EPA-10-WA-CLARK-POV-CL-77

DRAFT ENVIRONMENTAL IMPACT STATEMENT

for

VANCOUVER LAKE RECLAMATION STUDY
PORT OF VANCOUVER
CLARK COUNTY, WASHINGTON

NOVEMBER 1977

Prepared By

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
SEATTLE, WASHINGTON 98101

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Date

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SUMMARY

DRAFT ENVIRONMENTAL IMPACT STATEMENT

VANCOUVER LAKE RESTORATION

1. Type of Statement: Draft (X) Final ( )

2. Type of Action: Administrative (X) Legislative ( )

3. Description of Action:

The subject action for this environmental impact statement is the awarding of grant funds to the Port of Vancouver for the rehabilitation and restoration of Vancouver Lake. The primary objective in the restoration of Vancouver Lake is to improve the water quality and lake conditions to the extent that residents of Clark County and the greater Portland metropolitan area can use and enjoy the lake for recreational purposes. Gradual pollution and sediment input into Vancouver Lake, compounded by major silt deposition during the 1948 flood, has resulted in lake depths of only 1-4 feet and water quality which is characterized by high levels of bacteriological pollution, excessive organic and inorganic nutrients, blue-green algae, weeds, sediments and turbidity. The measures outlined in the Master Plan for the Rehabilitation of Vancouver Lake, as discussed below, are proposed to improve the water quality and increase the depth of the lake to the extent that water-oriented recreation may occur within and adjacent to the lake.

The Port of Vancouver is the primary project sponsor and has commissioned numerous studies of Vancouver Lake Rehabilitation over the past ten years. These have included studies by Washington State University as well as by the engineering firm of Stevens, Thompson and Runyon. During 1976-77 the Port retained the consulting firm of Dames and Moore to prepare a Pilot Dredge Study for Vancouver Lake. The intent of this study was to specifically investigate the engineering and environmental factors related to dredging, dredged material placement and spoil conditioning. A variety of dredging and disposal methods were evaluated and the merits and applicability of various equipment possibilities were tested.

In addition, the restoration of Vancouver Lake is a major element in the Section 208 Areawide Wastewater Management Plan, currently being prepared by the Regional Planning Council of Clark County and funded by the Environmental Protection Agency. The other two work elements include reduction of point source pollution from Burnt Bridge Creek and reduction or elimination of future pollutants from non-point sources. The restoration plans for Vancouver Lake represent approximately 30 percent of the effort being expended within the 208 program. The consulting firm of Dames and Moore recently completed a Master Plan for the Rehabilitation of Vancouver Lake which outlines specific lake restoration and maintenance measures. The Clark County Regional Planning Council is scheduled to adopt the Master Plan at their late October meeting. The Burnt Bridge Creek Management Plan is currently being reprinted in final form and is also scheduled for adoption in late October. The draft report, outlining measures to reduce or eliminate future pollutants due to non-point sources, will be available for public review during October. Of primary corcern in that report are animal wastes resulting from agricultural activities and urban drainage resulting from residential uses and new construction activities.

The Grant Application and Master Plan for the Rehabilitation of Vancouver Lake outlined three major steps to be taken to achieve restoration of the lake: 1) dredging the lake to enhance recreational use opportunities, improve water circulation and remove a portion of the polluted bottom sediments, 2) construction of a flushing channel to bring Columbia River water into the lake thus diluting the currently polluted water and enhancing the water circulation within the lake, and 3) reducing the non-point waste sources which have contributed to the present water quality degradation. In addition, construction of major sewage collection facilities within the Burnt Bridge Creek drainage area are expected to limit the future pollutants entering the lake from that source.

The following alternatives are considered in this draft environmental impact statement:

Alternative 1	No Action
Alternative 2	Scale of Development
2A	12-15 Million Cubic Yards of Dredging
2B	8-10 Million Cubic Yards of Dredging
2C	6 or Less Million Cubic Yards of Dredging
Alternative 3	Disposal Material Placement
3A	Land Disposal
3B	Shoreline Disposal
3C	Combination of Land and Shoreline Disposal
Alternative 4	Dredging Methods
Alternative 5	Dredged Material Handling Methods

Alternative 2 - Scale of Development is the most significant alternative discussion since the design of the flushing channel and the non-point source waste control measures are consistent throughout the program. Alternatives 2A, 2B and 2C evaluate the effects of dredging, and thus disposing, of significantly different quantities of bottom sediments from the lake. Potential disposal sites were screened by the Regional Planning Council of Clark County and Dames and Moore and were included within the Master Plan for Rehabilitation of Vancouver Lake. Only those disposal sites included within the Master Plan were evaluated in this draft environmental impact statement.

4. Summary of Environmental Impacts and Adverse Environmental Effects:

While the majority of the beneficial effects of the project relate to the increased recreational use of the lake resulting from the improved water quality, the majority of the adverse environmental effects would relate to the disposal of the dredged materials. These impacts and their magnitudes will vary according to the alternatives proposed. Alternative 1 represents a no action alternative which presumes that the Environmental Protection Agency would not provide grant funds for assistance with lake restoration. If that were to occur, it is doubtful that local funding sources would be sufficient to support the project, therefore lake restoration as currently planned would not occur. The result of selection of Alternative 1 would be continued eutrophication of Vancouver Lake, and no future increased development of recreation use and facilities around the lake.

Alternative 2 defines the various levels of dredging that could be done to accomplish lake restoration, ranging from a maximum of 12-15 million cubic yards to a minimum of 6 million cubic yards or less. While dredging of 15 million cubic yards would maximize both water quality and recreation benefits, Alternative 2B would maximize water quality benefits, but delete the construction of the proposed sailing course. The Master Plan for Rehabilitation of Vancouver Lake states that the minimim amount of dredging necessary to achieve the necessary water quality benefits would be 8.1 million cubic yards, therefore, it is questionable whether selection of Alternative 2C would result in any discernible beneficial effects.

Selection of either alternative 2A or 2B would result in halting the further eutrophication processes in Vancouver Lake. Increasing the flushing flow and water circulation in the lake coupled with control of pollution sources should result in increased water quality. However, it is believed that in order to provide water quality sufficient for water contact sports, groundwater must be pumped along the swimming beach.

The major benefits resulting from lake restoration would accrue to area recreationists. The Port of Vancouver has calculated that recreation benefits would equal or exceed $4,000,000 annually as a result of park development and other features which would provide for picnicking, fishing, sailing, hunting, hiking and other recreational pursuits.

The major adverse effects resulting from the project would be associated with the disposal of the bottom sediments dredged from the lake. A variety of wetland habitats exist around Vancouver Lake, preservation of which is strongly encouraged by Presidential directive and Environmental Protection Agency policy. EPA is currently conducting a study of these wetlands to determine their classification, value and role in the local ecosystem. Once these wetlands have been classified, it will be possible to determine the effects which would result from disposal of dredged materials on portions of those areas. In addition, much of the land around the lake is in productive agricultural use or is slated for future industrial use. Placement of dredged materials on those lands would result in loss of future productivity and could be determined to be in conflict with the adopted Vancouver Lake Land Use Plan.

Measures to mitigate short term impacts of the project resulting from dredging and the disposal of dredged materials are outlined in detail in the Master Plan for the Rehabilitation of Vancouver Lake.

5. Comments

The following State, Federal and local agencies and interested groups were invited to comment on the Draft Environmental Impact Statement:

FEDERAL AGENCIES

Council on Environmental Quality
U. S. Department of Agriculture
U. S. Department of Defense
U. S. Department of Interior
U. S. Department of Health, Education and Welfare
U. S. Department of Housing and Urban Development
U. S. Department of Transportation
Federal Energy Office
National Marine Fisheries Service
Advisory Council on Historic Preservation

MEMBERS OF CONGRESS

Warren G. Magnuson, U.S. Senate
Henry M. Jackson, U.S. Senate

STATE AGENCIES

Office of the Governor
Department of Ecology

Department of Fisheries
Department of Natural Resources
Department of Game
Department of Social and Health Services
Department of Commerce & Economic Development
The State Ecology Commission
State Parks and Recreation Commission
State Oceanographic Commission
State Utility and Transportation Commission

LOCAL AGENCIES & INTERESTED GROUPS

City of Vancouver
City of Vancouver Public Library
Port of Vancouver
Regional Planning Council of Clark County
Greater Vancouver Chamber of Commerce
Clark County Public Works
Clark County Parks Department
Port of Richfield
Diking Improvement District #14
Vancouver Lake Sailing Club
Alcoa
Washington State University
Dames & Moore
National Wildlife Federation
Sierra Club
League of Women Voters
Audubon Society

INDIVIDUALS

John Coop
John DeBenedem
Bob Bottman
Jerry Olin
Lee Liston
Harley Mays
John Roe
Mr. & Mrs. Donald H. Tilson
Rich Kosterman
John Winther
Ernest Q. Miller - Vancouver Wildlife League
Kit Metlen
Alan Ham
James F. Nelson
Marla A. Shirts
Paul Norman

Robert K. Laus
James N. Crane
Gretchen Starke
Kent Anderson
David L. Hickman
John Neel
Nancy Jackson - KVAN
Russ Maynard
Yvonne Viers
H. L. Firestone
Alex Tyrpak
Jim Kosterman
Larry Lange - The Columbian
Glenn H. Hough, P.E.
Norman L. Glenn - DOE
Dept. Natural Resources

Garland Pittman
Mary Legry - League of Women Voters
Francis J. Mortek
Lloyd H. Kessler
Larry Swatosh
Earl R. Kadow
Don Monbrod

Merril Firestone
Mary G. Baur
Ernie L. Dyer
Pierre Henrichsen - Washington State High Dept.
John Thomas

This Draft Environmental Impact Statement was made available to the Council on Environmental Quality (CEQ) and the public on NOV 4 1977

SECTION I - INTRODUCTION

Project Location and Grant Applicant

As shown in Figure 1, Vancouver Lake is located adjacent to the City of Vancouver in southwestern Clark County, within the greater Portland metropolitan area. A combination of dredging, flushing and pollution control measures are being proposed to rehabilitate this 2,600 acre, eutrophic lake. Agriculture is the predominant land use adjacent to the lake although significant recreational parcels are located on the west and south shorelines. Industrial activity occurs south of the lake, including a large Alcoa plant. The only residential uses in the proximity of the lake occur in conjunction with farming.

Vancouver Lake drains a watershed of approximately 19,000 acres. Its major tributary is Burnt Bridge Creek which enters the lake from the southeast. Water from Vancouver Lake flows into Columbia River via Lake River. The hydrologic and water quality characteristics of these waterways are discussed in detail in Section II.

The Port of Vancouver has requested a grant of federal funds to assist in restoration of the lake as outlined in Section 314 of the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500). Section 314 authorizes the Environmental Protection Agency to expend federal funds to assist with programs that will restore publicly owned freshwater lakes. The Port of Vancouver has requested federal grant assistance to cover $4,139,000 of the projected $8,278,000 rehabilitation costs. Additional state funding in the amount of $1,837,500 would be received through Washington State Department of Ecology's Lake Rehabilitation Program. The remainder of the necessary funds would come from local sources either through direct costs incurred by the Port of Vancouver or through in-kind contributions from Clark County and Diking Improvement District 14. (A more detailed discussion of project costs can be found in Section III). The Port of Vancouver is the implementing agency and would be responsible for project construction and maintenance.

The restoration of Vancouver Lake has been adopted as a significant element in the Section 208 Area-Wide Waste Treatment Management planning program currently being prepared by the Regional Planning Council of Clark County. Roughly 30 percent of the total 208 grant is being utilized for studies to determine the best and most cost effective means to achieve lake restoration.

Project Objectives and Major Features

Section 314 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) established the Clean Lakes Program, the primary intent of which is to restore publically owned freshwater lakes which have experienced historic water quality degradation. The approach to the rehabilitation is defined as twofold: 1) restricting the input of undesirable materials, and 2) providing in-lake treatment for the removal or inactivation of undesirable materials.

The primary objective in the restoration of Vancouver Lake is to improve the water quality and lake conditions to the extent that residents of Clark County and the greater Portland metropolitan area can use the lake for recreational purposes. After the restoration has been completed, proposed recreation uses include swimming, fishing, sailing, hunting, canoeing, and picnicking. With the exception of swimming, all of those recreation uses currently occur at the lake, however, boating, sailing and fishing use is often curtailed due to insufficient water depths.

Gradual pollution and sediment input into Vancouver Lake compounded by major silt deposition during the 1948 flood, has occurred historically, to the point that the lake now averages 1 to 4 feet in depth and is characterized by high levels of bacteriological pollution, excessive organic and inorganic nutrients, blue-green algae, weeds, sediment, and other water quality problems.

The grant application prepared by the Port of Vancouver outlines the following sources of water pollution and sedimentation:

> "Urbanization in the Burnt Bridge Creek drainage basin has substantially increased storm water runoff and associated silt loads in the creek, which in turn deposits sediments and pollutants in the lake. Subsoils conditions over much of the basin are unsuitable for subsurface disposal of domestic wastewater, so that septic tank effluent enters the stream. Runoff from agricultural crop lands into Burnt Bridge Creek also results in a seasonal problem.
>
> During periods of tidal inflow, the direction of flow in Lake River is reversed, and Vancouver Lake serves as a receiving body of water for pollutants from dairy farms, crop lands, boat moorages and a number of Lake River tributaries. The largest such tributary is Salmon Creek, which carries nutrients and silt load from a developing drainage basin characterized by significant agricultural, gravel mining and construction activities.
>
> Non-point waste sources* adjacent to Vancouver Lake consist predominantly of runoff from pasture and crop lands. Drainage from roads, railroad facilities, parking lots and lawns may also contribute pollutants to the lake. There are no direct municipal, storm water or industrial discharges into Vancouver Lake.
>
> The worst conditions of water quality in Vancouver Lake prevail during late summer and early fall, when the potential for water-oriented recreation is optimum. During this low water period, the availability of nutrients such as phosphate and nitrates is great because of less quantity of water for dilution. This condition coupled with favorable water temperature promotes algae growth,

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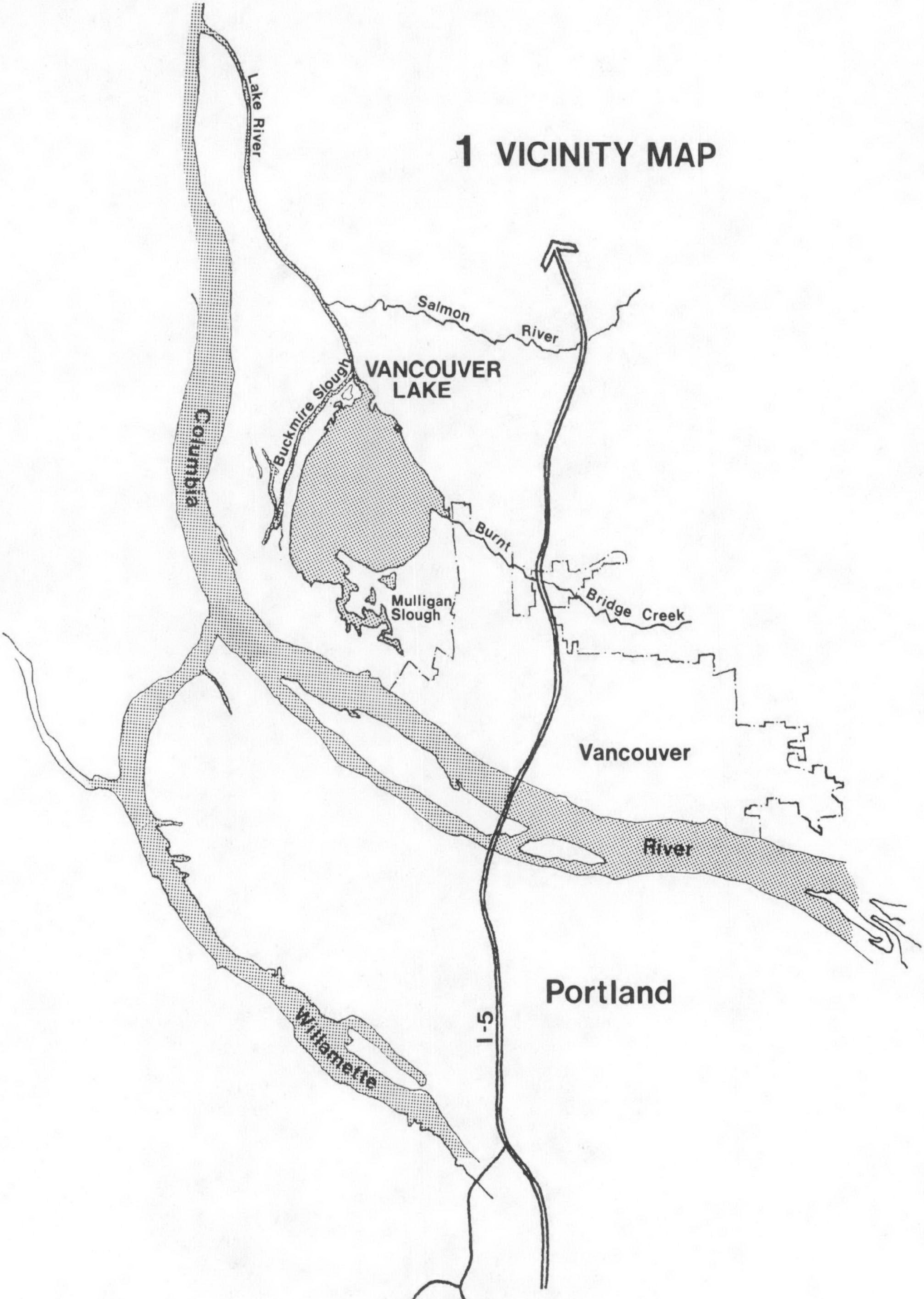
* Non-point source is defined as a generalized discharge of waste into a water body which cannot be located as to a specific source. Conversely, point source is defined as a specific site from which identifiable and often measurable quantities of recognizable pollutants derive.

1 VICINITY MAP



which in turn adversely affects other water quality parameters... According to the Water Quality Management Plan Summary Report by CH2M/Hill (April, 1974), Vancouver Lake does not meet state water quality standards and is unacceptable for the following uses: fish and wildlife, drinking, swimming, viewing and boating." (1)

The restoration program recommended by the Grant Applicant has three major components: "(1) dredging the lake to remove the most polluted sediments and enhance recreational use opportunities; (2) construct a flushing channel to bring Columbia River water into the lake, and (3) reducing the non-point waste sources which have contributed to the present water quality degradation." (2) The applicant believes that all three efforts are necessary in order to restore the lake to water quality and depth conditions that will allow public recreation use.

Project History

Since the late 1920's, various methods have been proposed for increasing the use of Vancouver Lake. Early proposals centered around increased industrial use of the lake, while later proposals have emphasized recreation and the necessary water quality improvements to provide an adequate recreational setting.

In the 1920's local farmers proposed that Vancouver Lake be drained and used for cropland. This plan was abandoned, and in 1948 it was proposed that Vancouver Lake be dredged to a depth that would permit the mothballing of Liberty Ships within the lake. This proposal integrated with Port of Vancouver desires to use the lake vicinity for industrial purposes and the Port and Vancouver Chamber of Commerce were the primary agents in support of that plan. Recreation was a part of this proposed industrial development, but played a secondary role. In 1966, the Port of Vancouver prepared a second major development plan for Vancouver Lake which included construction of a barge channel into the lake and barge loading facilities within the lake, as well as significant recreation facilities.

In 1968 a new plan for lake use was developed which placed primary emphasis on recreation use. Current State of Washington law allows Port authorities to become involved in recreational facilities only if approved by the local government having jurisdiction and if consistent with adopted plans and programs. Both of these criteria have been met by the 1968 plan, as revised and currently proposed.

In 1966 the Port of Vancouver and the Washington Department of Ecology contracted with Washington State University to prepare a series of water quality studies for Vancouver Lake and to propose methods for rehabilitation of the lake. Since that time, a number of private contracts have been awarded to study and design various aspects of the proposed restoration program.

The primary concern throughout the study and design process has been the significant cost of restoring Vancouver Lake to full public use. Even with the combination of state and local funds, the necessary financial resources have not been available at the local level to fully implement the necessary steps. When the federal Environmental Protection Agency was formed, the Port of Vancouver made initial inquiries into the availability of federal funding assistance. Since EPA instituted the Clean Lakes Program, these efforts have been pursued in earnest.

EPA's Environmental Responsibilities

The National Environmental Policy Act of 1969 (NEPA) Public Law 91-190, requires all federal agencies to "...utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment..." Section 102 (2)(c) of that act also requires the agency to prepare an environmental impact statement (EIS) on, "...major federal actions significantly affecting the quality of the human environment..." This is to be accomplished in consultation with the Council on Environmental Quality (CEQ), established by Title II of the act.

