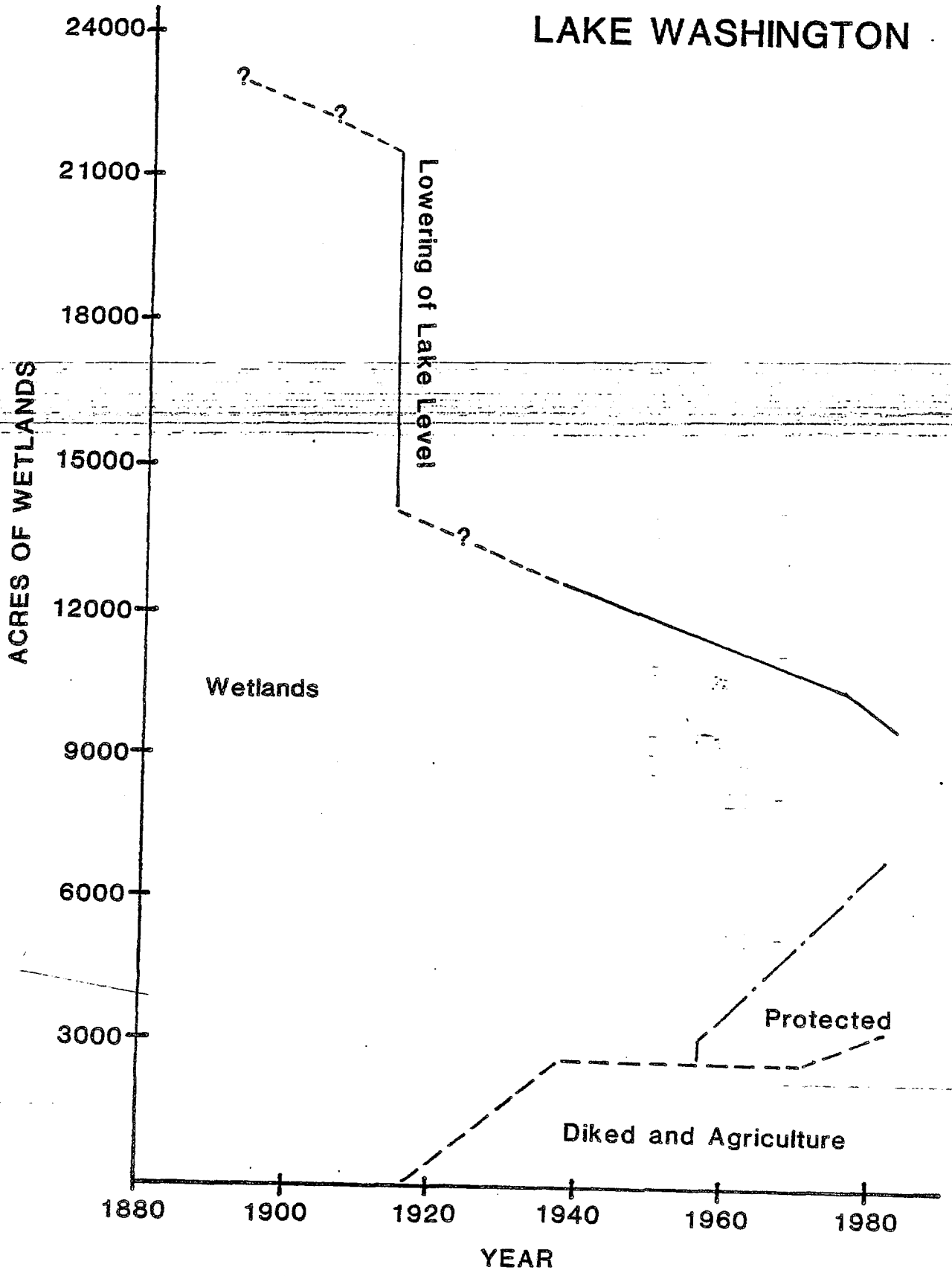
COMMENCEMENT BAY



Sources: Hart-Crowser and Associates, Inc.