Through Section 314 of PL 92-500, EPA has the authority to make grants to state or local public agencies for the restoration of publically owned freshwater lakes. Concurrent with this authority is the responsibility to assure that federal funds will produce a project that will have maximum beneficial effects on the environment and minimum adverse effects.

The public laws quoted above, along with the CEQ and EPA regulations, constitute the authority and responsibility for the preparation of environmental impact statements on lake restoration programs.

Citizen Concerns and Issues

A variety of citizen and special interest groups have been involved in the preparation of the current Vancouver Lake Restoration Program. In the early 1970's the Vancouver Lake Task Force was appointed by the Clark County Commissioners to prepare a specific land use plan for the project area. That plan has been adopted by the county and integrated into the draft county land use plan which is presently under review.

As part of Clark County Regional Planning Council's 208 program efforts, a Vancouver Lake Technical Advisory Committee was formed to review and comment on the implementation program. This TAC is composed of local agency personnel, federal and state resource agency personnel, representatives from the local Park Board, lake front property owners and local business people. The group meets monthly to review specific design proposals and has spent considerable time and effort on the delineation of acceptable dredged spoil disposal areas. The Regional Planning Council staff feels that achieving consensus among this group on project features will insure general public support for the project.

Support for the proposed project appears to be county-wide and includes a wide variety of diverse groups including local business organizations as well as recreation groups. The Port of Vancouver has received official project endorsements from a large number of public and civic organizations, and reports that no one group has ever publically expressed opposition to the proposal.

In conjunction with the preparation of this Draft Environmental Statement, a public information meeting was held in Vancouver on June 16th. The purpose of the meeting was to review preliminary findings and to receive input from local residents. Issues which generated the most discussion at that meeting included: 1) water quality benefits of the proposed project, 2) cost of construction and maintenance, 3) cost of providing the recreation facilities, in particular the sailing course, and 4) the relationship between lake rehabilitation and future industrial use.

Consultation With Others

The following agencies or groups were contacted in relationship to the data collection and analysis phases of this document:

- U.S. Fish & Wildlife Service, Department of Interior
- U. S. Soil Conservation Service, Department of Agriculture
- U.S. Army Corps of Engineers, Portland District (Environmental Resources and Flood Management Branches)
- Washington State Department of Fisheries
- Washington State Department of Game
- Washington State Department of Environmental Quality (Air Quality, Water Quality and Natural Resources Division)
- Washington State Historic Preservation Officer
- Washington State Archaeology Department
- Clark College
- Port of Vancouver
- Clark County Regional Planning Council
- Clark County Parks Department
- Clark County Public Utilities District
- Southwest Air Pollution Control Authority
- Columbia Region Association of Governments

SECTION II. EXISTING CONDITIONS

Climate

The Vancouver Lake area experiences a predominantly temperate marine climate, typical of western Washington and northwestern Oregon. It is characterized by mild, wet winters and moderately warm, dry summers. The climate reflects the influence of the Coast Range to the west plus the Cascade Range and the Columbia River Gorge to the east. In the six month period from April through September 25 percent of the total annual precipitation occurs (see Table 1), while 75 percent of the precipitation occurs between October and March.

TABLE 1

Temperature and Precipitation
Data for Vancouver Area

Month	Average Daily Maximum Temperature	Average Daily Minimum Temperature	Average Total Precipitation	Average Snowfall
January	44.5°F	33.1°F	5.6 Inc.	5.1 In.
February	49.3	35.4	4.4	.8
March	55.0	38.3	4.0	(4)
April	62.8	42.4	2.3	(4)
May	69.2	47.2	2.0	0
June	73.2	51.9	1.9	0
July	79.8	55.1	.5	0
August	79.7	54.7	.7	0
September	75.4	51.5	1.6	0
October	64.4	46.0	3.6	(4)
November	52.6	38.8	5.6	(4)
December	47.1	36.2	6.7	(4)
Annual	62.7	44.2	39.0	5.9

1. The annual precipitation was 62.65 inches for the wettest year and 25.74 inches for the driest year. The greatest monthly precipitation was 15.04 inches.
2. The highest temperature on record is 105°F.
3. The lowest temperature on record is -10°F.
4. Trace

Source: Department of Commerce National Oceanographic and Atmospheric Administration, 1976.

The average January temperature is 38°F, with an average minimum temperature of 33°F. The July average temperature is 67°F, with a maximum daily average of 80°F. Total average snowfall for January is 5.1 inches, while the average yearly snowfall is 8.4 inches. Annual total precipitation in the area averages 37 inches.

Air Quality

The Vancouver Lake area is not specifically monitored for air quality measurements. However, there are several stations located to the south and to the east of the lake. These stations monitor suspended particulates, and certain stations in the area have recorded routine ambient air standards violations. Primary sources of this type of pollution are industrial, and Allied Chemical Corporation and the Carborundum Company have been identified as significant contributors. Other sources of suspended particulates are plywood processing, grain handling, and building activities. Because of consistent violations of the state and federal air quality standards, the Southwest Air Pollution Control Authority (a five county municipal corporation) will closely review any proposals for expansion within the Vancouver industrial area. All future development or alteration of industrial activites in the area must gain approval from the Air Pollution Control Authority, to ensure that local air quality is not further jeoparized.

Other parameters of air pollution, such as carbon monoxide and sulfur dioxide, are not monitored in the Vancouver Lake area.

Topography and Setting

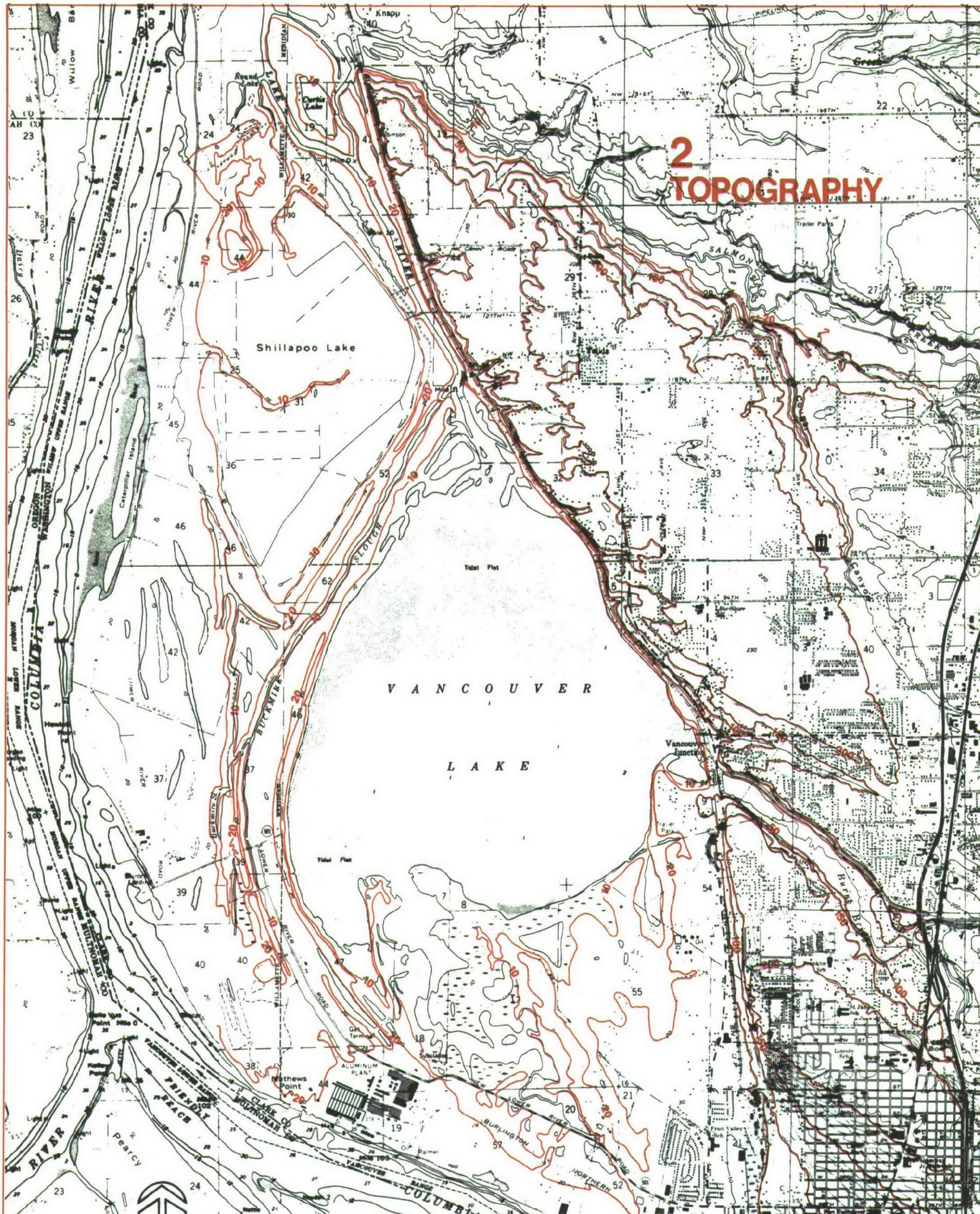
Vancouver Lake lies to the northwest, and adjacent to, the City of Vancouver, in the southwestern portion of Clark County. The lake is approximately 2,600 acres in surface area, with water depths ranging between one and four feet. The lands to the northwest and south are low-lying flatlands, and subject to seasonal flooding. The Columbia River, which flows within one mile of the southwestern shore, has both tidal and seasonal freshet influence on the lake. The lowlands lying between the lake and Columbia River have an elevation of from 10 to 20 feet Mean Sea Level (MSL). The northeast border of the lake, however, is characterized by bluffs rising to the Felida-Lakeshore area, with an average elevation of 200 feet MSL. (See Figure 2)

The main inflow to Vancouver Lake is Burnt Bridge Creek, which enters in the southeast corner of the lake. This stream drains approximately 17,660 acres of Clark County, for several miles to the east. The lake outflow is through Lake River, which drains from the north end of the lake. Lake River is a slow moving river, joined 2 miles north (downstream) of the lake by Salmon Creek. Salmon Creek drains a watershed that extends beyond Battle Ground to the foothills of the Cascade Mountains.

The surrounding lowlands of Vancouver Lake were formed by Columbia River depositions. The present location of the lake is believed to have been the old course of the Columbia. Most of the low lying ground is seasonally flooded, except where dikes now control surface waters.

Geology

Vancouver Lake is believed to have been the old river course of the Columbia River. Over the years as the Columbia shifted its course,


2
TOPOGRAPHY
Shillapoo Lake
VANCOUVER
LAKE
Round Lake
Curtis Lake
Caterpillar Island
Tidal Flat
Vancouver Junction
Mathews Point
ALUMINUM PLANT
Pearcy
Knapp
SALMON
BURLINGTON
NORTHERN
COLUMBIA
RIVER
FRIENDLY
REACH
Port of Vancouver
1" = 2000'
VANCOUVER LAKE
REHABILITATION
EIS
WILSEY & HAM

substantial deposits of alluvium were left behind. These alluvial deposits eventually cut off the lake waters from the main river course, causing the formation of the current land composed of mixed sands and silts. The Troutdale formation is found to the northeast where the bluff begins its ascent. It is a sandstone and conglomerate mix, exposed almost exclusively along the bluff face. Lying above the Troutdale are Lacustrine deposits of unconsolidated gravel, sand, silt, and clay, of detaic origin. The area south of Burnt Bridge Creek is similar in origin and nature to the Lacustrine deposits on the bluff, but contain more substantial gravel components.

Soils

Four principal soil series are represented in the Vancouver Lake area. The Sauvie soil series predominates in the lands to the west and the south of the lake, while the Wind River soil series is the principal soil found south of Burnt Bridge Creek. In the bluff areas to the northeast of the lake, the Hillsboro series is the primary soil type. Occurrence of the Newberg series is less frequent, and it is found in strips along the Columbia River shore. The general location of each soils series is mapped on Figure 3. Map symbols, capability classifications and slopes are shown on Table 2.

The Sauvie series is the most significant soil group found in the project area, as it covers the greatest area of land and is the most intensively formed. It consists of deep, moderately well drained to poorly drained, sloping soils. Formed in river alluvium, the soils are generally loamy and typical of local bottomlands. The native vegetation consists of willows, cottonwoods, ash, and various grasses. The Sauvie series is represented by four varieties, ranging in slope from 0 to 8 percent. All four varieties (map symbols SpB, SmA, SmB, and SnA) are considered to have high fertility, and a high available water capacity. Except when certain soils are wet, tillage is considered easy. Erosion is slight, except where the Columbia River floodwaters may scour. Heavy winter precipitation, along with spring river freshets, causes a seasonal high water table. The soils all have a capability II rating with minor individual restrictions (see Table 2). Truck crops, row crops, hay and pasture are typical uses of these soils.

The Wind River soils series predominates in the Burnt Bridge Creek area, much of which has been converted from agricultural to urban uses. The soils consist of deep, somewhat excessively drained soils, on nearly level to very steep slopes. These gravelly soils, of mixed origin, were formed on Columbia River alluvium. Permeability is moderately rapid in the upper part of the soil, but water tends to perch above a depth of 24 inches. Where the slope is 10 percent or greater, the soil carries a severe limitation for septic tank suitability. Typical native vegetation is Douglas fir, grand fir, Oregon white oak, hazel, dogwood, salal and vine maple. The soils found in the 0-8 percent slopes (map symbol WnB) have the best agricultural capabilities classification (IIIe), and cover the majority of the Burnt Bridge Creek area. When in crop production, the Wind River series is used mainly for pasture, tree fruits, nuts, and row crops.

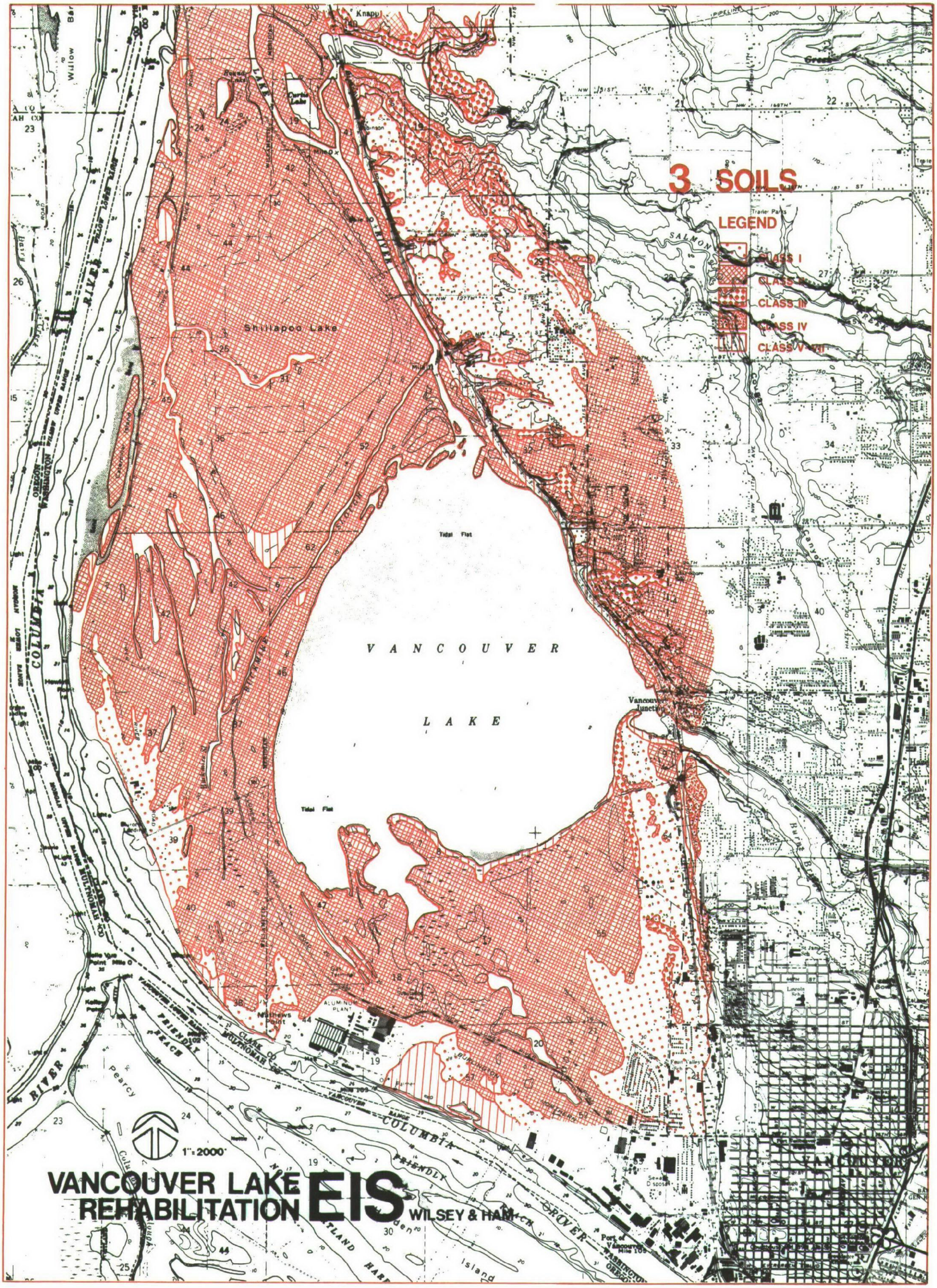

3 SOILS
LEGEND
CLASS I
CLASS II
CLASS III
CLASS IV
CLASS V-VIII
VANCOUVER LAKE
Shillapoo Lake
Tidal Flat
Vancouver Junction
COLUMBIA RIVER
1" = 2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

TABLE 2

SOILS CHARACTERISTICS

Soil Name	Map Symbol	Capability Classification	Slope
Sauvie silt loam	Sm A	II w	0-3%
Sauvie silt loam	Sm B	II e	3-8%
Sauvie silt loam, sandy substratum	Sn A	II w	0-3%
Sauvie silty clay loam	Sp B	II w	0-8%
Hillsboro loam	Hl B	II e	3-8%
Hillsboro loam	Hl E	IV e	20-30%
Hillsboro loam	Hl F	VI e	30-50%
Hillsboro silt loam	Ho A	I	0-3
Hillsboro silt loam	Ho B	II e	3-8
Hillsboro silt loam	Ho C	III e	8-15
Hillsboro silt loam	Ho D	III e	15-20
Hillsboro silt loam	Ho E	IV e	20-30
Hillsboro silt loam	Ho G	VI e	30-65
Wind River sandy loam	Wn B	III e	0-8
Wind River sandy loam	Wn D	IV e	8-20
Wind River sandy loam	Wn G	VI e	30-65
	Nb A		
Newberg silt loam	Nb B	I	0-3
Newberg silt loam		II e	3-8
Cove silty clay loam	Cv A	V w	0-3
Gee silt loam	Ge B	III e	0-8
Lauren gravelly loam	Lg B	III e	0-8
Odne silt loam	Oa B	IV w	0-5
Pilchuck fine sand	Ph B	VI s	0-8
Fill land	Fn	VIII w	
Riverwash (sandy)	Ra		
Rough broken land	Ro		

The Newberg soil series is located in bands along the Columbia River shoreline (see Soils Map, NbA and NbB). It consists of deep, well-drained loamy soils that have developed mainly in recent river alluvium. Located on the floodplains, the slope range is from 0 to 8 percent. Available water capacity and fertility are high, and there is no erosion hazard. The soils have a good agricultural capabilities rating, and typically produce truck crops, row crops, hay and pasture.

The Hillsboro soil series covers almost the entire area above the bluff to the northeast of the lake. The soils consist of well-drained, deep soils on terraces formed atop old Columbia River alluvium. This medium-textured soils type is among the most productive soils found in Clark County. The native floral groups representative of the Hillsboro series are Douglas fir, grand fir, big leaf maple, dogwood, salal, Oregon grape and vine maple. When cultivated, typical crops are pole beans, strawberries, sweet corn, cucumbers, and other truck crops, as well as hay and pasture. The Hillsboro varieties range considerably in capability classification (see Table 2), primarily due to slope.

Other soils occurring within the project area are scattered and found only on small parcels. They are represented on Figure 3 and their agricultural capabilities and restrictions are designated in Table 2.

Soils associations and series are rated for generalized agricultural capability on a scale from Class I to Class VIII. Class I soils have few limitations which would restrict their use for agricultural purposes and are considered to be the most productive soils for crop growing. Class VIII soils and land forms have limitations that preclude their use for the growing of any cultivated plants and restrict their use to recreation, wildlife, water supply or aesthetic purposes. Classes II through VII are gradations between those two extremes. Capability subclasses are defined as follows and designated on Table 2.