Bortleson, C.G., et al., 1980

FIGURE B-5

LAKE WASHINGTON



Sources: Hockett, C.A., 1976
Ellman, N. and J.P. Schuett-Hames, 1979

FIGURE B-6

TENINO

15' QUAD

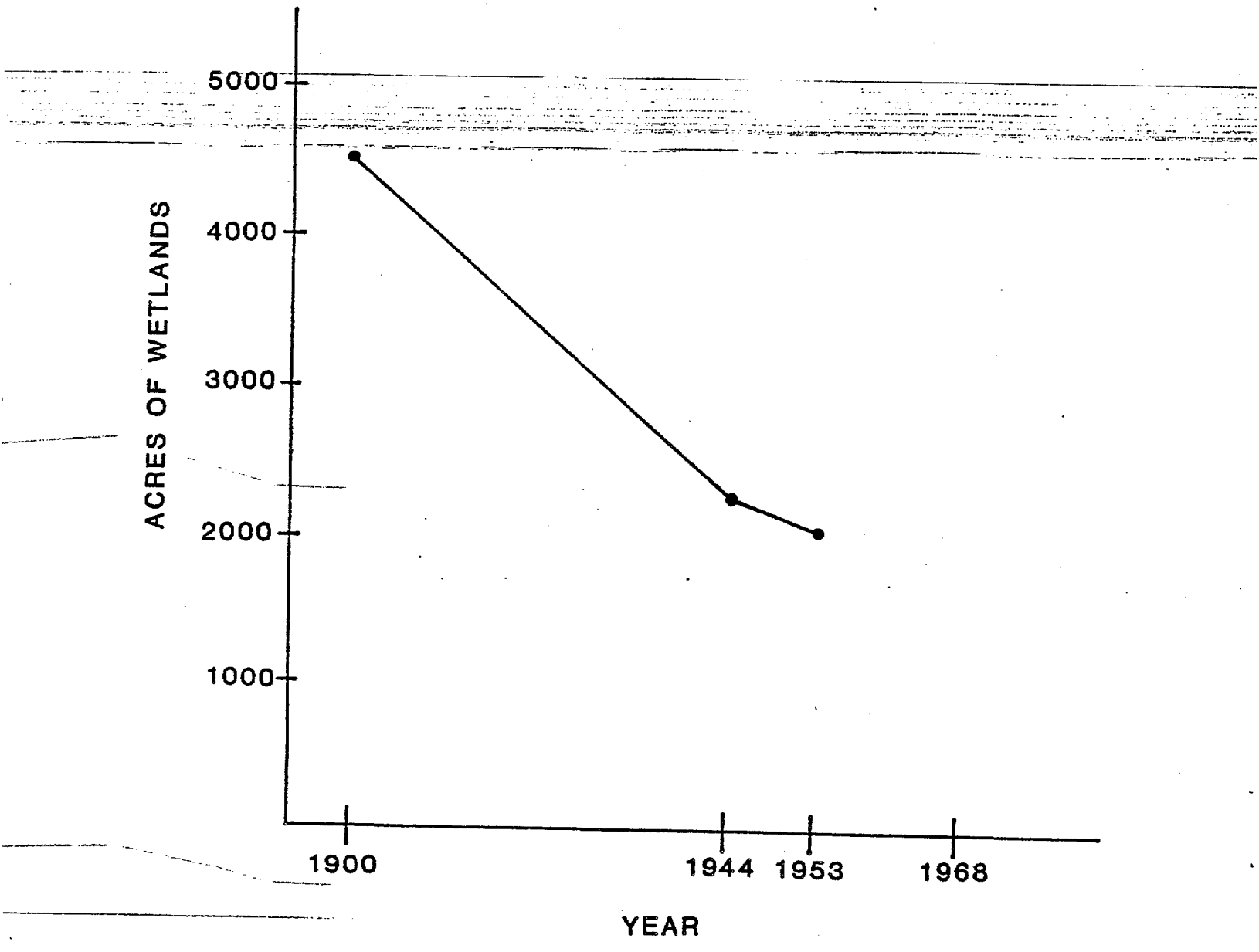


FIGURE B-7

YELM