- E - indicates that the main limitation is risk of erosion unless close-growing plant cover is maintained,
- W - indicates that water in or on the soil interferes with plant growth or cultivation.
- S - indicates that the soil is limited mainly because it is shallow, droughty or stoney.

Within the project area, the majority of the soils fall within capability Classes II and III.

Hydrology and Flood Hazards

Vancouver Lake

Vancouver Lake covers approximately 2,600 acres and drains a watershed encompassing about 19,000 acres. The average shoreline length is about eight miles. Along the northeastern shoreline of the lake are high bluffs which have been developed for residences. The western shoreline parallels Columbia River and is separated from the river by marshy or sandy lowlands. The southern edge of the lake is adjacent to a marshy area known as Mulligan Slough which appears to have once been a channel connecting the lake to Columbia River.

The principal influent stream into Vancouver Lake is Burnt Bridge Creek, with a mean annual flow of 20 cubic feet per second (cfs) (3). Smaller streams which empty into the lake are Whipple Creek and Flume Creek. The lake empties into the Columbia River via Lake River. The flow of Lake River is sometimes reversed so that Columbia River waters and the discharge from Salmon Creek flow into Vancouver Lake.

The level of Vancouver Lake is determined principally by the level of the Columbia River, and the mean depth of the lake varies accordingly. During much of the year (August through April) the mean depth of the lake is between 3 and 4 feet (4). During this time, the volume of the lake is approximately 3×10^8 cubic feet. Beginning in April, the level of the Columbia normally begins to rise sharply as a result of upstream snowmelt. Because the level of the lake is tied to the level of the river, there is a corresponding increase in the level of the lake, which reaches a maximum mean depth of about 12 feet in early summer (5). At this time the volume of the lake is about 12×10^8 cubic feet, or about four times the volume at minimum level. During April, May and June, the flow of Lake River is reversed, bringing a significant amount of Columbia River water into the lake. During this reverse flow phase, net inflow into the lake from the Columbia has been observed to be as high as 200 cfs (6). In July, August, and September, the level of the Columbia River falls, and there is a corresponding drop in the level of Vancouver Lake. At this time, discharge from the lake via Lake River has been observed to be as high as 150 cfs (7). From late August through April, the level of the lake is relatively constant, and there is little net flow from the lake to or from the Columbia. In summary, under average conditions, the Columbia River and Vancouver Lake are at a minimum stand during September and October (less than 6 feet above mean sea level) and at a maximum during May, June and July (exceeding 12 feet above mean sea level). (8). Clearly, the mean depth of the lake varies directly with the variation in lake level. During much of the year (August through April) the mean depth of the lake is between 3 and 4 feet. (9). The mean depth of the lake increases with the spring runoff in Columbia River to a maximum of about 12 feet in early summer.

In addition to seasonal changes in the level of Vancouver Lake, there is a detectable tidal influence on the level of the lake. During late summer and fall (i.e., periods of low flow) the level of the Columbia River at Vancouver rises and falls as much as two-three feet under the influence of the Pacific tides. A tidal variation in the Columbia River of 2 feet will produce a change in elevation in Vancouver Lake of 1 to 2 inches (10). A change in mean depth of this magnitude is itself of little consequence to limnological conditions in the lake; however, these elevation changes in the lake level imply that Columbia River and Salmon Creek water are entering Vancouver Lake on rising tides. Thus, the water quality in the lake is influenced even though there is little net flow to or from the lake.

The amount of groundwater flowing to or from Vancouver Lake has not been documented, although the net groundwater flow to the lake has been estimated at an annual rate of 20 cfs. (11). Well water resources in the Vancouver Lake area appear to be substantial. Several wells have been drilled in the north and east areas of Vancouver Lake, with production ranging from 20 gallons per minute (gpm) to several hundred gpm. The range in individual well production is usually due to limited needs for water (typically domestic or irrigation needs), rather than due to a lack of water availability south of the lake. Alcoa Aluminum has established several wells for industrial purposes and the production of some of these wells exceeds 3,000 gpm. West of Vancouver Lake only a few wells have been drilled and their production ranges between 22 and 750 gpm (12). Due to the projected groundwater reserves available around Vancouver Lake, sufficient supply is considered available for large production of water resources (13).

In summary, the hydrology of Vancouver Lake consists of two distinct phases. During one phase, from August through April, the lake is very shallow. During this phase the lake receives water from Burnt Bridge Creek and other smaller tributaries, and on rising tides from Columbia River and Salmon Creek. On a falling tide, flow is out of the lake via Lake River to the Columbia. During the second phase, from April through July, the lake level first rises continuously with the rising level of the Columbia River, and then falls steadily back to a low level in August. During April, May, and early June, Columbia River water enters the lake via Lake River until the volume of the water in the lake has increased about four fold. In June the level of the Columbia River begins to fall, and the lake discharges to Columbia River, falling to a very shallow level by August.

Due to the influence of Columbia River, Vancouver Lake and Lake River frequently flood, inundating land along the southern and western lake shoreline, as well as land along the western shore of Lake River. A partial system of dikes and levees was constructed in the past, but the Corps of Engineers does not have current data on their functioning and flood control capability. The spring-summer flood season in the Vancouver Lake area reaches the 14 foot contour line on an average yearly basis, while the fall-winter season reaches the 13.5 contour levels annually. These Corps of Engineers flood contours would indicate that approximately 2,700 acres of land around the lake experience some degree of annual flooding. Every five years the spring-summer seasonal floods reach an average contour of 18 feet, while the fall-winter flood season reaches the 16 foot contour level. This represents approximately 3,500 acres of land which may be vulnerable to inundation every five years. The above figures do not estimate the extent to which those lands susceptible to flooding are protected by the existing dike and levee system. The existing levee system was originally constructed to a height of 24-25 feet. The Corps of Engineers has indicated that the levees are now considered to be functional to an elevation of 16 feet, although they have not prepared estimates of the number of acres that are not flooded as a result of this levee placement.

Additional diking improvements within Diking District 14 were first proposed in 1950, and the project has been reviewed intermittently since then. The Corps of Engineers is currently preparing a Phase I Design Memorandum proposing to construct dikes on the alignments shown on Figure 4. This Design Memorandum is expected to be completed in June, 1978, with construction proposed for late 1979 or early 1980.

Burnt Bridge Creek

Burnt Bridge Creek flows from east to west through commercial and suburban sections of Vancouver, beginning at about N.E. 162nd Street and emptying into Vancouver Lake. It drains an area of approximately 27 square miles. A tributary of Burnt Bridge Creek, Cold Creek, drains a more rural area north of Vancouver and joins Burnt Bridge Creek near Vancouver Lake. Mean annual stream flow is about 20 cfs, but much higher flows are observed during storms (14). For example, peak flows in May, 1976 measured 48 cfs (15). Because of the extensive urbanization of the basin, storm runoff is much more rapid than would be the case under normal conditions. Burnt Bridge Creek flows are usually 3 to 10 cfs.

No floodplain or flood flow data are available for Burnt Bridge Creek (16).

Columbia River

The Columbia River is the ninth longest river in North America and experiences an average annual flow at Vancouver of 201,800 cfs. The volume is distinctly seasonal, with flows in the late fall as low as 49,400 cfs, increasing in the spring when snow melt can cause flows as great as 649,200 cfs.

Because of the variation in flow, there is a considerable seasonal difference in the level of the river at Vancouver. Maximum river stage averages more than 15 feet above mean sea level, while in August river stage falls to +2 to +6 feet above mean sea level. Tidal influences are greatest during low flow months. Average values of the tidal fluctuation in the Columbia River are as much as 2.25 feet in August (17).

Lake River

Lake River connects Vancouver Lake with Columbia River. The average depth of the river is 16 feet in July when the level of the Columbia is high because of spring runoff. During much of the year, the average depth of Lake River is only 3 feet. Due to tidal effects, a delta has developed from Lake River into Vancouver Lake. This tidal flat at the entrance to Lake River usually prevents Vancouver Lake from dropping below a surface elevation of 4 feet above mean sea level (18).

The volume and direction of flow of Lake River is directly related to seasonal and tidal changes in the stage of the Columbia River. During April and May, the level of the Columbia River rises sharply with spring runoff, and during this time Columbia River water flows through Lake River into Vancouver Lake. During this phase, flows reach 200 cfs into Vancouver Lake. In June and July the level of the Columbia River begins to fall quickly and the direction of flow in Lake River reverses to discharge from the lake into the Columbia. At this time, from late June to mid-September, net outflow falls from about 150 cfs to less than 50 cfs (19).

During much of the year, approximately August through March, the level of Vancouver Lake is at its minimum, so that the direction of flow in Lake River is influenced by Pacific tides. On rising tides, water from the Columbia River flows into Vancouver Lake and on falling tides it flows from Vancouver Lake into the Columbia River.

No floodplain or flood flow data are available for Lake River (20).

Water Quality

Vancouver Lake

Because of its extremely shallow depth, Vancouver Lake does not stratify and the temperature of the lake is generally determined by ambient weather conditions. Winter temperatures as low as 4°C. (39°F.) and summer temperatures as high as 26°C. (79°F) have been observed (21).

Due to the shallowness of the lake and the lack of stratification, fine bottom sediments are resuspended into the lake by wind induced turbulence. When the lake is very shallow, boats also cause noticeable turbidity while plankton cause additional turbidity in the summer months (22). Turbidity has been observed to range from 4 to 70 Jackson Turbidity Units.

o Major Ions

The concentrations of major ions (Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, $SO_4^=$, HCO_3^-) in Vancouver Lake are low to moderate. The available data indicate that the water of Vancouver Lake is more diluted than the average for North American rivers (23). The total concentrations of all ions, and the relative concentrations of individual ions, imply that the minerals dissolved in the lake stem largely from atmospheric precipitation, with additional ions derived from rock weathering (24).

There is some evidence that concentrations of major ions vary seasonally in response to the hydraulics of the lake. This evidence is summarized in Table 3.

Clearly, the lake is more diluted in July and August, and more concentrated in December. Mean values reported for the Columbia River for chloride and bicarbonate ions are 4.3 mg/l (ppm) and 26 mg/l (ppm), respectively. Evidently, the major ion concentrations in the lake in July and August reflect the intrusion of Columbia River water into the lake during the late spring, while the higher values observed later in the year indicate that the water chemistry is more dominated by water and stagnation of the lake itself.

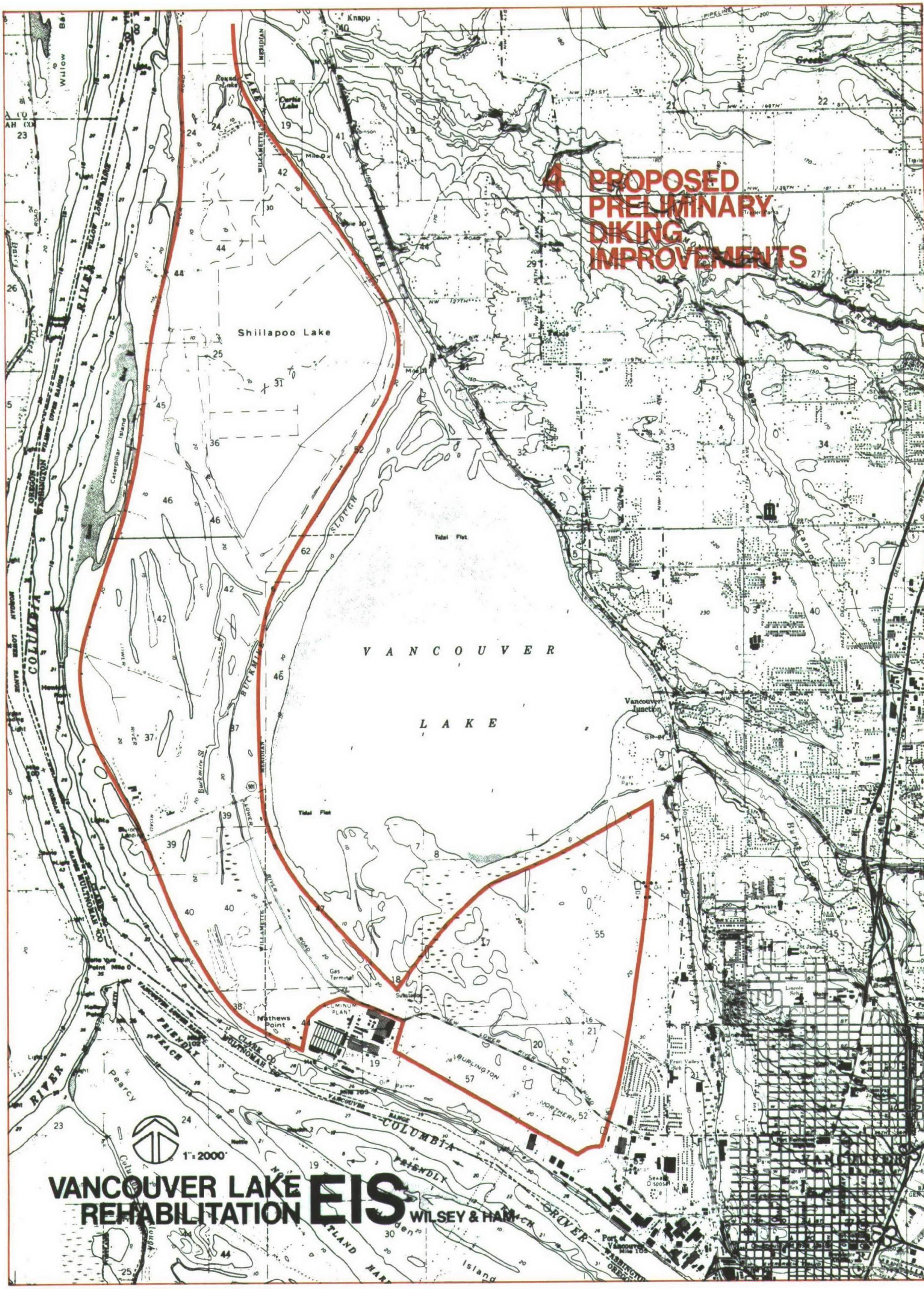

4 PROPOSED PRELIMINARY DIKING IMPROVEMENTS
Shillapoo Lake
VANCOUVER LAKE
Tidal Flat
Caterpillar Island
Vancouver Junction
Mathews Point
ALUMINUM PLANT
Gas Terminal
COLUMBIA RIVER
1"=2000'
VANCOUVER LAKE REHABILITATION EIS
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TABLE 3

CONCENTRATIONS OF MAJOR IONS
mg/l

	Vancouver Lake		Lake River	
	Cl-	HCO_3^-	Cl-	HCO
July, 1967	2.5 - 3.5	37 - 40	1.5 - 3.0	33 - 40
August, 1967	2.5 - 4.5	30 - 39	2.0 - 4.0	25 - 35
December, 1967	4.5 - 5.0	67 - 120	5.0 - 6.0	71 - 103

Source: From Bhagat and Funk, 1968.

The range of pH observed in the lake is from 6.7 to 9.3 units. Higher pH values occur when there are algal blooms in the lake, and lower values occur in the winter, reflecting the acid (pH 4.5) rainfall of the Pacific Northwest (26).

o Metals

Detectable levels of copper, mercury and zinc are present in the sediments of Vancouver Lake (27). During the pilot dredge monitoring program undertaken by Dames and Moore in 1976, sediments were analyzed for seven trace metals including arsenic, cadmium, chromium, copper, lead, mercury and zinc. Of these, only mercury was found in the dredged sediments in concentrations considered hazardous to organisms (greater than 0.05 ug/l). The atomic absorption method was used by Dames and Moore to detect heavy metals occurence.

Bioassays done by the Washington State Department of Ecology on seven fish from Vancouver Lake revealed that only a carp and a sucker, both bottom feeders, had detectable levels of mercury (28). Detection levels were 0.02 micrograms mercury per gram of fish. No attempt was made to indicate whether this mercury in the sediments was in the inorganic form or the more toxic form of methylmercury. In one study undertaken elsewhere, 80 percent of the mercury in the fish assayed was in the form of methylmercury; however, no methylmercury was found in the sediments. Benthic organisms had 50 percent of the mercury found in their tissues in the form of methylmercury indicating that the food chain is the manner of uptake of the methylmercury. Inorganic mercury is converted to methylmercury by bacterial action within the sediments (29).

The organic pesticides lindane, aldrin and dieldrin were also found in the Vancouver Lake sediments (30). These pesticides were associated with the dredged material particulates and have not been reported in fish species. DDT was detected in the above referenced bioassays, and bioaccumulation via the food chain was evident. However, the DDT levels observed were below the FDA's "Action limit." (Sample observations reached 0.126 ppm DDT, while the Action limit has been established at 5.0 ppm).

o Nutrients

Inorganic nutrients in Vancouver Lake are rather high and are no doubt an important ingredient in the high algal productivity observed seasonally in the lake. Phosphate has been reported to range from 150 to 1600 ug PO_4/l (49 to 552 ug P/l) and nitrate from 20 to 540 ug NO_3/l (4.5 to 122 ug N/l). Kjeldahl nitrogen values ranged from 280 ug N/l to 8680 ug N/l (31). Lakes with more than 30 ug/l total phosphorus and more than 500 ug/l total nitrogen are considered hypereutrophic. (32). Clearly, there is sufficent phosphorus and nitrogen in Vancouver Lake to support extensive algal growth.

For normal growth, plants require 4 to 20 times as much nitrogren as phosphorus On this basis, there appears to be significantly less inorganic fixed nitrogen in Vancouver Lake than inorganic phosphorus. This relative excess of phosphate probably favors the development of nitrogen (N2) fixing planktonic algae.

The sources of phosphorus and nitrogen in the lake are from the drainage basin, and from phosphorus contained in Columbia River water which seasonally enters the lake. Additional nitrogen is probably supplied by fixation. Nitrogen and phosphorus values reported for Burnt Bridge Creek give an indication of the significance of the drainage basin in supplying nutrients to the lake. For Burnt Bridge Creek, total phosphorus values are reported to be from 60 to 170 ug P/l, and total nitrogen (Kjeldahl- N, nitrate=N, nitrite- N, and ammonia (NH3) combined) from 800 to 2300 ug N/l (33). These values are four times greater than natural background levels, and are characteristic of watersheds influenced by agricultural activities and urbanization (34).

The phosphorus loading from Burnt Bridge Creek alone is sufficient to supply the lake with about 0.2 g P/m2/yr. This level of phosphorus is considered to be sufficient to cause extensive cultural (human-made) eutrophication of a lake (35). It is believed that additional phosphorus is supplied by other streams and assorted non-point sources.

Because the lake is extremely shallow, sediment supplies of phosphorus must also be considered an active part of the nutrient pool in the lake. It has been shown that much of the phosphorus in the lake sediments may be available to algae, and there is some evidence that this is the case in Vancouver Lake, also (36).

o Algae

Ths phytoplankton observed in Vancouver Lake are a further indication of the eutrophic character of the lake. The diatom species reported (Fragilaria crotonensis, Stephanodiscus niagarae, Asterionella formosa) form an assemblage characteristic of eutrophic waters. Species of blue-green algae (Aphanizomenon flos-aquae, Anabaena sp., Oscillatoria limos, Spirulina laxa) also indicate eutrophic or hypereutrophic conditions. Some blue-green algae including species of Aphanizomenon and Anabaena are capable of fixing atmospheric nitrogen (N2), which probably contributes to the supply of fixed nitrogen in the lake.

TABLE 4
WATER QUALITY DATA

Parameter	Vancouver Lake		Columbia River		Burnt Bridge Cr.	
	Ave	Range	Ave	Range	Ave	Range
Temperature °C	-	4 - 26	14	4 - 22	12	2 - 18
p^H Std. units	7.9	6.7 - 9.3	7.3	6.4 - 8.3	7.6	6.9 - 8.0
Turbidity (JTU)	33	4 - 70	15	1 - 29	15	3 - 70
NO_3-N mg/l	-	0.005 - 0.12	0.25	0.01 - 0.60	1.88	0.95 - 3.60
NO_2-N mg/l	-	- -	0.01	0001 - 0.05	0.02	0.01 - 0.03
NH_3-N mg/l	-	- -	0.07	0.01 - 0.31	0.12	0.05 - 0.38
Total P mg/l	0.23	0.05 - 0.52	0.08	0.02 - 0.23	0.13	0.07 - 0.42
Total coliforms #/100 ml	3000	100,000	2600	25 - 11600	10360	380 - 45000

Note: Vancouver Lake Data, Bhagat, 1968.

Burnt Bridge Creek, KCN-WRE, 1976.

Columbia River, EPA STORET

The shallowness of Vancouver Lake and the relatively high concentrations of nutrients indicate that the growth of phytoplankton is not restricted by nutrient supply. The relatively high turbidity, from resuspension of bottom sediments, may tend to reduce algal growth somewhat by light limitation. (37).

Dissolved Oxygen

Dissolved oxygen values have been observed to range from 5.7 to 14.8 mg/l. Dissolved oxygen reflects the eutrophic conditions and the shallowness of the lake. Oxygen concentrations are sometimes well above saturation (e.g. 14.8 mg/l in August, 1967) probably as a result of photosynthetic production of oxygen by phytoplankton (38). At other times, oxygen is less than saturation (e.g. 5.7 mg/l), presumably because of respiration by algae and bacteria. (39) No oxygen values below 5.7 mg/l have been reported, in spite of the highly eutrophic conditions of the lake. The shallowness of the lake prevents stratification and permits reaeration from the atmosphere.

o Biochemical Oxygen Demand

The enriched state of the lake is also shown in the BOD values. BOD values range from 2.5 to 25 mg/l; which is quite high for natural waters (40).

o Bacteria

The enriched condition of the lake also provides organic nutrients which support bacterial growth. Total bacterial counts as high as 100,000 per 100 ml have been reported. (41). Ten to 40 percent of the total coliform bacteria found in Vancouver Lake were fecal coliforms, indicating the presence of warm blooded animals, birds, mammals or humans. Bacteria counts have been observed to exceed standards set for recreational activities. (42).

o Fish

Most of the fish in the lake are warm-water species such as large mouth bass, bluegills, crappies, carp and perch (Figure 5). Some of the deeper areas have juvenile sturgeon and rarely adult sturgeon are found (43). Temperatures above 20 C. are not conducive to trout or other salmonids, however, trout were found in the lake at the mouth of Burnt Bridge Creek in November, 1976 (44).

o Sediments

Test borings of Vancouver Lake indicate that the sediment on the bottom of the lake consists of a variety of sediment types, including clay, silt and sand (45). Lake sediments, particularly in shallow productive lakes, often contain significant reservoirs of nutrients such as nitrogen and phosphorus. Analysis of shallow cores from Vancouver Lake revealed measurable quantities of these nutrients with somewhat higher concentrations in the top six inches of sediment. Bioassays indicate that some of the nutrients in this surface sediment are available to algae, and can stimulate algal growth (46).


5 SPAWNING AREAS
LEGEND
PERCH
LARGEMOUTH BASS
CHANNEL CATFISH
CRAPPIE
LM BASS, CHANNEL CATFISH, CRAPPIE
CHANNEL CATFISH CRAPPIE
VANCOUVER LAKE
Shillapoo Lake
Tidal Flat
Caterpillar Island
COLUMBIA RIVER
Vancouver Junction
ALUMINUM PLANT
Mathews Point
Gas Terminal
BURLINGTON NORTHERN
Knapp
Round Lake
1" = 2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

Burnt Bridge Creek

The temperature of the water in Burnt Bridge Creek varies seasonally. Temperatures sometimes exceed 20°C (68°F) in July and August, and fall below 10°C (42°F) during November to March. The upper reaches of the stream are unshaded and as a result the water becomes quite warm during the summers. Seasonal average temperatures for three years ranged from 7.9 to 9.1°C for winter, 12.3 to 16.2°C for spring, 15.8 to 18.0°C for summer and 8.0 to 10.8°C for fall.

Turbidity in the stream reflects land use within the drainage basin. Urban storm water runoff, agricultural activity and natural fluvial processes all contribute to the turbidity levels. Turbidity was observed from 3 to 70 Jackson Turbidity Units (JTU) during 1975, but ran as high as 200 JTU during storm runoff in May, 1976 (47). Total suspended solids data is not available for Burnt Bridge Creek.

Observations indicate that dissolved oxygen in Burnt Bridge Creek remains rather high, and is above the minimum required for aquatic organisms. Concentrations from a low of 8.4 mg/l in August to a high of 14.0 mg/l during a cold spell in January have been reported (48). Observations also indicate that pH remains within a range acceptable for aquatic life. In general, pH in Burnt Bridge Creek is between 6 and 8 units. Relatively low pH values measured during 1974 were evidently related to highway construction (pH 6 to 7) (49).

Inorganic nutrients in Burnt Bridge Creek are considerably higher than would be observed in a natural stream. Total phosphorus is highly variable, ranging from 50 to nearly 1000 ug P/l (50). Concentrations of phosphorus are somewhat higher during the winter, perhaps because of septic tank intrusion, and again in late spring at a time when fertilizers are applied in the basin (51). Nitrate (N/l) has been observed in concentrations from 900 to 2300 ug/l; nitrite from 3 to 20 ug/l; and ammonia from 40 to 180 ug/l (52). All of these nutrients are chronically present at concentrations sufficient to support nuisance algal blooms in Burnt Bridge Creek. In addition, Burnt Bridge Creek is an important source of nutrients to Vancouver Lake.

Bacterial count data from Burnt Bridge Creek show a great deal of fluctuation. Total coliform counts in Burnt Bridge Creek range from 380 to 45,000/100 ml. (53). At the mouth of Burnt Bridge Creek total coliform levels have been measured from 2,000 to 43,000/100 ml., while fecal coliform counts have ranged from 700 to 19,000/100 ml. (54). The Washington State Standard for Class AA Watercourses (which includes Burnt Bridge Creek) is less than 50/100 ml. with less than 10 percent above 230/100 ml. if fecal contamination is present. Thus, the bacterial counts in Burnt Bridge Creek exceed the State standards. Septic tank intrusion and use of manure fertilizers in the drainage basin are probable sources of bacteria.

A biological survey of Burnt Bridge Creek was carried out in March and April of 1976 (55). As part of this survey, data were collected on the distribution of benthic organisms, macrophytes and periphyton. The results of this work indicate that there is a distinct zonation of organisms in the stream. In the upstream reaches, periphyton is dominated by diatoms. Species of *Melosira* and *Navicula* were abundant, and species of *Fragilaria*, *Tabellaria*, *Diatoma*, *Synedra*, and *Gomphonema* were observed. There were also moderate to heavy growths of macrophytes in the upstream reaches. *Potomogeton* was the dominant macrophyte. A wide variety of insect larve were collected in upstream benthic samples, including some forms (alder-flies and caddisflies) which are characteristic of clean water.

In downstream reaches, there was a distinct shift to more pollution resistent species of periphyton. Filamentous green algae were more common while diatoms were less common than in the upstream areas. Some blue-green algae were also observed. Macrophytes were largely absent in downstream reaches and the benthic organisms collected were forms more resistent to pollution (i.e. sludge worms.).

The general pattern that appeared is evidence of the cumulative impact of increasing levels of pollution from point sources and non-point sources on the downstream reaches. The change in species present was probably the result of a moderate degree of nutrient enrichment and possibly the influence of turbidity or some toxic compounds. However, nowhere in Burnt Bridge Creek did there appear to be evidence of heavy pollution by organic or toxic wastes.

Sculpins and trout were observed at various locations throughout the length of the creek.

Columbia River

The concentrations of chemicals in the Columbia River also show considerable annual variation. Conductivity data indicates that there is a distinct bimodal pattern in the concentrations of the major ions (56). Conductivity is highest in the spring (148 - 208 umhos/cm) and fall (165 - 200 umhos/cm) and lowest in the winter (71 - 178 umhos/cm) and in the summer (100 - 120 umhos/cm) indicating a similar pattern in the concentrations of the major ions. Alkalinity values show a similar pattern, with values of 29.6 to 56.8 ppm (as $CaCO_3$) in January, 48.1 to 64.9 ppm in April, 37.7 to 44.3 ppm in June and 55.6 - 67.4 in December. The range of the major ion concentrations is indicated in the table below:

TABLE 5
COLUMBIA RIVER
CONCENTRATIONS-MAJOR IONS
mg/l

ION	Mean Value
Ca^{++}	17.30
Mg^{++}	1.92
Na^{+}	5.71
K^{+}	1.07
SO_4^{--}	13.08
Cl^{-}	4.29
HCO_3^{-}	25.97

Source: EPA STORET, 1974

The total of these averages indicates a mean salinity of about 70 mg/l, which is about one half the average for North American rivers (57).

Water temperatures of the Columbia River are distinctly seasonal, with winter temperatures near 4 C°(39°F) and summer temperatures near 20°C (68°F). The average pH of the Columbia is 7.3 units, with a range of 6.4 to 8.3. The highest pH is observed in the early fall (58).

Suspended sediments in the Columbia River are primarily inorganic, crystalline material resulting from rock weathering. At Vancouver, Washington, the estimated particle size composition of the 1963 total sediment discharge which reached 6.3 million tons was 35 percent sand, 50 percent silt and 15 percent clay. The average suspended sediment content at Vancouver is 25 ppm (59). This amount is highly variable, generally increasing with flow and is, therefore, particularly high during winter floods. For example, a daily average concentration of 2660 ppm was measured during the flood of December 25, 1964. Concentrations during the normal low flood of August through October generally range between 5 ppm and 10 ppm (60).

Nutrients are present in sufficient amounts to support algal growth at all times. The range of total phosphorus (P/l) concentrations is from 28 to 231 ug/l, with a mean value of 78 ug/l. Nitrate is present in concentrations of 10 to 600 ug N/l, with a mean of 254 ug N/l; and ammonia is between 5 and 310 ug N/l, with an average of 70 ug N/l (61). Total phosphorus concentrations in lakes of 10 to 30 ug P/l and total nitrogren concentrations of 500 to 100 ug N/l are sufficient to cause eutrophic conditions (62). Total phosphorus concentrations above 30 ug P/l give rise to hypereutrophic conditions. The inorganic phosphorus concentrations in Columbia River do not fall below algal requirements at any time (63).

Trace metal concentrations appear to be quite low and well below concentrations which could be expected to cause problems to aquatic organisms (64).

Phytoplankton density in Columbia River varies strongly with the season. Total cell counts fall below 10×10^5 cells during winter months, begin to increase sharply in March and April, and reach a maximum of about 150×10^5 cells/l in July. Populations decline swiftly in the fall to reach winter lows (65).

Increasing phytoplankton populations are correlated with increases in discharge, water temperature and incident solar radiation. The availability of solar energy is probably the most direct cause of changes in the phytoplankton density. The Columbia River is thoroughly mixed from top to bottom, and, since Secchi disk transparency is only about one meter, the available light is "diluted" (66). Since nutrients are always present in concentrations sufficient to support additional algal growth, it appears probable that population densities of algae are limited by light availability.

Diatoms are the most abundant division of phytoplankton throughout the year, in terms of number of taxa and, also, in terms of population densities. Dominant species of diatoms are *Asterionella formosa*, *Stephanodiscus astrea*, *Melosira italica*, *Fragilaria crotenensis*, and *Melosira ambigua*. These species indicate eutrophic conditions (67). Most non-diatom

TABLE 6

TRACE ELEMENT CONCENTRATIONS
COLUMBIA RIVER, ROOM 84

Trace Elements (ug/l)	Mean	Maximum	Minimum
Arsenic, Dissolved	1,669.33	5,000.00	2.00
Arsenic, Total	5.00	5.00	5.00
Cadmium, Dissolved	1.00	1.00	1.00
Cadmium, Total	1.00	1.00	1.00
Chromium, Dissolved	9.83	35.00	2.00
Chromium, Total	5.50	9.00	2.00
Copper, Dissolved	13.69	233.00	1.50
Copper, Total	5.78	10.00	3.50
Iron, Dissolved	143.15	450.00	50.00
Iron, Total	605.29	2,410.00	105.00
Lead, Dissolved	24.85	280.00	2.60
Lead, Total	25.97	100.00	2.00
Zinc, Dissolved	68.78	730.00	10.00
Zinc, Total	23.70	50.00	12.00
Selenium, Dissolved	60.00	60.00	60.00
Mercury, Dissolved	1.78	5.00	.60
Mercury, Total	1.40	2.70	.50
Major Ions (mg/l)			
Calcium	43.19	95.00	18.00
Sodium	5.70	15.00	3.50
Potassium	1.07	2.10	.50

Source: EPA STORET, 1974.

species of the phytoplankton belong to the Chrysophyceae and Chlorophyta (68). Blue-green algae were most common in the late summer and fall, but were never very abundant.

Changes in the population densities of zooplankton are quite similar to changes in phytoplankton. Populations are low in mid-winter (500 to 100/m3) and increase to maximum values (10,000 - 20,000/m3) in July and August, and then decline rapidly. A few taxa dominate the zooplankton Common rotifers are Brachionus and Asplanchna, and common cladocerans are Bosmina and Daphnia. Remaining zooplankton was mostly cyclopoid copepods (69).

Lake River

Water quality conditions in Lake River are similar in character to either the Columbia or to Vancouver Lake depending on the direction of flow. In addition, Lake River receives discharge from Salmon Creek. The Salmon Creek drainage is predominantly rural in character, however, there is some suburban development and a variety of agricultural activities. Salmon Creek receives nutrient enrichment and bacterial pollution from agricultural runoff, boat moorages, septic tank seepage and street runoff.

At the outlet of Lake River, water quality conditions are similar to those in the Columbia River. Turbidity is relatively low. Algal populations are predominantly diatoms and temperatures are lower. At the inlet end of Lake River, conditions are more similar to Vancouver Lake. In late summer, the river contains significant populations of blue-green algae (Aphanizomenon flos-aquae). Temperature, turbidity, and bacterial counts are higher. In general, water quality is higher when Lake River is under the influence of the Columbia and poorer when it is under the influence of Vancouver Lake.

Lake River sediments are predominantly silts and clays near Vancouver Lake. Sand content increases downstream, and the sediments are predominantly sand at the mouth.

Fisheries

Lake Vancouver is a popular fishing area for regional residents, supplying a considerable resource of spiny rayed (warm water) fishes. Due to the excessively warm water, salmonids are not recognized residents of the lake, but are known to migrate up Burnt Bridge Creek. The spiny rayed fish are not native to Washington, but have been established in areas such as Lake Vancouver for many years.

The predominant spiny rayed fishes are the yellow perch, large mouth bass, bluegill, channel catfish, black crappie and the white crappie. These fishes are found in considerable numbers in the lake, particularly in Mulligan Slough during spawning season. The slough area is a prime spawning location, and draws numerous fishermen into the backwater sites. Due to habitat type, Mulligan Slough experiences the heaviest spawning activity of the spiny rayed fish in the lake since it offers a preferred aquatic vegetation and adequately warm temperatures (above 55 F). Other spiny-ray spawning areas occur at the mouth of Burnt Bridge Creek. Although they have not been specifically identified, it is believed that a few, smaller spawning areas occur in Lake River and Mulligan Slough.

Though the numbers of fish in the lake are considerable, recent catches indicate a lack of full sized fish available. Most of the fish caught are somewhat stunted, which is either caused by the low water levels of recent seasons, or possible over-population of the aquatic environments. Although toxic substances can cause stunted fish growth, fish exposed to toxic materials usually show abnormal behavior and/or deformities in addition to their stunted growth. Neither of these conditions has been observed in fish caught in Vancouver Lake. More likely, the stunted growth is a result of population pressure, since the fish caught from the lake are uniform in size per species and appear normal in all other characteristics. There have been no detailed surveys or studies undertaken to determine the present, and near future conditions of the fish populations.

Native fish include the sturgeon, trout, and salmon. Juvenile sturgeon have been caught in the lake, with an occassional adult occurrence. These fish are usually found in the deeper areas, such as the Pilot Dredge Study hole in the southwest corner of the lake. Trout (cutthroat) have been netted at the mouth of Burnt Bridge Creek, presumably caught prior to an upstream spawning run. Steelhead and salmon make native runs up Burnt Bridge Creek using Lake River and Vancouver Lake as access routes.

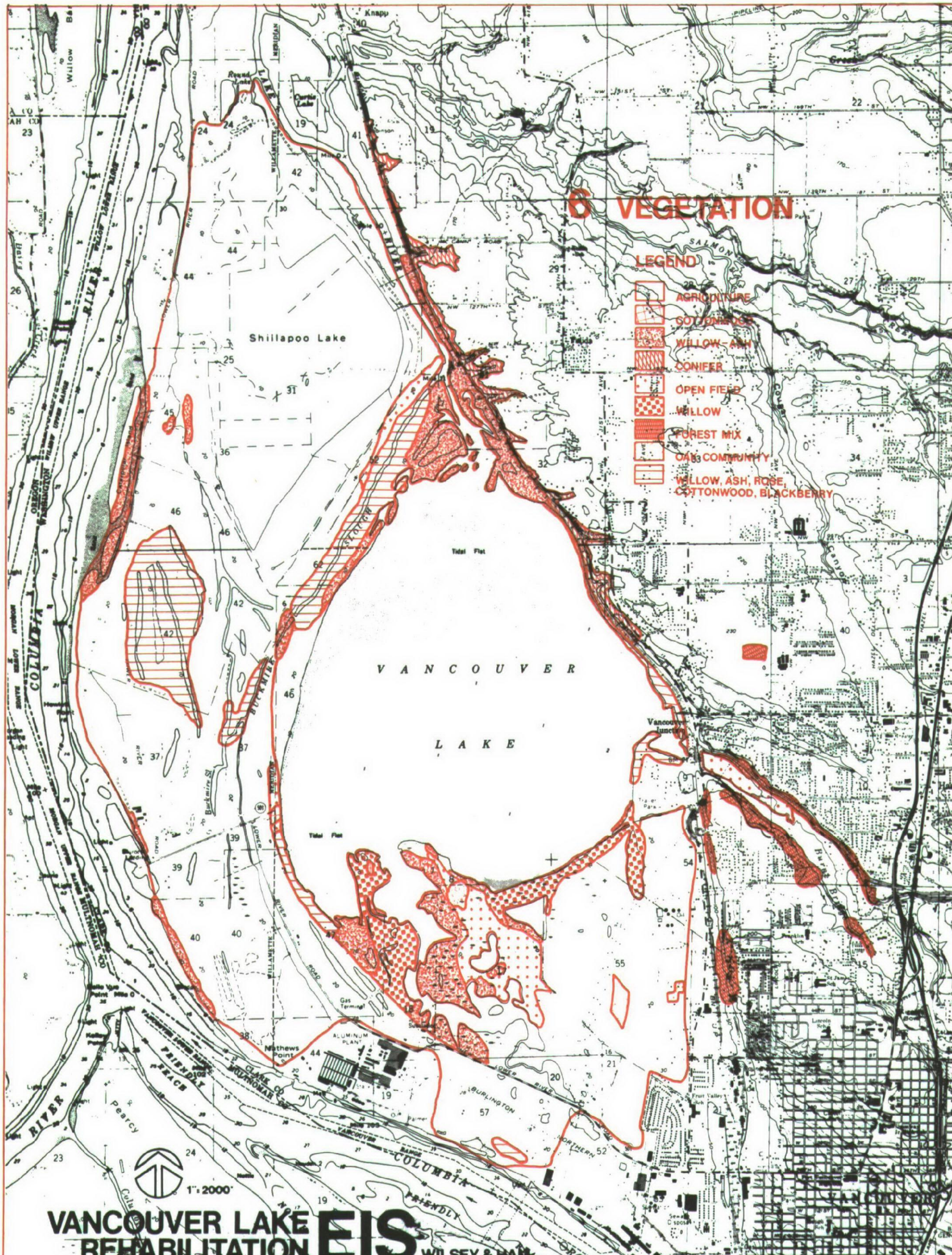
The Washington State Department of Fisheries does not maintain an active management program in Vancouver Lake.

Wildlife/Vegetation

The Vancouver Lake area is primarily comprised of floodplains and agricultural lands, except for the urbanized areas of Burnt Bridge Creek and areas to the northeast of the lake. The low-lying lands, however, are predominantly agricultural and riparian. Agricultural lands have been diked off in an effort to inhibit periodic inundation by floodwaters. Most lands that are not in agricultural use have primarily water related floral assemblages. Vegetation communities are shown on Figure 6.

Agricultural Land

Approximately 5,000 acres of land are currently used for the production of truck crops, row crops, hay and pasture. Wildlife and natural vegetation is limited in these areas, as the human controls imposed upon the land have greatly restricted the natural influences and processes. Mammalian representatives found in these areas include the insectivores (shrews and moles), rodents (mice, voles and squirrels), and rabbits. Field birds (sparrows and meadow larks), raptors (hawks and owls), and game birds (pheasant and doves) use the farmlands for feeding. The field perimeters provide emergency cover and breeding habitat for fauna where shrubs are allowed to establish. Much of the farmlands becomes inundated by winter and spring high water, which provides excellent habitat for great numbers of migrating waterfowl. Mallards, pintail, widgeon, Canada geese, and sandhill crane and whistling swan use flooded fields for feeding and loafing purposes through the migration and winter seasons.