15' QUAD

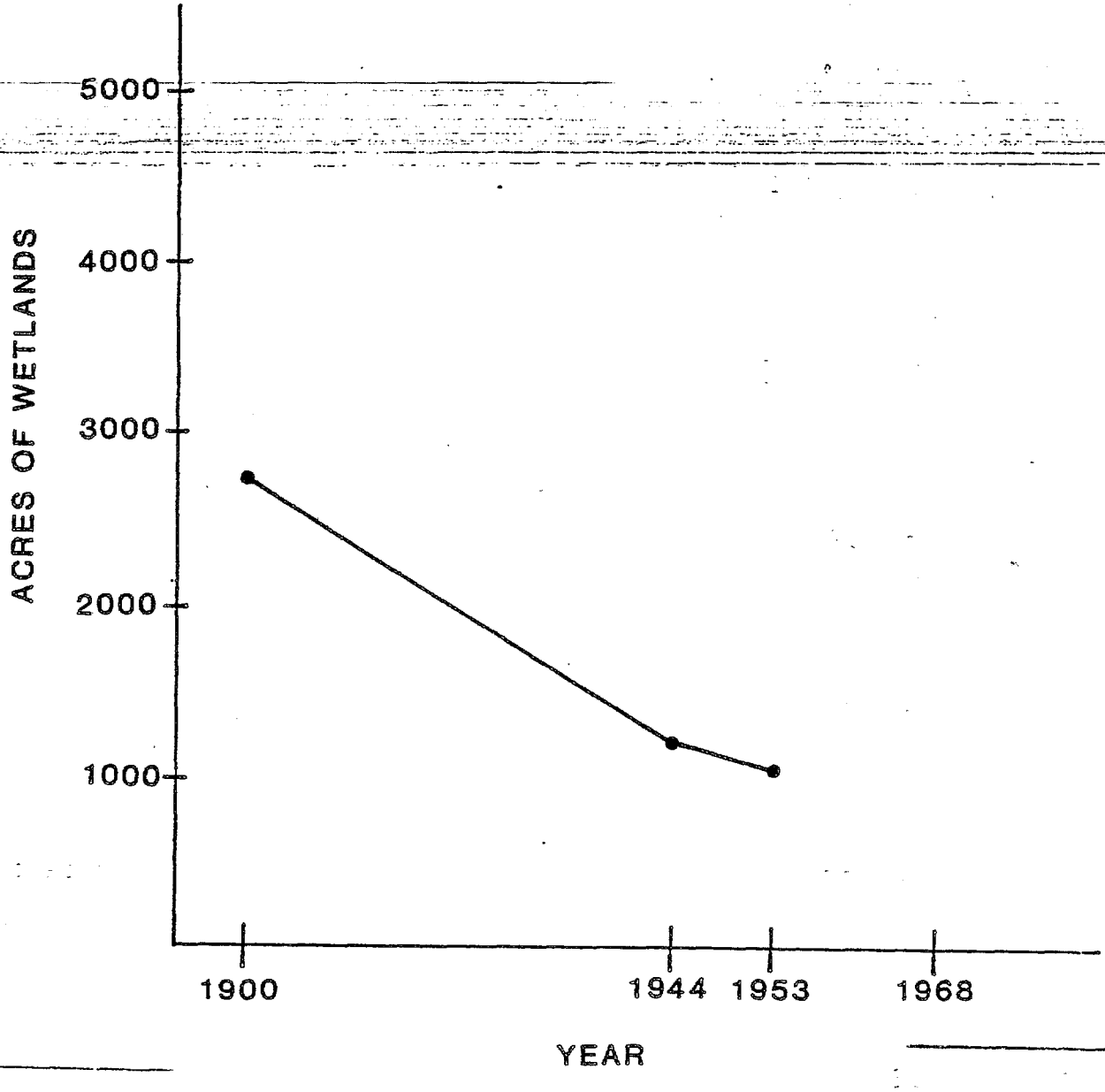


FIGURE B-8

GRAYS HARBOR

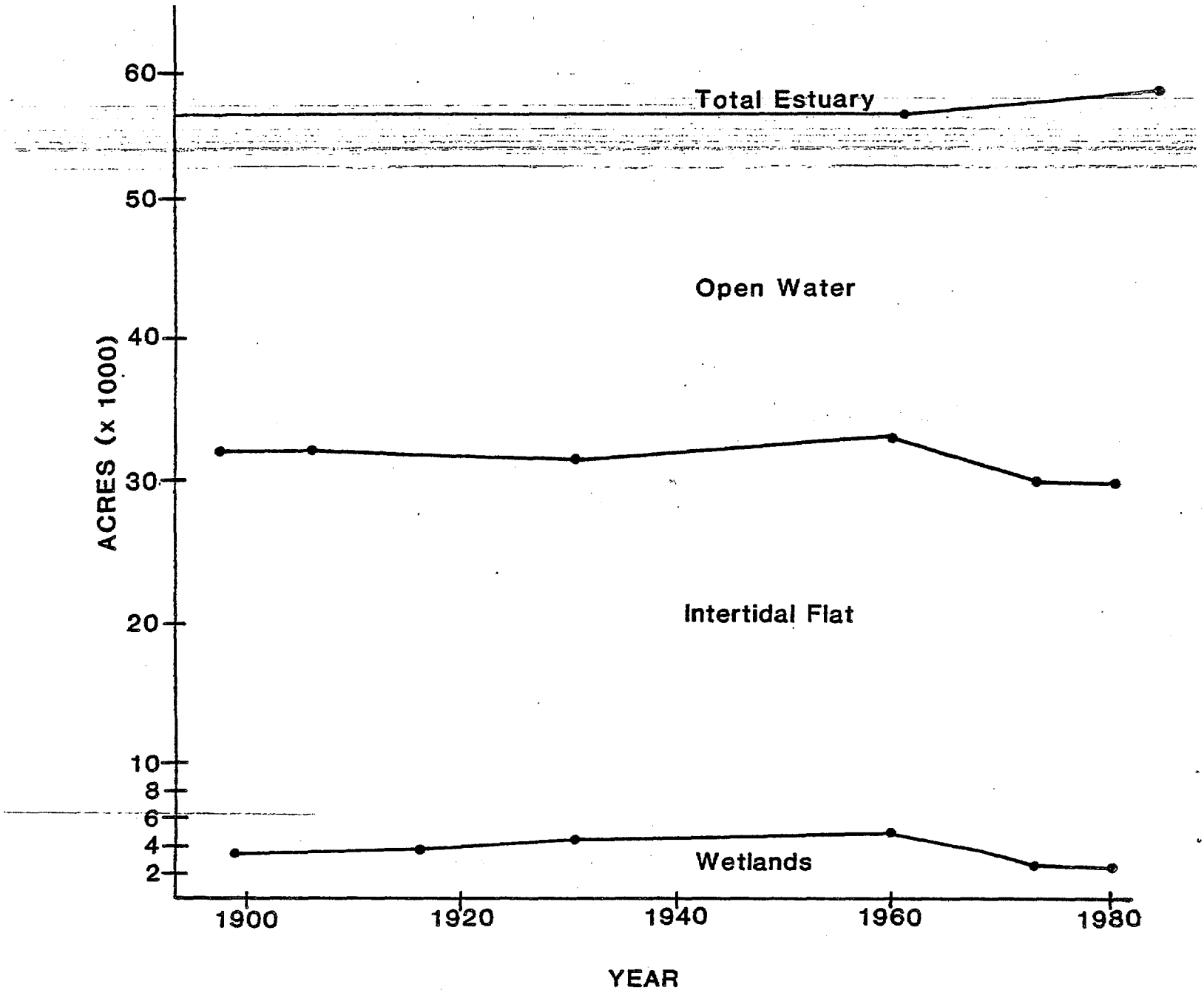