6 VEGETATION
LEGEND
AGRICULTURE
COTTONWOOD
WILLOW - ASH
CONIFER
OPEN FIELD
WILLOW
FOREST MIX
OAK COMMUNITY
WILLOW, ASH, ROSE, COTTONWOOD, BLACKBERRY
Shillapoo Lake
VANCOUVER LAKE
Tidal Flat
COLUMBIA RIVER
1" = 2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

Marshland

The marshlands are found primarily on the south end of Vancouver Lake. Mulligan Slough, a shallow channel that meanders down to the Lower River Road dike, is the most extensive marsh in the project area. Much of it is under water for parts of the year, fluctuating in water depth according to precipitation, Columbia River flow, and tidal variations. Marshes exist along the more established channels. The size and extent of marshlands within the Vancouver Lake area have not been previously mapped; therefore, specific acreage figures are not available. The Environmental Protection Agency has recently contracted a study to determine the extent of Class I wetlands around the lake. At the conclusion of that study a more definitive acreage figure should be available. The immediate areas surrounding these freshwater marshes have thick stands of green ash and willow. The Mulligan Slough area is an important water fowl area, since it has a good food source, and provides excellent protection. It is used extensively for breeding and nesting purposes, and is a popular hunting area in the fall. Nesting fowl include cinnamon teal, mallards, and woodducks. Shorebirds using the area include snipe, yellowlegs, and dowitchers. The protected waters in the slough also act as important spawning areas for many of the lake fish. The surrounding willow and ash thickets make much of the area inaccessable to humans, which further enhances the area for wildlife. This area is one of the more important biologic communities in the project area because of its natural protection and marshland characteristics. It is further discussed below in the Significant Wildlife Areas section.

Riparian

Riparian biota is very important in the Vancouver Lake area, with healthy stands occurring at the south and north end of the lake. Riparian ground that is frequently inundated by water is comprised ofOregon ash and willow. These thickets are not tall (3-13 feet), but grow in great densities. They do not harbour great numbers of fauna, primarily due to their lack of floral diversity. However, they do act as excellent coverage (for land mammals and birds feeding on the water), buffer zones (for waterfowl activity), and nesting sites (for woodducks and warblers). Amphibians are found primarily in these zones, including the spotted, tree, and bull frogs and the northwestern, Pacific giant, and ensatina salamanders. Reptiles found in the riparian areas include the racer, garter and gopher snakes, and the painted turtle. Mammals using these areas include nutria, bats, raccoons, and rabbits. The winged seeds of the ash provide foodstuffs for certain seedeaters (grosbeaks, etc.), and provide insect feeding conditions for flycatchers and vireos. The willow provides food in its bark for mammals (cottontail squirrel, woodrats, and meadow mice), and insect food for perching birds much like the ash does.

Cottonwood, another typically riparian tree species, is found in scattered groups throughout the project area. It is usually located on drier lands behind the thick belts of willow and ash. Wild rose, blackberry, and elderberry are often found in the understory. Mammal species are the same as for the willow-ash communities, but the avifauna is more diversified. Woodpeckers and towhees, along with the other riparian species, readily use these areas. The raptors and perching birds use the tall cottonwoods for nesting and feeding purposes. These raptors include the red-tailed, sharp-skinned, rough-legged hawks, osprey, marsh hawk, kestrel (American), bald eagle, barn, great-horned, screech and pygmy owls. Such prominent perches are especially important to the raptors, as surrounding open fields and water provide favorable hunting conditions.

Open Grasslands

Limited areas within the vicinity of Vancouver Lake are characterized by a grass-scotch broom vegetation community. These areas typically represent land that was cleared at one time, but was not maintained for domestic purposes. Grasses and shrubs have claimed the area, and the land is now fairly open, inhabited by cottontails, wood rats, voles, and mammals moving from one eco-type to another. These areas act as important feeding grounds for local hawks and owls, and typically harbor local goldfinches.

Coniferous Forest

Conifers exist on the northeast bluff of Vancouver Lake. These trees, predominantly Douglas fir, have been cut back over the years to what are now only thin stands of trees. Found at the edge of the bluff, and along the short drainages in the immediate area, the trees represent the basic vegetal community of western Washington. Other species found in the community include red cedar, big leaf maple, dogwood, red alder, thimbleberry, salal, red-flowering current, and various ferns. Squirrels, voles, shrews and moles are the usual mammalian residents. Avifauna include wrens, kinglets, grosbeaks, thrushes and owls.

No studies have been conducted to determine the extent of aquatic vegetation within Vancouver Lake. Species, numbers and locations of the macrophytes and other in-water flora are not presently known.

The Washington State Department of Game manages designated areas within the project vicinity. The upland game bird season runs from October 15 to December 11 and pheasant and chuckar are planted throughout the season, particularly in the area between Shillapoo Lake and Caterpillar Island. The rabbit season occurs from mid-October until the end of February and is quite popular in southwestern Washington. No active stocking of game occurs. Duck hunting is extremely popular around Vancouver Lake and the season extends from mid-October to early January. Woodducks and teal are the primary game species and Vancouver Lake and its associated wetlands are considered to be one of the best duck production areas in southwest Washington.

Endangered species within the Vancouver Lake area include the bald eagle and the white-tailed deer. Five to six eagles use the general Sauvies Island-Vancouver Lake area during the winter and spring seasons. White-tailed deer have been sited in the Ridgefield Wildlife Refuge area and are suspected of ranging as far as Vancouver Lake. However, populations and movements of this species are not known.

Peregrine falcons appear in the area during migration, but the specific species has not been identified. The southern race (*Falco peregrinus*) is considered to be rare. Two northern races, the Peale's (Falco peregrinus pealei) and the tundra (Falco peregrinus tundris), do appear in the general area regularly during migration and winter seasons. These races are not considered to be endangered. American osprey appear in the area during spring; a species considered "comparatively rare" in Washington which is, therefore, protected.

Significant Wildlife Areas

A variety of significant wildlife areas exist within the project area. Each is mapped on Figure 7 and discussed below.

o Mulligan's Slough is a particularly important wildlife zone in the Vancouver Lake area, as it provides essential habitat for some important members of the biologic community. The extensive channels and marsh areas that spread down to Lower River Road provide the most important spawning areas for the spiny rayed fish that inhabit the lake. This habitat offers adequate plant life that supplies protection (cover from predators) and food (micro-organisms and invertebrates existing in the plant communities). The spiny rays (perch, crappie, bass, etc.) often become stranded in the channels and ponds as the waters recede, thus offering a good feeding opportunity to raptors (hawks, osprey), waders (heron, egrets), and mammals (raccoon). This stranding activity may also play an integral role in the regulation of the population, as many adults and juveniles are lost each year to this process.

Important loafing, feeding and nesting areas for waterfowl are available in Mulligan Slough. The marsh-related slough flora provides good food for the pond ducks (mallards, pintails, teal, woodducks and widgeon), and substantial protection due to the thick willow-ash growths. Perching birds (such as warblers, flycatchers, vireos and swallows) find excellent feeding in such wetlands because of the insect populations produced in the warm, still waters. The extensive willow-ash thickets that surround the entire marsh area offer excellent over-all protection and substantial nesting sites.

o The Shillapoo Lake - Vancouver Lake area provides important wintering grounds and migration stopover habitat for various waterfowl and related bird species. The Shillapoo Lake area is an old lake bed which is now in agricultural use, and is inundated with water during high water seasons. This area combined with Vancouver Lake, offers comparable habitat to that found at Ridgefield Wildlife Refuge to the north and Sauvies Island Game Refuge across the Columbia River. These three areas are linked together in their role as major stopover grounds for thousands of migrating birds. The Vancouver Lake area hosts grebes, whistling swan, Canada geese, mallard, pintail, widgeon, shoveler, teal, wood duck, scaup, and bufflehead, among others during various parts of the migration season. As Ridgefield Refuge and Sauvie Island experience heavy hunting on certain days, the Vancouver Lake area provides important resting sites for weary birds. The farmlands around Shillapoo Lake provide good feeding habitat, as local farming activities will often leave large quantities of foodstuffs available to dabbling and grazing waterfowl. The Vancouver Lake area is a popular waterfowl hunting area for regional residents, and the lake has an open season (no closure days during the waterfowl season). Due to its size, Lake Vancouver can still provide adequate resting areas for fowl, given that the numbers of hunters on the lake at one time is not too great.

Vancouver Lake also acts as an important feeding ground for great blue heron, who use the lake regularly and in significant numbers. It is suspected that these herons come down from the Bachelor Island rookery, a colony of some 500 herons that nest as a group seven miles to the north. The herons wade through the shallow waters preying on fish, amphibians, and invertebrates. The heron, because of its peculiar habits and aversion to human disturbance, has been used as an indicator species for determining the relative state of certain eco-systems. The bird is considered one of the more significant faunal species found in the northwest.

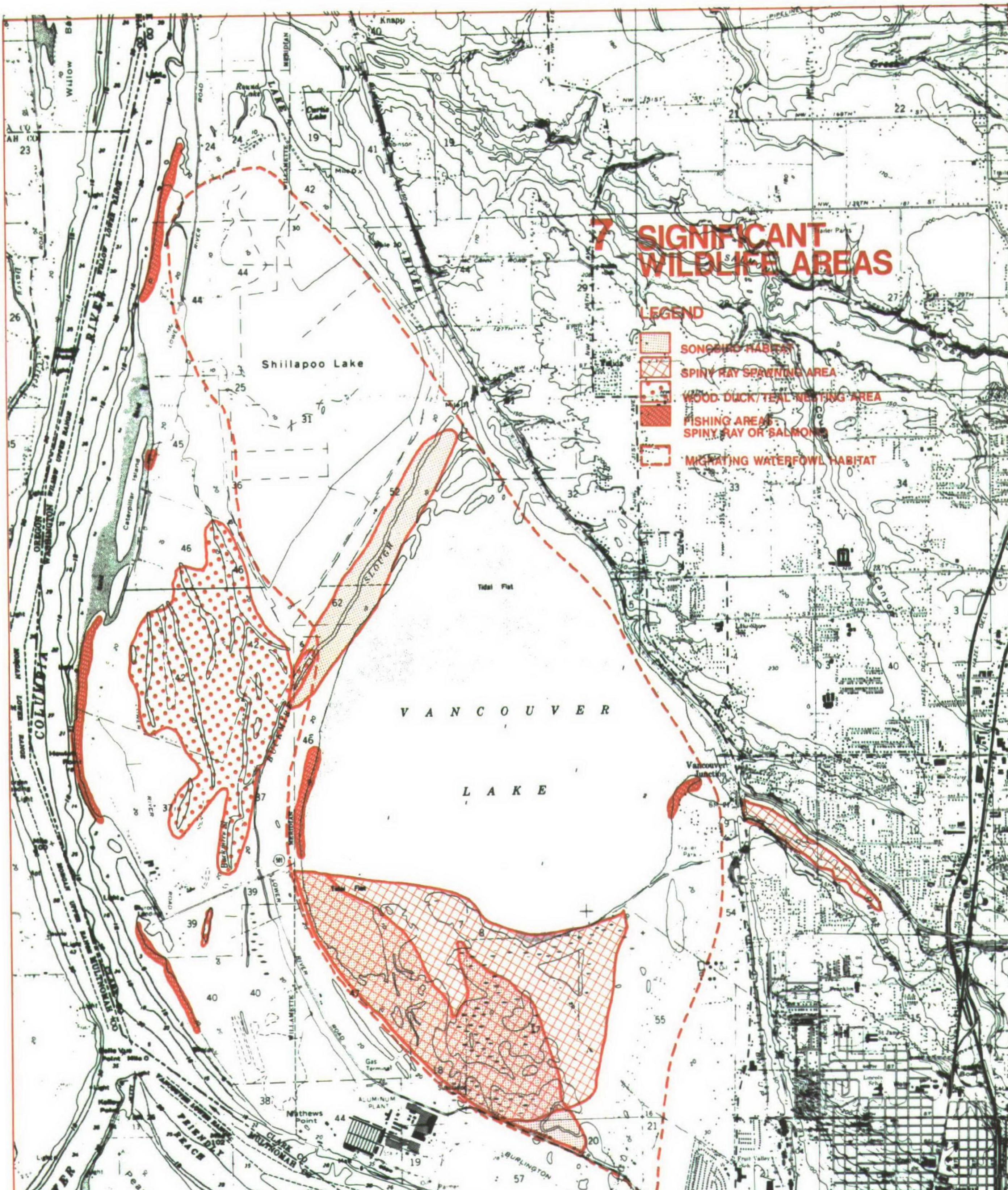
o A woodduck/teal nesting area exists on the west shore of Vancouver Lake. The thick stands of willow and ash, combined with the various channels of Buckmire Slough provide good nesting habitat for these two birds. They have used the area for a number of years, and presumably many of the birds raised in the area return to nest in the same locale. Such habitats are declining in abundance due to human disturbance.

o Just north of the woodduck/teal nesting area exists a good songbird habitat, where thickets of willow/ash, and cottonwood/blackberry mixtures provide a diversified floral assemblage. Warblers, vireos, thrushes, sparrows, and chickadees establish themselves in this area each year, making full use of the nesting and feeding opportunities. Because so much of the surrounding area is under unnatural influences, the perching birds are heavily dependent upon these small ecosystems.

o Burnt Bridge Creek acts as a spawning area not only for spiny rayed fishes, but also for some salmonids. The spiny rayed fishes spawn in the lower reaches of Burnt Bridge Creek where the waters are slow and ample aquatic vegetation exists. The salmonids migrate up Burnt Bridge Creek to spawn in the upper areas of the drainage. Salmonids have been caught in Burnt Bridge Creek, but not in notable numbers.

o Sport fishing areas of significant popularity are designated on the Significant Wildlife Areas Figure 7. These sites have been identified by state and federal agency representatives as areas of the most intensive recreational fishing usage, exclusive of boating areas.

o Wetland areas are generally described as areas that are periodically inundated by water and are characterized by vegetation that requires water saturation for growth and reproduction. The Environmental Protection Agency has recently contracted a study to identify existing wetlands in the Vancouver Lake area and to evaluate the habitat value of those wetland areas. Although there are believed to be considerable valuable wetland areas around Vancouver Lake, the extent of those wetlands is not known until the study has been completed. Wetlands fall within the jurisdiction of Sectic 404 of the Federal Water Pollution Control Act Amendments of 1972, which requires the issuance of a permit by the U.S. Army Corps of Engineers before the discharge of dredged or fill material may occur. The Environmental Protection Agency assists the Corps of Engineers in establishing evaluation criteria and has veto power over projects which would have an unacceptable adverse impact on water quality, fisheries, and wildlife resources. In addition, Executive Order 11990, dated May 24, 1977 directs each federal agency to "provide leadership....to minimize the destruction, loss or degradation of wetlands." (70).


7 SIGNIFICANT WILDLIFE AREAS
LEGEND
SONGBIRD HABITAT
SPINY RAY SPAWNING AREA
WOOD DUCK/TEAL NESTING AREA
FISHING AREAS: SPINY RAY OR SALMONID
MIGRATING WATERFOWL HABITAT
Shillapoo Lake
VANCOUVER LAKE
Tidal Flat
COLUMBIA RIVER
Vancouver Junction
Mathews Point
ALUMINUM PLANT
Gas Terminal
BURLINGTON NORTHERN
1" = 2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

Population Growth and Projections

Clark County has experienced steady increases in population growth since the 1940's, marked by periods of rapid growth such as the influx of workers for the shipyards during World War II. As shown in Table 7, the number of persons residing in Clark County increased by 36.9 percent between 1960 and 1970. This growth rate has only been exceeded by the war induced immigration of the 1940's. Historically, Clark County has shared the population growth of the metropolitan area; however, this growth has been more pronounced since 1965. As shown in Table 7, Clark County's growth rate of 36.9 percent for the period from 1960 to 1970 was substantially higher than the SMSA growth rate of 22.5 percent.

TABLE 7

Population Growth 1960-1970
(Thousands)

Area	1930	1940	1950	1960	1970	Percent Increase 1960-1970
Clark County	40.3	49.9	85.3	93.8	128.5	36.9
Portland SMSA*	455.0	501.3	704.8	821.9	1,007.1	22.5

* The Portland SMSA (Standard Metropolitan Statistical Area) includes Multnomah, Clackamas and Washington Counties in Oregon and Clark County, Washington.

Source: CRAG, Economic Indicators, An Annotated Statistical Abstract of the Greater Portland-Vancouver Metropolitan Area, 1972.

Local planners have reported that the largest proportion of population growth in Clark County is due to migration. Between 1960 and 1970, the county's population increased by about 35,000. Of that total, approximately 70 percent is attributed to migration. (71)

In 1976-77 Clark County Regional Planning Council contracted with Boeing Computer Services, Inc. to prepare population and employment projections for the county. They prepared three different projections based on the following three methodologies: Alternative 1 forecasts the population of Clark County based on employment in the Portland SMSA and a time trend. This relationship from 1960 to 1975 explained 99.5 percent of the movement in Clark County population. Alternative 2 forecasts the population of Clark County based on employment in the Portland SMSA and employment in Clark County. This relationship from 1960 through 1975 explained 98.8 percent of the movement in Clark County population.

Alternative 3 forecasts future population based on both demographic and economic activity within the region and Boeing determined that this forecast represented the median level. Table 8 shows the resulting population projections based on each of these methods.

TABLE 8

Clark County Population Projections
(Thousands)

	1975	1980	1990	2000
Alternative 1	151.3	167.8	203.0	238.4
Alternative 2	149.1	167.7	198.1	227.8
Alternative 3	142.3	166.3	201.4	250.2

Source: Clark County Regional Planning Council, Clark County Washington Employment, Population and Land Use Forecasts, 1977.

The Boeing report discussed a variety of variables which make projecting Clark County's growth rate difficult, including the current traffic congestion on I-5 and the proposed construction of I-205. In conclusion they reported that: "Without the announcement of the I-205 bridge corridor opening in late 1981 or early 1982, it is quite likely that the historic growth rate for Clark County would decline as commute times (on I-5) increased. However, with the "still cheap" land prices, it is likely that the historical relationships will be maintained and the growth forecast (in Alternative 3) will be realized". (72)

Population Characteristics

Age

As illustrated in Table 9, Clark County population recorded a definite shift towards increasing numbers of young families between 1960 and 1970. In 1960, 9.5 percent of the population was between the ages of 20 to 29 while by 1970 that number had risen to 14 percent. The number of small children (ages 0 to 9) fell by 2 percent during this period as a result of the declining birth rate.

TABLE 9
Age Distribution

	Percent 1960	1970
0-9	21	19
10-19	18	20
20-29	9.5	14
30-39	14	11
40-49	13	12
50-59	10	11
60-69	8.5	7
70-over	6	6
	100%	100%

Source: U. S. Bureau of Census, 1970

Income

Family income rose markedly between 1969 and 1974 due to a combination of factors. As shown on Table 10, the largest numerical increase occurred in the $15,000 to $24,999 category which jumped from 16 percent of the total population in 1969 to over 30 percent in 1974. All categories under $15,000 declined in percentage in 1974, while all categories above $15,000 increased. Although a large portion of these increasing household incomes must be attributed to inflation, a portion of this change is due to the influx of better educated professional and technical workers into Clark County.

TABLE 10
Income Distribution

	Percent	
	1968	1974
Under 3,000	8.0	2.0
3,000-5,999	12.0	9.0
6,000-9,999	28.0	19.0
10,000-11,999	15.0	12.0
12,000-14,999	18.0	17.5
15,000-24,999	16.0	30.5
25,000-49,999	2.0	8.0
50,000 & over	1.0	2.0
	100.0%	100.0%

Source: Housing Market Analysis of Clark County, Regional Planning Council of Clark County, 1974.

Mobility

As shown in Table 11, little change in residential mobility was noted in Clark County between 1960 and 1970. The most significant shift was a substantial decrease in the number of residents who had previously lived elsewhere in the Portland metropolitan area.

TABLE 11
Residential Mobility
Clark County

Residence in 1955	Number	Percent
Same House	39,303	46.8
Different House within SMSA	30,797	36.7
Different House outside SMSA	12,798	15.2
Abroad, or Moved and Not Reported	1,060	1.3
	83,958	100.0
Residence in 1965		
Same House	54,599	46.8
Different House within SMSA	31,596	27.0
Different House outside SMSA	21,494	18.4
Abroad, or Moved and Not Reported	9,166	7.8
	116,854	100.0

Source: Housing Market Analysis of Clark County, Regional Planning Council of Clark County, 1974.

Economic Base

A majority of Clark County's industry is extractive or heavy industry and is typified by plants with large capital investments. Many of these are clustered around the current Port of Vancouver facilities or are located along Columbia River between downtown Vancouver and the port docks. Seventy percent of Vancouver's industrial land is classified as general, while somewhat less than 30 percent of the county's industrial land is in general usage. The county has representation from each of the four industrial classification: Light (3.0%), General (29.5%), Heavy (32.0%) and Extractive (35.5%) (73).

The Portland SMSA and Clark County both have well diversified industrial bases which shelter them somewhat from national economic fluctuations, as reflected by fairly stable unemployment rates in relationship to other parts of Oregon and Washington. Economic growth in Clark County has become more closely tied to growth in the general metropolitan area; however local business leaders are continuing to work towards increased economic self-sufficiency. The Port of Vancouver has been pursuing an aggressive economic development policy and is actively seeking to promote increased industrial activity within and adjacent to their existing facilities.

The overall industrial land use has remained very stable, and the industrial sector of the 1944 Land Use Map is in close approximation to current industrial land location. New industry has developed and old ones have grown, but they have remained in the same general strip fronting Columbia River.

Approximately 500 acres within the Vancouver Lake vicinity (primarily south of the lake) are currently being used for industrial purposes, which constitutes about 40 percent of the industrial activity in Clark County. The lowland areas along Columbia River have been an attractive area for industry because of the level terrain, proximity to the Portland metropolitan area, major rail service and Columbia River deep draft navigation channel. Major industries within the project area are Alcoa (Aluminum manufacturer) and Carborundum (abrasives manufacturer). The Port of Vancouver facilities are located south of Vancouver Lake and include berthing capacity for three or four vessels, a roll on/roll off dock, 500,000 square feet of warehouse storage and about 75 acres of open storage area. The Port is engaged in diversified trade including the export of lumber and wheat, and the import and export of wood chips, paper, fertilizer and automobiles.

Land Use Plans and Policies

Clark County Comprehensive Plan

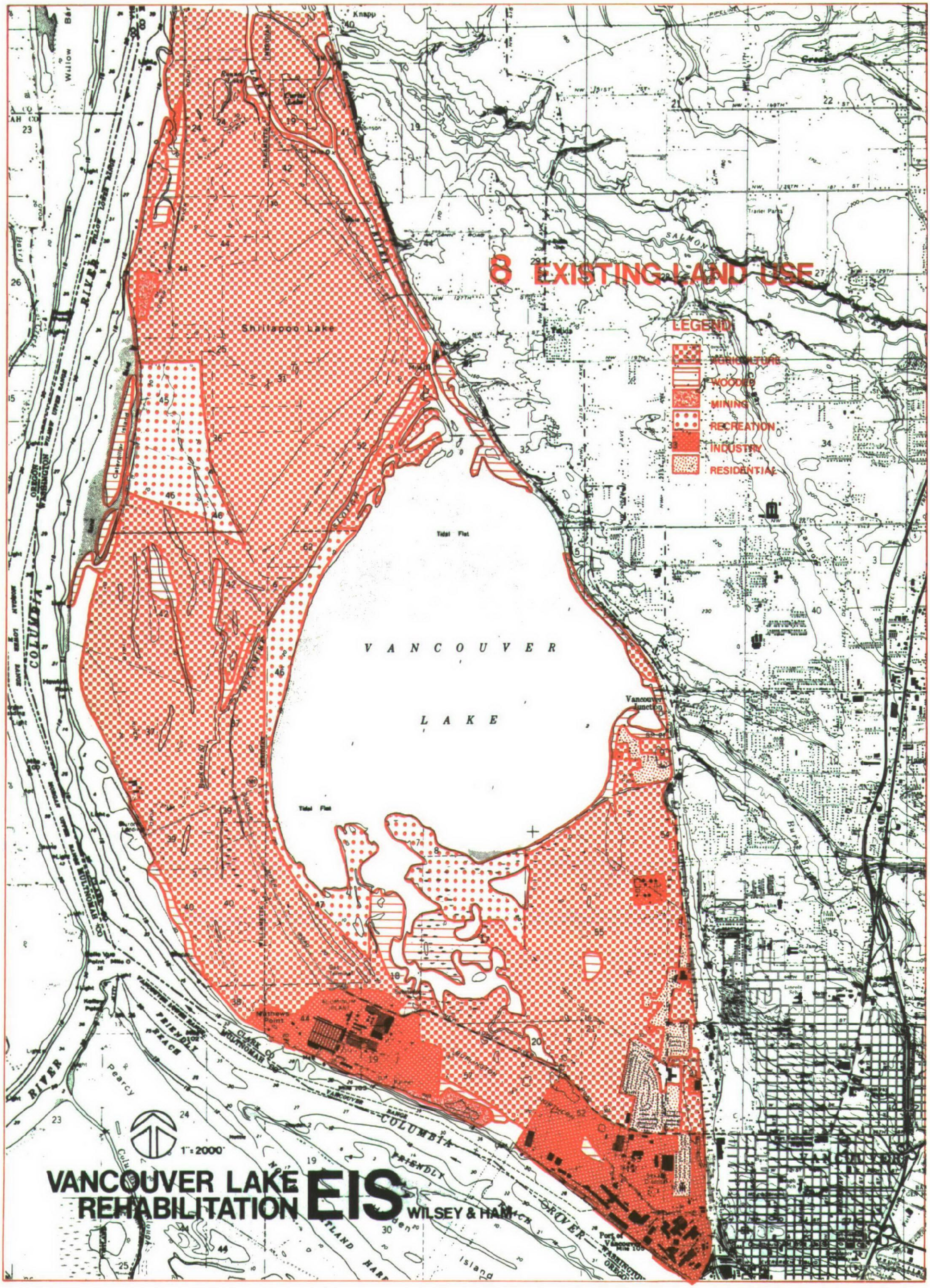
In August 1976, Clark County Regional Planning Council issued a discussion draft of goals and guidelines for the Clark County Comprehensive Plan. This discussion draft has been receiving public review and input since that time, and adoption by the County Commissioners is expected sometime during the winter of 1977. In keeping with the Columbia Region Association of Governments format, land use is divided into three separate classifications: urban (including urban intermediate and urban future), rural, and natural resource (including both conservation and preservation categories).

TABLE 12

Existing Land Use
Vancouver Lake Land Use Plan

		Acres
RESIDENTIAL*		227.9
Single Family	188.6	
Multi-Family	20.5	
Mobile Homes	18.8	
COMMERCIAL		50.7
Retail	49.9	
Wholesale	.8	
INDUSTRIAL		489.5
Light	.4	
General	159.3	
Heavy	274.3	
Extractive	55.5	
COMMUNITY FACILITIES		430.5
School	4.1	
Government	.7	
Other Institutions	10.3	
Amusement	109.3	
Transportation & Utilities	306.1	
OPEN SPACE		
Agriculture	5,664.9	6,313.1
Parks	250.0	
Wooded & Game Preserves	398.2	
WATER		5,207.6
STREETS		188.0
UNUSED		533.6
	TOTAL	13,440.9

*Includes parts of Vancouver statistics that were not easily separated.


8 EXISTING LAND USE
LEGEND
AGRICULTURE
WOODED
MINING
RECREATION
INDUSTRY
RESIDENTIAL
Shillapoo Lake
VANCOUVER
LAKE
Tidal Flat
Vancouver Junction
Mathews Point
COLUMBIA
RIVER
1" = 2000'
VANCOUVER LAKE
REHABILITATION
EIS
WILSEY & HAM

The plan includes the following goals and guidelines which can be used to evaluate the effects of the proposed Vancouver Lake restoration project.

It should be noted, however, that these Comprehensive Plan elements provide only general guidance for the Vancouver Lake area since the Vancouver Lake Land Use Plan discussed below is the major policy document governing use of the project area.

o Preservation Element

- encourage the preservation of open space, scenic views and sites, historic and archaeological sites,

- encourage and maintain important fish and wildlife habitats,

- maintain ecologically "sensitive areas" such as natural areas, wetlands and excessive slopes in as natural a state as possible.

o Conservation Element

- encourage the maintenance of agricultural land uses in those areas that are agriculturally productive,

- encourage the maintenance and creation of those farm sizes needed to accommodate the types of agriculture which are or could be present in Clark County.

o Transportation Element

- new and expanded Port facilities should be provided (at locations designated in the comprehensive plan) for the transfer and storage of goods that are not adequately provided for by other marine facilities in the area.

o Economic Element

- potential tourism in Clark County should be accommodated by the provision of public park and recreation areas at appropriate points along the shorelines of lakes and rivers.

Vancouver Lake Land Use Plan

In December 1974 the Regional Planning Council of Clark County accepted the Vancouver Lake Land Use Plan included in the report submitted to them by the Vancouver Lake Task Force. In 1976 the Board of County Commissioners of Clark County accepted the Regional Planning Council recommendation and adopted the Land Use Plan for Vancouver Lake that was prepared by the Task Force.

As shown in Figure 8, the existing land use in the project area is predominantly agricultural, ranging from dairy farming to intensive agriculture with high yield crops of cabbage, cucumbers and potatoes. Industrial activity is concentrated in the southern portion of the project area at the Alcoa and Port of Vancouver sites. Substantial recreational lands are located along the lake shoreline including

Vancouver Lake Park which is operated by Clark County and portions of Mulligan's Slough which are managed by the Washington State Game Department for fishing access and wildlife habitat maintenance. The Vancouver Lake Task Force prepared an inventory of existing land uses for the project area. Table 12 includes the acreages for individual types of land use that were calculated by the Task Force.

Figure 9 shows the land uses designated on the adopted Vancouver Lake Land Use Plan. The lake and its shoreline are designated for recreation and open space use, while agricultural uses are shown for areas to the west, northwest and southeast. Heavy industrial uses are indicated for the southwestern portion of the project area along Columbia River. An area of light industrial and commercial use is designated at the south-eastern tip of the project area between the existing residential and agricultural parcels. The Task Force felt that the ability of the lowlands area to support multiple land uses was one of its most important assets. For that reason, their land use plan is comprised of co-existing land uses representing diverse interests that they believed offered a wide range of choices to the community.

The Task Force report strongly recommended the continued recreation use of Vancouver Lake. They established the following policies relative to actual use of lake shoreline and waters:

- provide public access to and along shorelines
- establish recreation and/or park zones
- preserve the wetlands southwest of Vancouver Lake
- dredge the lake to the recommended depths for lake restoration
- continue efforts to reduce the pollutants from the tributaries and runoff drainage to Vancouver Lake
- flush the lake by introducing Columbia River waters through a channel and culverts.

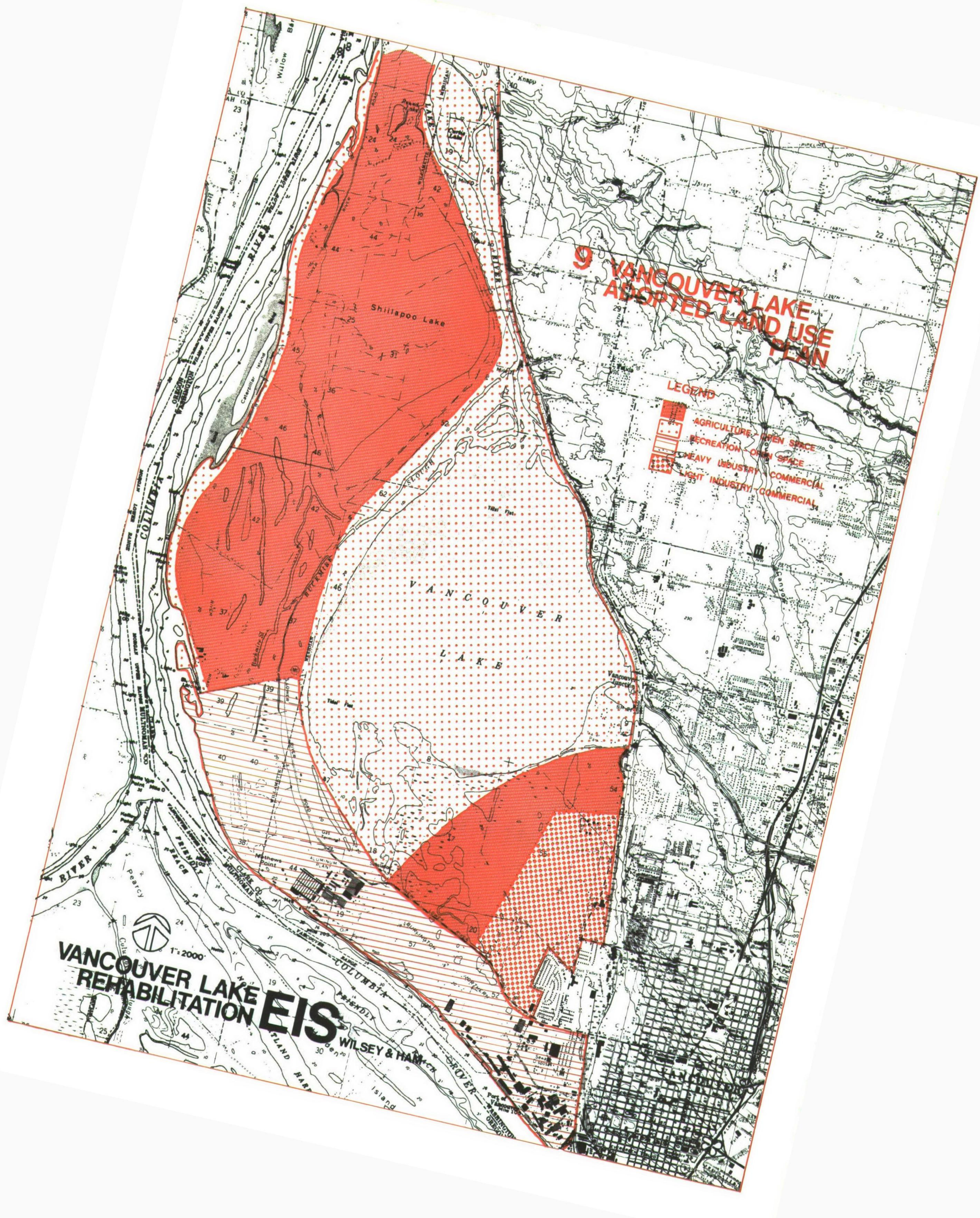
The following policies were adopted relative to land fill and diking proposals within the project area:

- land fills along shoreline areas intended for water dependent and/or public land uses should be given priority over other land fills

- construct an adequate new dike to the south of Vancouver Lake, preserving Mulligan's Slough and its associated wetlands.
- diking should be sought to support the land uses proposed, but not more intensive land uses.

In Resolution No. 1976-05-41, adopted by the Clark County Board of Commissioners on May 24, 1976, the Commissioners attached the following conditions to their adoption of the Vancouver Lake Land Use Plan:

- That the Board recognizes that the Task Force report is a general land use concept which addresses the whole lowlands area generally, but which does not address the peculiarities and unique aspects of individual sites or premises; thus, although an individual site may be identified as a larger categorization, closer review and further scrutiny, particularly


9 VANCOUVER LAKE
ADOPTED LAND USE PLAN
LEGEND
AGRICULTURE - OPEN SPACE
RECREATION - OPEN SPACE
HEAVY INDUSTRY - COMMERCIAL
LIGHT INDUSTRY - COMMERCIAL
Shillapoo Lake
VANCOUVER LAKE
COLUMBIA RIVER
1" = 2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

with respect to the amenities of the proposed use, may dictate that the site may be more appropriately used for industrial, commercial or other purposes..."

- That the proposed implementing amendment...should...permit a reviewing body to permit land uses at variance with general concepts if it can be demonstrated that the proposed use at variance is the appropriate use of the particular site or premise at issue and that community needs require its conversion."

- "That, as it is established that the needs of the community have changed, commercial and industrial development should be considered for expansion into the lowlands area, but only to the extent dictated by the needs established." (74).

Shoreline Management Master Program

The statewide adoption of the Shoreline Management Act in November 1972 established a cooperative management effort between local government and the Washington State Department of Ecology. This placed three significant responsibilities on local government:

1. Establishment of a system for the administration and enforcement of a permit requirement for shoreline developments;
2. Completion of a comprehensive inventory of shorelines falling under jurisdiction of the act; and
3. Development of a master program for the regulation of shoreline uses.

With the assistance of the Regional Planning Council, the Clark County Citizen Advisory Committee for Shoreline Management prepared a Shoreline Management Master Program which was adopted in August, 1974. Vancouver Lake and its ponds, sloughs, lakes, channels, streams and islands are defined as "shorelines of statewide significance" within that program. As such, these shorelines must be managed in a manner which:

- recognizes and protects the statewide interest over local interest,
- preserves the natural character of the shoreline,
- results in long term over short term benefits,
- protects the resources and ecology of the shoreline,
- increases public access to publicly owned areas of the shorelines, and
- increases recreational opportunities for the public in the shoreline.

The Shoreline Management Act further states that the management of shorelines and shorelines of statewide significance is not limited to the water areas or to the underlying beds, but includes wetlands associated with those lakes and streams. Wetlands are defined in the act as follows:

"Wetlands or wetland areas mean those lands extending landward for 200 feet in all directions as measured on a horizontal plain from the ordinary high water mark; and all marshes, bogs, swamps, floodways, river deltas, and floodplains associated with the streams, lakes and tidal waters which are subject to the provisions of these chapters; the same to be designated as to location by the Department of Ecology."

The Clark County Shoreline Management Master Program contains the following goals which are relative to the evaluation of the proposed project:

- Public Access Element: To improve the quality of existing points of public access and promote the acquisition or designation of additional shoreline areas for public access, while assuring that all such sites are appropriate and safe for public use, and that improvements and utilization will not result in detrimental effects on these natural sites or adjacent properties.

- Recreational Element: To promote the continued public acquisition of appropriate shoreline areas for recreational opportunities and to influence development of these sites in a manner which will preserve the natural characteristics of the shoreline.

- Conservation Element: To provide for management of natural resources in shoreline areas by means that will insure the preservation of nonrenewable resources, including unique, scenic and ecologically sensitive features, while allowing sound utilization of renewable resources in a manner consistent with the public interest.

- Shoreline Improvement Element: To encourage the restoration of degraded shoreline areas to conditions of natural environmental quality, and promote the revitalization of abandoned shoreline facilities for practical and productive activities.

Four shoreline environmental designations are provided for in the master program: urban environment, rural environment, conservancy environment and natural environment. These designations provide a uniform basis for applying management criteria within different shoreline areas and with different objectives regarding their use and development. Portions of Vancouver Lake have been designated urban, rural and conservancy, generally as follows:

- Urban: South of Burnt Bridge Creek.
- Rural: All of Vancouver Lake, Lake River and associated wetlands north of urban boundary except for east bank of Vancouver Lake, Lake River and Lower Salmon Creek between mouth of Burnt Bridge Creek and Burlington Northern rail line crossing of Salmon Creek, an easterly portion of Lake River inside city limits of Ridgefield.
- Conservancy: Easterly bank from mouth of Burnt Bridge Creek northerly to Burlington Northern rail line crossing of Salmon Creek.