FIGURE B-9

GRAYS HARBOR

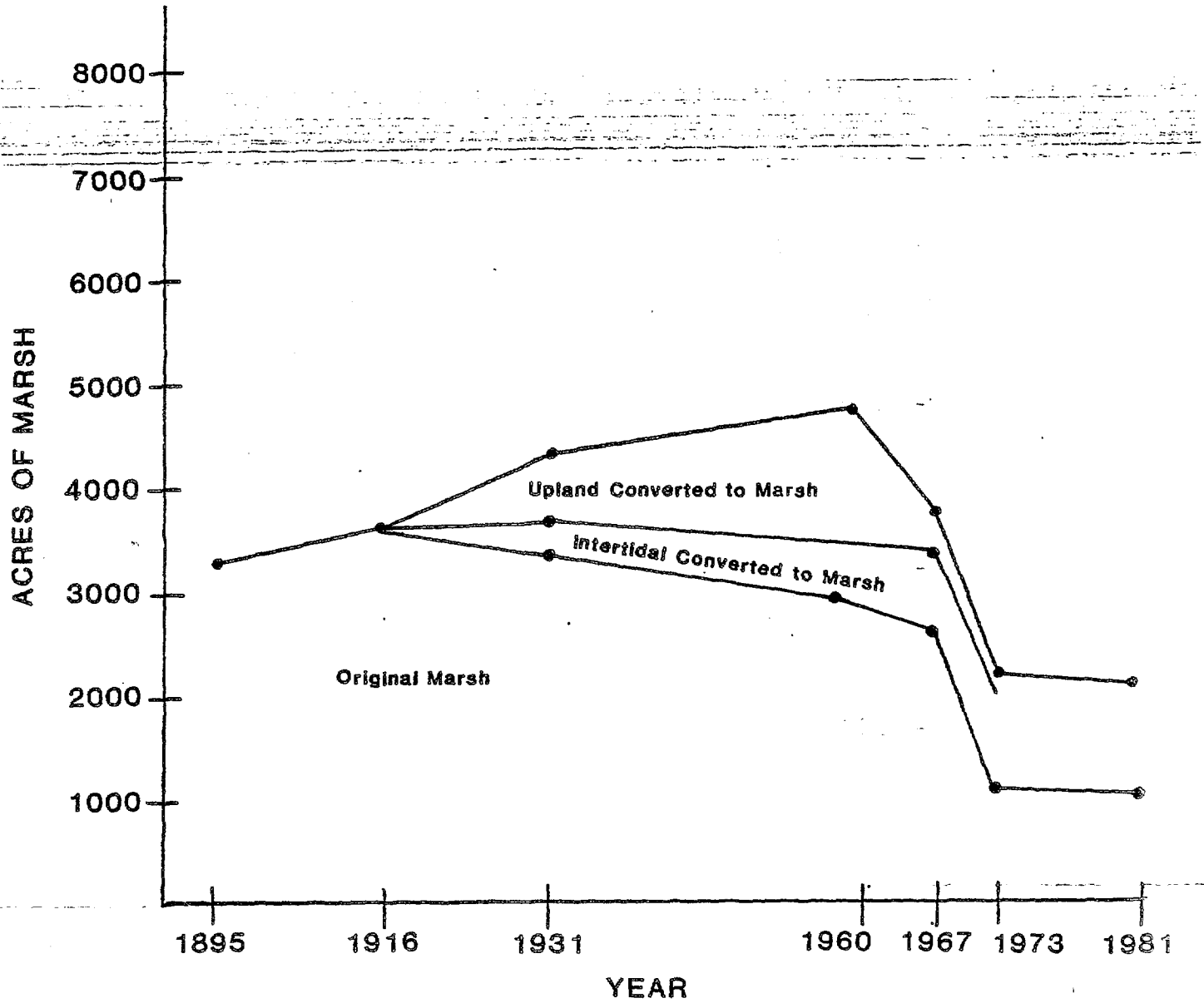


FIGURE B-10

WILLAPA BAY