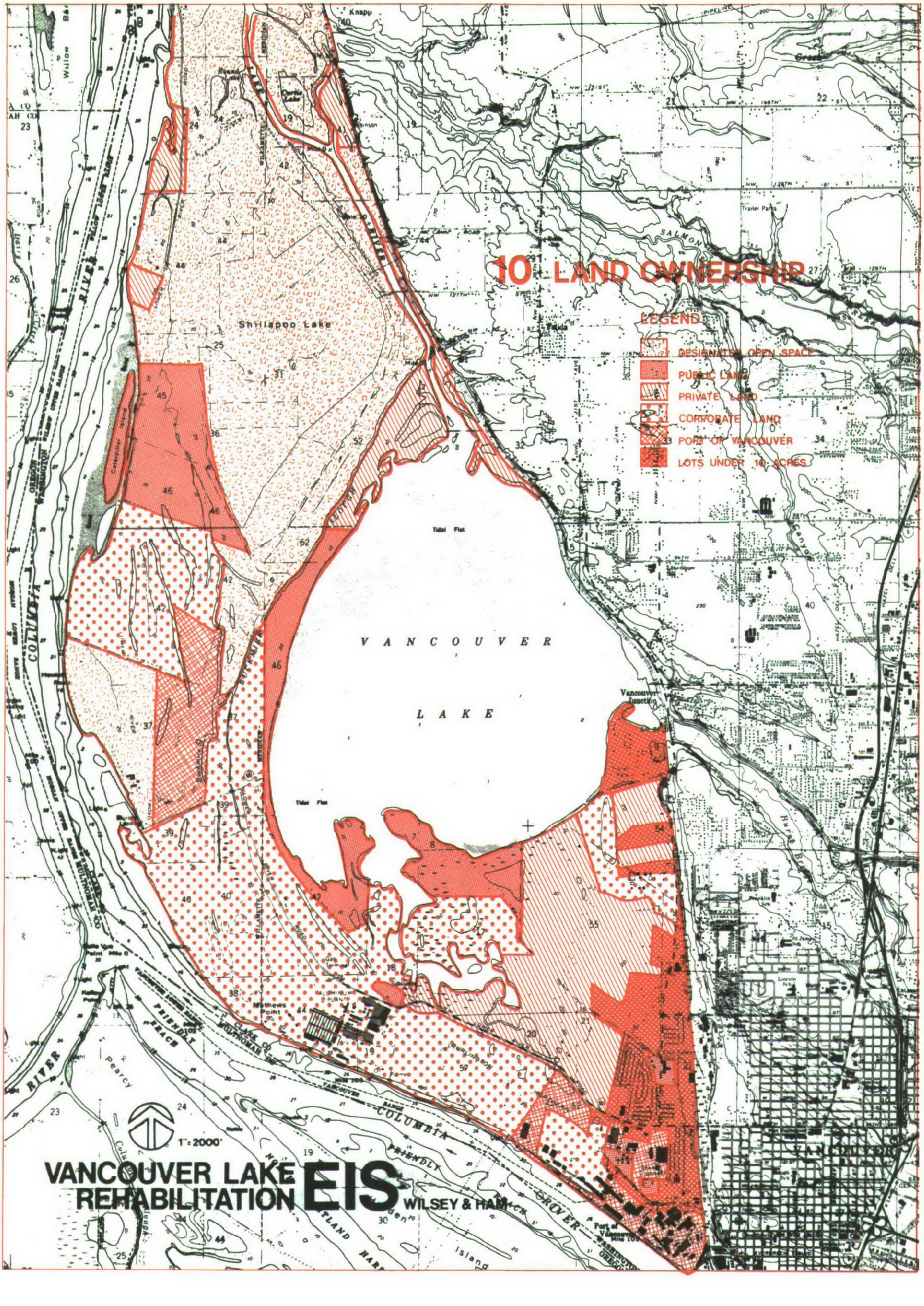

10 LAND OWNERSHIP
LEGEND
DESIGNATED OPEN SPACE
PUBLIC LAND
PRIVATE LAND
CORPORATE LAND
PORT OF VANCOUVER
LOTS UNDER 10 ACRES
VANCOUVER LAKE
Shillapoo Lake
Tidal Flat
Vancouver Junction
Mathews Point
COLUMBIA RIVER
1"=2000'
VANCOUVER LAKE REHABILITATION EIS
WILSEY & HAM

TABLE 13

Land Ownership
Vancouver Lake Land Use Plan

Owner	Acres
Esther Dugan Estate	314
Pacific Coop Supply	103
Port of Vancouver	767
Elmer Rufener	279
Clark County	234
U.S. Government	660
Alcoa	1,558
Scherruble Brothers	186
Egger Family	1,303
Grant Wiley et. al.	281
Chris Herzog	233
John Mettler	204
Fazio Brothers	803
Washington State Department of Game	580

Source: Vancouver Lake Task Force report, 1974.

Land Ownership

Table 13 lists the major property owners within the project area and Figure 10 illustrates the general distribution of public, private and corporate lands. Many of the parcels within the project area are over 200 acres in size, reflecting the need of the existing agricultural and industrial land uses for large land areas. This largeness provides a future potential for conversion to other uses.

208 Areawide Waste Water Management Plan

Regional Planning Council of Clark County is currently preparing a Section 208 Areawide Wastewater Management Plan which has three basic work elements: 1) restoration of Vancouver Lake, 2) reduction of point source pollution from Burnt Bridge Creek, and 3) reduction or elimination of future pollutants from non-point sources.

The restoration plans for Vancouver Lake represent approximately 30 percent of the effort being expended within the 208 program. Dames and Moore recently completed a Master Plan for the Rehabilitation of Vancouver Lake which outlines specific lake restoration and maintenance measures. The Clark County Regional Planning Council is scheduled to adopt the Master Plan at their late October meeting.

The Burnt Bridge Creek Management Plan is currently being reprinted in final form and is also scheduled for adoption in late October. The draft report outlining measures to reduce or eliminate future pollutants due to non-point sources will be available for public review in October. Of primary concern in that report are animal wastes resulting from agricultural activities, urban drainage resulting from residential uses and new construction activities.

Recreation Plans and Policies

A variety of recreational opportunities currently exist in the project area, ranging from limited hunting in the Ridgefield Wildlife Refuge to sailing on Vancouver Lake. There are approximately 1,200 acres owned by Federal, State or County government and used for fishing, hunting, sailing and canoeing. In early 1973, Clark County purchased the 234 acre Vancouver Lake park site from Alcoa Corporation. This long, linear strip of park land covers approximately two and one-half miles of shoreline on the southwestern and western side of the lake, and is currently undeveloped. The park lies between Vancouver Lake on the east and State Highway SR 501 on the west, extending from the Mulligan Slough marshlands on the south, northward to Buckmire Slough and then along the slough to within one mile of the lake outlet into Lake River. The area presently provides fishing access to the lake, which hosts a large spiny rayed fishery. Other popular recreation facilities within the project area include Frenchman's, Tena's and Davis Bar on the Columbia River which provide access to salmon and steelhead fishing.

In 1973 a Master Plan Study for Vancouver Lake Park was prepared for the Clark County Parks and Recreation Department with funding provided by the Port of Vancouver. The master plan proposed the creation of the recreation zones and construction of the specific park facilities shown on Figure 11. The only significant change that has occurred in the plan since that time is the elimination of power boat use (other than small engine fishing boats) in the lake, and a proposal for an Olympic sailing course to be established in the south central portion of the lake. The site and facilities at Vancouver Lake have been designed to accomodate 12,000 to 15,000 park users per day, with approximately 5,000 people using the site at any one time. Consistent with the design philosophy, automobile parking is limited to 50 percent of the potential demand, or 650 cars. In 1973 construction of the proposed facilities was estimated to approach $1.4 million.

Implementation of the water improvement program is projected to have the greatest potential to improve the recreational use of the park by providing: 1) sufficient water depth for small boats, 2) the opportunity to upgrade the aquatic life so that the lake can support increased numbers and types of species for improved sport fishing, and 3) clean water for swimming and other water sport activity. In addition, the Master Plan states that creative use of the dredged materials resulting from lake restoration measures could enhance the useability of the lake by creating additional shoreline property and raising some of the existing land above flood levels (75).

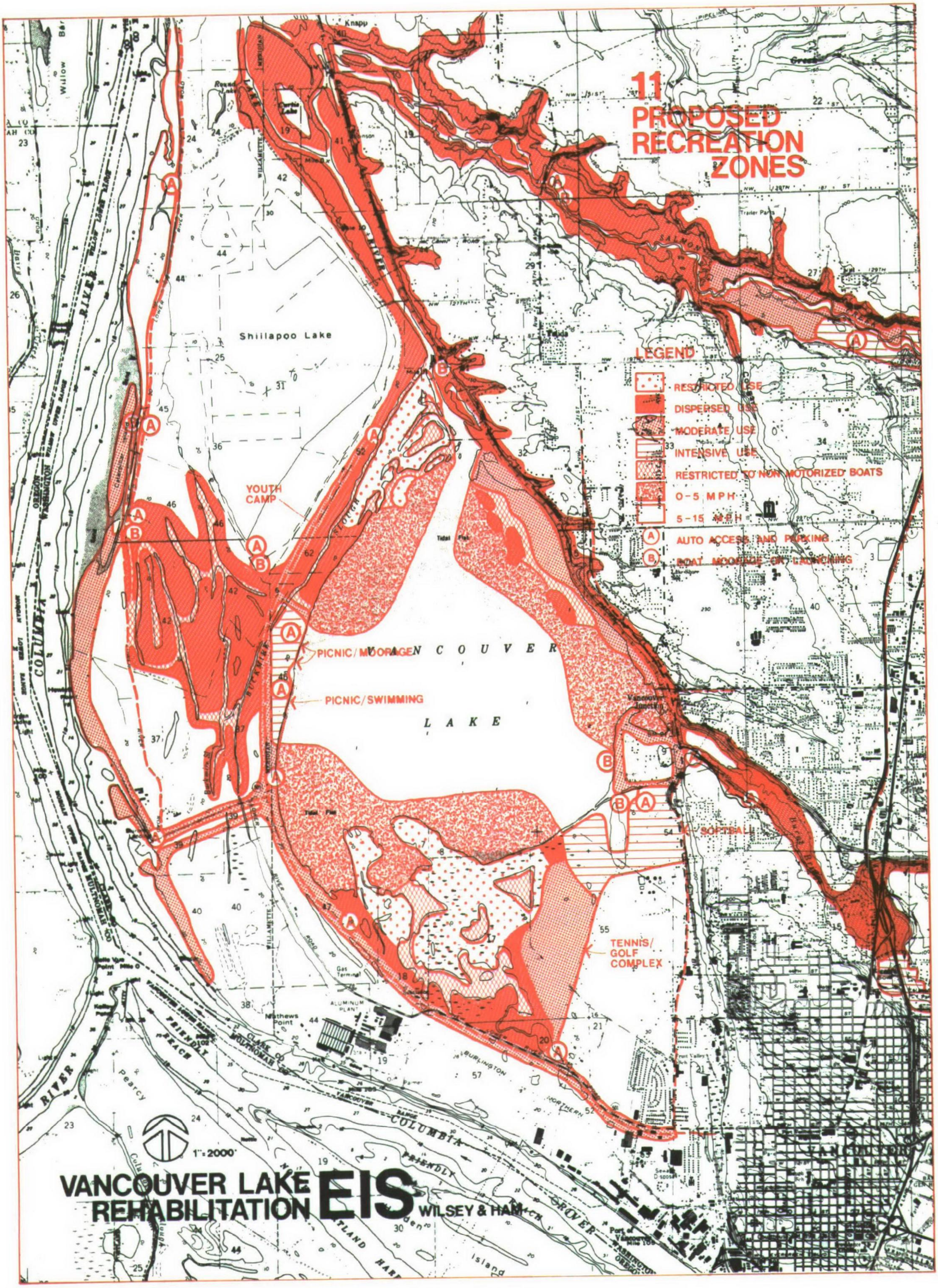
In 1971 the Columbia Region Association of Governments published a recreation report entitled The Urban Outdoors: A New Proposal for Parks and Open Spaces. In that report, the CRAG staff suggested that Vancouver Lake offered a unique opportunity for water based recreation since it is the region's second largest lake. However, they noted that it was currently too shallow and that the water quality had deteriorated due to silting and pollution. Therefore, a costly rehabilitation program would be necessary in order to realize the lake's recreation potential.

In addition to the preparation of the Vancouver Lake Park Master Plan, Clark County Park and Recreation Department has also prepared plans for a greenway system linking Burnt Bridge Creek, Vancouver Lake, Lake River and Salmon Creek. The primary purpose of this system is to link the urban areas with existing and future park sites and to preserve public access to area waterways.

Recreation Demand

Only limited facilities are available in Clark County to serve the still water/lake recreationist. Lake Merwin is the largest such facility and is privately owned, but available for public use. Three other facilities are available in the metropolitan Portland area, one each in Multnomah, Washington and Clackamas counties.

The demand for water-related recreation sites is based primarily upon three major factors:



11
PROPOSED
RECREATION
ZONES
LEGEND
RESTRICTED USE
DISPERSED USE
MODERATE USE
INTENSIVE USE
RESTRICTED TO NON MOTORIZED BOATS
0-5 MPH
5-15 MPH
AUTO ACCESS AND PARKING
BOAT MOORAGE OR LAUNCHING
Shillapoo Lake
YOUTH CAMP
PICNIC/MOORAGE
PICNIC/SWIMMING
VANCOUVER
LAKE
SOFTBALL
TENNIS/ GOLF COMPLEX
COLUMBIA
RIVER
1"=2000'
VANCOUVER LAKE REHABILITATION
EIS
WILSEY & HAM

- the population of the recreation area of influence,
- recreation user preferences within the recreation area of influence, and
- the availability of water-related recreation sites within the recreation area of influence and nearby areas.

Nationally, the demand for all types of recreation areas continues to grow rapidly due to increased leisure time and disposable income, as well as people's desires to increase their recreational activities. Past trends have indicated that participation in outdoor recreation in the United States is growing 25 percent faster than the adult population, and these trends are expected to continue for the immediate future. Projections also indicate that water-related recreation activities will make up three of the five fastest growing recreation activities between 1972 and 1978 (76).

Because of Vancouver's role as an integral part of the CRAG region and its proximity and similarity to Oregon features, it is assumed that Oregon recreation projections can be applied to Clark County recreation demand. In Oregon, water-related recreation activities continue to be among the most popular. The rate of growth of boat ownership has far surpassed the population growth as indicated by the 52 percent increase in boat registration from 1967 to 1972, compared with a 6 percent increase in population for that same period (77). In general, Oregon boaters prefer lakes to rivers as favored recreation areas, and fishing is the most widely participated in boating or boating related activity (78).

The Clark County Parks and Recreation Department has indicated that demand for water-related recreation sites within the county has not been evaluated. The recent experience of a new reservoir facility in Washington County, Oregon, however, may provide a point for comparison. Scoggins Reservoir in Washington County was opened in the summer of 1975, for recreational use, even though only 20 percent of the proposed recreational facilities were completed. Projections had indicated that approximately 100,000 visitors would use the lake during the first full recreation season; however, actual attendance reached 180,000 -- almost double the intended use. Washington County Parks Department surveyed a portion of the recreationists at Scoggins Reservoir to determine where they came from and what type of recreational facilities they were using. It was found that the majority of users, 68 percent, lived in Washington County, while 18 percent lived within 40 miles of the reservoir. Swimming and picnicking were the most favored activities, followed closely by boat fishing and motor boating (including water skiing.)

Recreation projections by both the Oregon State Highway Division and the Pacific Northwest River Basins Commission indicate a strong overall need for water-related recreational facilities in the Portland metropolitan area. In addition, the Scoggins Reservoir 1975 attendance figures indicate that recreation demand for swimming, boating, fishing and picnicking is sufficiently high to draw large numbers of visitors to a site even though the recreation facilities are not completed. At the present time Scoggins Reservoir is the only metropolitan area regional park that provides quiet water-related recreational facilities. A review of federal, state and local recreation plans indicates that no plan exists to significantly increase the supply of water-related recreation sites within the near future with the exception of Vancouver Lake.

Historical and Archaeological Resources

During the study investigations for this report, both the Wasington State Historic Preservation Officer and the Washington Archaeological Research Center (Washington State University) were contacted to determine the presence of historical and archaeological resources within the project area. The Washington Archaeological Research Center identified over 40 Indian relic sites that have been identified by both professional and amateur archaeologists. These sites are scattered along most portions of the lake shoreline and north along the banks of Lake River. Little information is available describing either the characteristics or the significance of these sites.

The Washington State Historic Preservation Officer identified only four sites within the project area. All of these were Indian relic sites that were included within the sites identified by the Research Center. There are no sites within the project area that are included on the National Register of Historic Places.

Implementation of any of the alternatives described in Section III (exclusive of Alternative 1, the "no-action" alternative) would require the Port of Vancouver to conduct a site specific archaeological investigation of the affected areas. This survey would be submitted to the Washington State Historic Preservation Office for review and acceptance. Any mitigating measures recommended by the State Historic Preservation Officer would be considered by the Port of Vancouver and the Environmental Protection Agency. Mitigation measures acceptable to all three parties (State Historic Preservation Officer, EPA and the Port of Vancouver) would be adopted and implemented.

SECTION III ALTERNATIVES AND THEIR EFFECTS

Alternative Selection Process

The basic proposal for lake restoration, including construction of a flushing channel and dredging of lake bottom sediments, was first presented in a Stevens, Thompson & Runyan report of 1973. In the studies undertaken in the current 208 planning program, Dames and Moore has suggested some revision to those features, but their basic characteristics remain the same. In addition, completion of the Pilot Dredge Study allowed analysis of lake bottom sediments for reuse, various methods of dredging and techniques for placement and handling of the dredged materials. Based on the above studies EPA selected the following alternatives for consideration in this Draft Environmental Statement:

ALTERNATIVE 1	No Action
ALTERNATIVE 2	Scale of Development
2A	Dredging of 12-15 million cubic yards
2B	Dredging of 8 -10 million cubic yards
2C	Dreding of under 6 million cubic yards
ALTERNATIVE 3	Disposal Material Placement
3A	Land Disposal
3B	Shoreline Disposal
3C	Combination of Land and Shoreline Disposal
ALTERNATIVE 4	Dredging Methods
ALTERNATIVE 5	Dredged Material Handling Methods

Impact Evaluation

In this section, possible environmental impacts associated with each alternative are discussed following a brief description of the alternative. Environmental impact may be categorized as adverse or beneficial, primary or secondary, and short term or long term. Any number of combinations of these categories are possible depending on the type of project involved. For each alternative, impacts on the natural and social environments are discussed in terms of these categories, where the categories can be applied. Elements of the natural and social environments are discussed in an order corresponding to Section II, Project Area Existing Conditions.

Most of the terms used to describe environmental impact are self-explanatory. However, for the purpose of this discussion, several need further clarification.

> Primary Impacts include short term impacts occurring during construction, and long term impacts related to construction and operation of the facilities. Examples of primary impacts include traffic disruption, disruption to vegetation, etc.

Secondary impacts are essentially those associated with growth and development. These impacts could include potential increases in air contaminants and traffic as a result of increased recreation use, need for increased public services, and other effects of growth related to lake restoration in general. Cumulative impacts will be discussed where applicable.

In addition to environmental impact, short term uses and long term productivity will be discussed, as well as any irreversible and/or irretrievable resource committments. The proposed alternatives will be analyzed in relationship to their effect on future options, and the availability of future resources. Resource committment is primarily a discussion of the environmental and monetary resources which would be committed to the project, and thus would not be available for future use.

Mitigating measures for each individual alternative must also be considered. Mitigating measures may be technological means to avoid and/or minimize adverse environmental impact, or policy methods to mitigate the impact of growth. For the purposes of this report, mitigating measures will emphasize means of reducing short term construction impacts of the project.

ALTERNATIVE 1 - NO ACTION

Alternative 1 is the "no project" alternative and assumes that EPA would not provide grant funds for the proposed lake restoration project. The no action alternative is used as a base line from which to evaluate impacts associated with action alternatives. The non-point source pollution control programs in Burnt Bridge Creek would continue as part of Clark County's 208 Areawide Wastewater Management Plan Program.

Air Quality

Projected trends for the Vancouver Lake area indicate that the U. S. Environmental Protection Agency and Washington Department of Ecology Ambient Air Quality Standards will be maintained in most instances. However, total suspended particulate levels will continue to be violated in the area just south of the lake if the Carborundum Company plant does not improve its pollution control efforts. The Clark County Air Quality Analysis prepared in 1976 projected continued violations of suspended particulates by Carborundum Company until new pollution controls are undertaken. An agreement concerning those pollution controls has been reached between the Southwestern Air Pollution Control Authority and the Carborundum Company.

Topography

No changes in the local land topography would be expected as a result of the pursuit of the no action alternative. Over a long period of time, however, the configuration of the lake bottom would be expected to change significantly due to continuation of the natural filling process. It has been estimated that since 1948, a foot of sediment deposition has occurred within the lake. This rate of deposition could be expected to decrease somewhat in the future due to less intensive home building and other construction activities in the adjacent drainage basin and increased control over urban runoff and erosion.

Hydrology and Flood Hazard

Selection of a no action alternative would suggest that no steps would be taken to change the flushing or circulation patterns within the lake. This would result in continued deposition of sediments throughout the lake, eventually creating marshlands in the shallowest areas. Although it must be pointed out that these processes occur over many years, eventually the circulation patterns would change slightly to accomodate increasing shallowness and a shrinking water surface area.

Pursuit of a no action alternative would have no effect on the flood hazard potential within the project area. Construction of the proposed diking improvements by the Corps of Engineers would provide flood protection to the agricultural land owners within the project area. The timing of the construction of these improvements, or whether they will be built at all, is unknown. The Vancouver Lake diking improvement program has been under consideration since early 1950. Recent questions have been raised as to its cost-benefit ratio, and the project's future is uncertain at this point. Further discussion of the diking improvement plans can be found under Alternative 2A.

Water Quality

Current total and fecal coliform levels within Vancouver Lake substantially exceed the acceptable standards for a Class AA Waterway (Lake Class). Although coliform levels are expected to decrease in Burnt Bridge Creek as a result of a variety of plans and programs, the decrease is not expected to be sufficient to lower the coliform levels in Vancouver Lake to within the acceptable Class AA levels.

The trophic status of a lake is determined by the residence time of water in the lake, the mean depth of the lake, nutrient loading of the lake from the drainage basin, and a variety of other limnological parameters. The single most important parameter in determining lake trophic status is phosphorus loading. Lakes can be defined as oligotrophic, eutrophic or hyper-eutrophic. In general, oligotrophic lakes have very little phosphorus, while eutrophic lakes are high in phosphorus content. Hyper-eutrophic lakes, by definition, evidence exceedingly high levels of phosphorus. Sedimentation and, to a certain extent, eutrophication are natural processes in the history of lake development, particularly in a lake which receives only marginal amounts of freshwater inflow. However, human activity can cause substantial acceleration of the process. Cultural eutrophication is the result of increasing the nutrient loading of a lake due to conditions and activities within the watershed. Any human activity which causes an increase in nutrient flow to a lake will cause cultural eutrophication. Common causes of cultural eutrophication include sewage, increased erosion from agriculture or construction activities, or use of plant fertilizers. When culturally derived nutrients are added to existing supplies in a lake, the lake becomes correspondingly more eutrophic.

Natural lake processes move on a continuum from oligotrophic to highly eutrophic, which are dependent upon a variety of watershed and configuration conditions. Although Vancouver Lake is not yet considered hyper-eutrophic, it is at the upper end of the eutrophic scale. If no action is taken, it is expected that Vancouver Lake will eventually reach hyper-eutrophic conditions. In the long term, coupled with continued sedimentation, the lake will eventually fill and convert to marshland.

Pursuit of other 208 Areawide Wastewater Management Plan elements, including reducing both point and non-point source pollution reaching Vancouver Lake, would decrease the amount of cultural eutrophication occurring within the lake. This would decrease the overall rate of the eutrophication process, but would not prevent the eventual occurrence of hyper-eutrophication and in-filling.

Fisheries

Over the long term, selection of a no action alternative would result in Vancouver Lake becoming increasingly shallow, which would further limit the aquatic environment. Turbidity problems would continue and would likely increase in magnitude. The lake fisheries would probably experience stunting, as biotic competition began to take its toll on the fish species. Over the long run, fisheries would probably be eliminated and the lake would evolve into a marshland, and much later, a terrestrial environment.

Vegetation/Wildlife

Selection of a no action alternative would have no marked effect on the vegetation and wildlife of the project area. Marsh areas would probably expand over time, and riparian vegetation would continue to spread along the shorelines. These processes would be extremely slow, and thus would not alter the present wildlife activity.

Significant Wildlife Areas/Environmentally Sensitive Areas

Selection of a no action alternative would have no noticeable effect on the present significant wildlife areas. Existing wetlands would be maintained in their natural state as mandated in Executive Order 11990 and Environmental Protection Agency's Wetlands Policies, and would continue to provide valuable wildlife habitat. Increases in agricultural activity around the lake could result in a depletion of wetlands and marsh areas if those lands were converted to more intensive pasture usage.

Population Growth/Economic Base

No changes in project area population growth would occur as a result of selection of a no action alternative. It is expected that agricultural use of the area could potentially increase over the long term as a result of continued deposition of sediments in the marshlands. This increase would be extremely slow. Selection of a no action alternative would have no effect on the continued industrial expansion that is forecast in the Vancouver Lake Task Force Land Use Plan.

Land Use Plans and Policies

The Vancouver Lake Task Force report and the accompanying adopted land use plan both endorse and recommend plans for the restoration of Vancouver Lake. Selection of a no action alternative would be contrary to the goals and policies outlined in that report and adopted by the Clark County Commissioners. If restoration of the lake did not occur, the recreation shoreline uses shown in the plan would not be implemented; however, industrial and agricultural use patterns could proceed as defined on the adopted land use map.

208 Water Quality Planning

The restoration of Vancouver Lake is a significant portion of the Section 208 Areawide Wastewater Management Plan currently being prepared by the Regional Planning Council of Clark County. In addition, the remaining two work elements -- drainage management in Burnt Bridge Creek and control of non-point source pollution around the lake -- are closely tied to the eventual cleanup of Vancouver Lake. If the no action alternative were selected, the goals of the 208 work program would not be fully realized. Significant public funds have been previously committed and spent on this project, and a fairly high level of public interest has been generated in the project. The future availability of Vancouver Lake for recreational use appears to be a popular local issue and adverse public reaction could be expected if the project were abandoned.

Completion of the two remaining 208 Program work elements would decrease the amount of nutrient inflow reaching Vancouver Lake, but this decrease would probably not be noticeable in relationship to overall lake quality.

Recreation

Selection of a no action alternative would be expected to result in the abandoning of county plans to improve their 234 acre Vancouver Lake Park. A major feature of the proposed park facility is water contact and access for swimmers, sailors and fishermen. Group and family picnic areas and a youth camp would be built to capitalize on the water access and use. The existing lake quality conditions are not adequate for this type of use, therefore the projected plans would be expected to be abandoned. Existing and future demand for water-related recreation areas would remain unmet, unless alternative sites were constructed or improved.

Archaeological and Historical Resources

No effects would be expected upon the existing archaeological sites if the no action alternative were selected. Amateur and, occasionally, professional archaeologists would continue to search the area for Indian artifacts and remove them from the project area.

Short-term Resource Use vs. Long-Term Productivity

Selection of a no-action alternative would not require any committment of additional monetary resources, nor would it change the environmental factors currently at play within the lake and its environs. The long-term productivity of the lake would be lost as the lake continued to in-fill, however, for the long-term the lake would be preserved as a valuable wetland habitat for waterfowl and other wildlife. Eutrophication represents the increasing nutrient enrichment of a body of water, and from that standpoint the lake would become increasingly productive. However, human use of its surface and shoreline would be extremely limited. Eventually, over the very long-term, the lake bottom would fill, creating marsh and swamp areas. These habitats are highly productive, but would replace and eliminate the existing aquatic habitat and species.

Irreversible and Irretrievable Commitments of Resources

If a no action alternative were selected, Vancouver Lake would be committed towards eventual hyper-eutrophication and in-filling over the long-term. The existing aquatic habitat would be replaced by wetland and marsh habitat, and eventually by upland vegetation. Increasing amounts of land area would be available for agriculture or other dry land uses.

Mitigating Measures

Although the implementation of point and non-point source pollution controls within the Vancouver Lake drainage basin would result in a decrease in nutrient input into the lake, it would not be sufficient to reverse the existing trends. There are no mitigating measures which can be suggested to achieve the project purposes under a no action alternative.

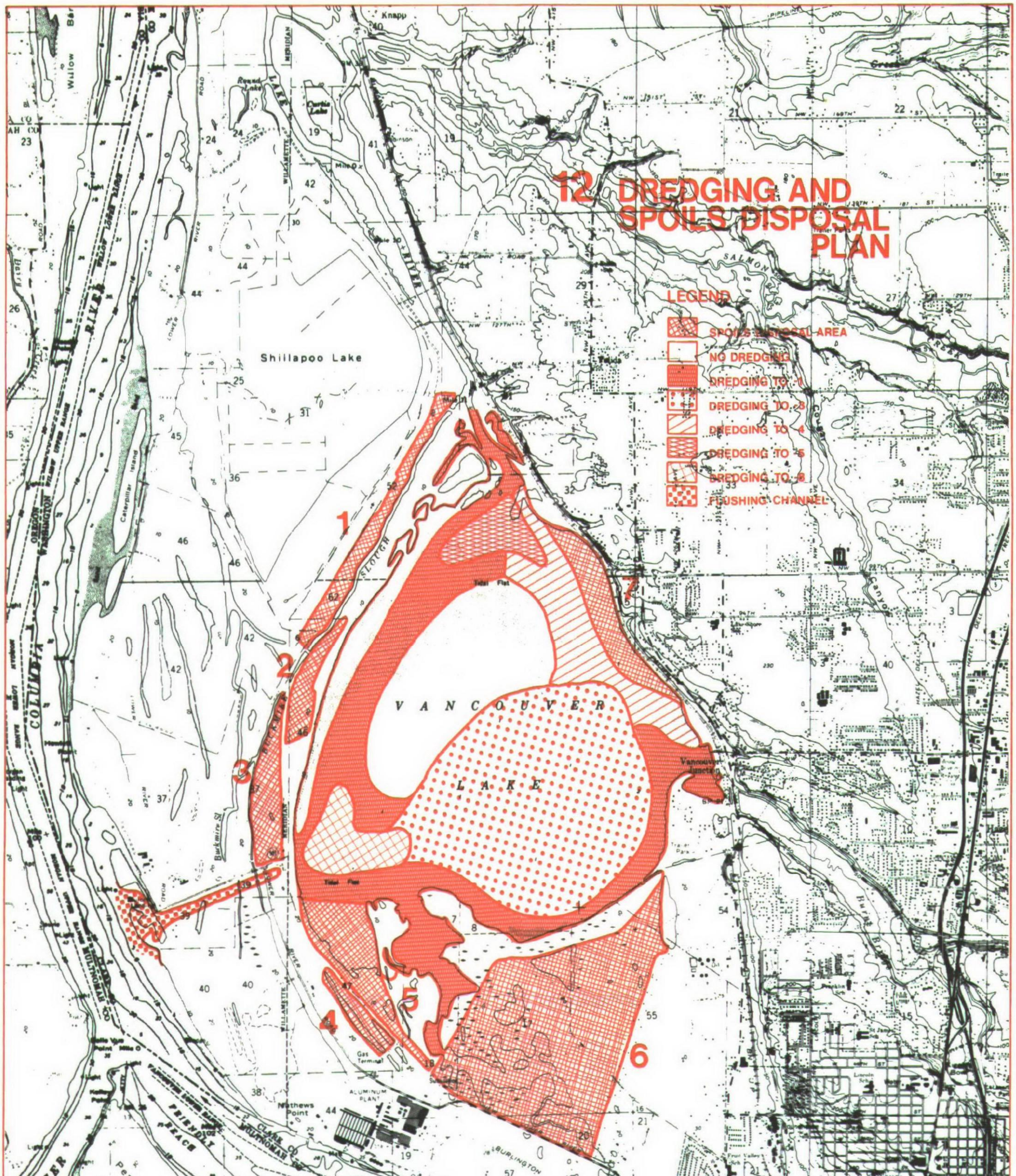
ALTERNATIVE 2 - SCALE OF DEVELOPMENT

In order to restore Vancouver Lake to the depth and water quality level that will allow more extensive human activity on and around the lake, the Master Plan proposes three major work efforts: 1) flushing the lake with relatively clean Columbia River water, 2) dredging the lake to provide for increased recreational usage, and 3) control of pollution entering the lake from non-point sources. Each of these major work elements is described below and illustrated on Figure 12 - Dredging and Spoils Disposal Areas.

1. Flushing Channel: The flushing channel would extend from Columbia River at Blurock Landing to Lower River Road, adjacent to the lake. A culvert system would extend the flushing channel below the highway corridor and would discharge into the lake through four 96" diameter culverts. The culverts would be equipped with sluice gates on the Columbia River side and with flap gates on the lake side. The flap gates would prevent reverse flow out of the lake through the culverts. The sluice gates could, if necessary, be used to prevent inflow into the lake during periods of high turbidity in the river, to isolate the lake from migrating salmonids, and for lake maintenance. An unlined channel with the bottom width of 50 feet at elevation -8MSL and 3:1 (horizontal to vertical) side slopes is recommended in the Master Plan (79).

2. Dredging of Lake Bottom Sediments: Figure 12 defines the areas within the lake which are expected to be dredged and the depths to which dredging would occur. Three purposes are expected to be achieved through selective dredging of the lake: 1) enhancement of lake flushing by creating channels on the east and west banks to aid in circulation and provide a short circuit for the nutrient rich Burnt Bridge Creek water, 2) removal of nutrient rich bottom sediments which may be providing phosphorus in quantities sufficient to promote or assist algal growth, and 3) deepening of the lake to allow increased recreational activity. The configuration of the proposed dredging includes a channel along the west shore to bring Columbia River water past the county park, an east channel to direct the flow from Burnt Bridge Creek out Lake River, a boating (sailing) basin in the south central portion of the lake, sediment basins at the flushing channel at the outlet and Lake River entrance, and a substantial undredged area in the north central portion of the lake and near most shorelines where the flats or sloughs are major spawning areas. The Master Plan states that this pattern of dredging will result in better water quality and more recreational potential than the same amount of dredging spread evenly over the entire lake (80).

Various levels of dredging have been proposed within the Master Plan. Total dredging evaluated in the study plan was 15.4 million cubic yards. However, the Master Plan concludes that reducing all dredged depths by one foot would decrease the total dredging to 12.9 million cubic yards with little effect on the recreation potential of the lake. The Master Plan states that approximately one-half of the above dredging is for development of the sailing area, which although it may provide the greatest


12 DREDGING AND SPOILS DISPOSAL PLAN
LEGEND
SPOILS DISPOSAL AREA
NO DREDGING
DREDGING TO -1
DREDGING TO -3
DREDGING TO -4
DREDGING TO -5
DREDGING TO -8
FLUSHING CHANNEL
Shillapoo Lake
VANCOUVER LAKE
1
2
3
4
5
6
7
Tidal Flat
Vancouver Junction
Gas Terminal
ALUMINUM PLANT
Mathews Point
COLUMBIA RIVER
SALMON
Caterpillar Island
Knapp
1"=2000'
VANCOUVER LAKE REHABILITATION EIS WILSEY & HAM

benefit in economic terms, is the least critical for achievement for a clean lake. The Master Plan indicates that only about 20 percent of the sailing area dredging is actually critical to achieve good water quality in the lake. This would reduce the above figures to 9.6 and 8.1 million cubic yards, respectively. The 8.1 million cubic yards is believed to be the minimum dredging that would be required to provide acceptable water quality (81).

The Master Plan for Vancouver Lake rehabilitation also outlines a program for lake maintenance. Columbia River flushing water and the continued flow of Lake River and Burnt Bridge Creek would continue to transport sediment into Vancouver Lake. The dredge plan includes zones specifically designed to collect these sediments and it is estimated that approximately 50,000 cubic yards of sediment would be deposited in the lake each year. In addition, annual maintenance dredging of between 3,000 and 6,000 cubic yards of material would be required within the flushing channel itself.

In order to remove the bottom sediments from Vancouver Lake, adequate sites for the disposal of those materials must be found. The Master Plan for Rehabilitation of Vancouver Lake identifies the potential dredge sites delineated in Figure 12. Since the availability of disposal sites has not been finally settled, the Master Plan found it necessary to identify more potential fill areas than would be ultimately required (82). Table 14 presents the possible fill areas and volume in each of those sites for alternative fill elevations ranging from 20 feet above MSL to 32 feet above MSL. If all of these sites were used, there would be more than sufficient capacity to implement the 15.5 million cubic yard dredging plan without filling any site above the 20 foot elevation. Since the availability of these sites is not yet known, the Master Plan proposes that the following criteria be utilized to guide the ultimate selection of the disposal areas and fill elevations:

A. "Proximity of disposal area to dredged site,
B. Suitability of dredged material for intended future use of site,
C. Irreversible commitment of resources due to filling, e.g., loss of wetlands or prime agricultural lands,
D. Potential damage to fish or wildlife habitat,
E. Suitability of on-site material for dike construction,
F. Potential damage to archaeological sites,
G. Potential disturbance to existing structures, and
H. Potential ground water pollution (83)."

It should be noted that each of the above criteria emphasizes a different set of values, whether it be engineering feasibility, future land use, cost considerations or environmental protection. Selection of the specific disposal areas may require that trade-offs be made between those varying sets of values.

The following paragraphs basically describe each of the potential fill areas based on information provided by the Regional Planning Council of Clark County.

Site 1 Northwest Shoreline West of Buckmire Slough: This 65 acre tract includes pasture land and vacant highway right-of-way. Compared to other pasture land in the lowlands, this area is not highly productive. In addition, it does not receive significant wildlife use. The site is well located for use for the west channel and Lake River sediment trap dredging.

Site 2 Northern Undeveloped Portion of Vancouver Lake Park: This 47 acre site is now used for pasture but is designed for future group picnic facilities and playfields in the proposed Vancouver Lake Park Plan. It is within normal pumping range for the west channel dredging.

Site 3 West Central Area West of Lower River Road to Buckmire Slough This 71 acre tract is owned by Alcoa and zoned for heavy industry, although it is presently used for pasture and has numerous low lying areas. The Vancouver Lake Land Use Plan calls for agricultural use, but with possible conversion to heavy industry if conflict with surrounding land uses can be mitigated. The Regional Planning Council recommended use of this site for filling based on two considerations: 1) the narrow site is located adjacent to Vancouver Lake Park and thus would be difficult to develop for heavy industry without adversely affecting the park and, 2) since it is not among the most productive pasture areas, it was thought that the temporary loss of productivity might not be unacceptable to the owner. The site is well situated for use in conjunction with dredging both the west channel and the flushing channel sediment trap.

Site 4 Southwest Area West of Lower River Road: This 33 acre strip is characterized by two low lying areas which provide water fowl habitat. There is little existing agricultural use. The area is zoned for heavy industry and Alcoa, the present owner, may be unwilling to allow non-structural fill. Without booster pumps, the site could be used only for dredging the flushing channel sediment trap.

Site 5 Southwest Embayment and Shoreline: The southwest embayment is very shallow -- one foot or less most of the year. It is a spiney ray spawning area, but provides no bank fishing access. The embayment is surrounded by a county park and would be filled to create an addition to the park. It is intended to create a rolling landscape with native plant materials and to encourage only limited access, thus essentially allowing the area to grow wild again with the few nature trails and view points. The upland area includes a willow swamp, grassy marsh and open meadow. The Regional Planning Council recognizes the wildlife habitat provided at this site, but believes that use of the site would allow other more valuable fish and wildlife areas to be preserved or enhanced.

TABLE 14

CHARACTERISTICS OF POTENTIAL DISPOSAL AREAS

Site Designation	Description	Area (acres)	Volume in Cubic Yards When Filled to Elevation (MSC)			
			+20	+25	+30	+32
1	Northwest Shoreline West of Buckmire Slough	65	350,000	900,000	1,400,000	1,650,000
2	West-Central Shoreline East of Lower River Road	47	300,000	700,000	1,000,000	1,100,000
3	West-Central Area West of Lower River Road	71	500,000	1,100,000	1,700,000	2,000,000
4	Southwest Area West of Lower River Road	33	300,000	450,000	700,000	800,000
5a	Southwest Embayment (Surface Elevation below +6)	65	1,650,000	2,200,000	2,750,000	2,950,000
5b	Southwest Shoreline (Above Elevation +6)	83	1,350,000	2,050,000	2,750,000	3,050,000
6	South Shoreline	650	8,100,000	13,350,000	19,000,000	20,800,000
7	Northeast Shoreline	112	3,200,000	4,100,000	5,000,000	5,200,000

Note: Areas and volumes are approximate

Site 6 South Shoreline: This 650 acre area is made up of productive wetlands and farmlands, State Game Department land, low lying sink holes, and a few vacant fields near the lake. The lakeward boundary of the area conforms to the line adopted by the Clark County Commissioners for a proposed dike presently being considered by the Corps of Engineers. The Vancouver Lake Land Use Plan designates agriculture and open space as the future use for this area. The provision of flood improvement dikes along this area is closely tied to the use of the area for spoils disposal. If flood protection is not provided, the property owners may decide not to make any land available for fill.

Site 7 East Shoreline of the Lake: This area of 112 acres would provide for deposition of up to 5 million cubic yards of dredged material and would open up a major portion of the east side of the lake to public access. It would connect the Burnt Bridge Creek and Salmon Creek Greenways thus providing fishing access to this entire shoreline (84).

3. Non-Point Source Pollution Control Measures: As discussed previously, the 208 Program currently being prepared by the Regional Planning Council of Clark County is aimed at reducing the flow of non-point source pollution from the drainage basin into Vancouver Lake. The major interceptors serving the Burnt Bridge Creek drainage area have been constructed and collectors are now being built to serve individual neighborhoods. The Regional Planning Council has proposed the establishment of a drainage district to control the storm runoff generated in the drainage basin, including a diversion of "first flush" storm water to sanitary sewers. In addition, efforts to control erosion, septic tanks, construction erosion and agricultural runoff have also been proposed for adoption.

Although construction of improvements to Vancouver Lake Park are not part of the proposed project, completion of lake rehabilitation would serve as the impetus to begin those park improvements. Because of the close tie between the proposed lake rehabilitation and the proposed park development, the park will be evaluated as a secondary impact of the proposed program. Specific park programs are discussed in Section II and outlined on Figure 11.

Cost Estimates

The grant application submitted by the project sponsor (Port of Vancouver) in April 1976, estimated the cost of the project to be $8,278,000. Of that total, federal participation represented some $4,139,000. Since that time, however, completion of the pilot dredge study and the Master Plan for the Rehabilitation of Vancouver Lake have altered the projected costs. Estimates made in the Pilot Dredge Study indicate that dredging and disposal of lake bottom sediments is expected to cost about $1.25 per cubic yard. Thus, the total cost of the project would vary greatly depending upon the amount of material to be dredged. The Port of Vancouver is currently exploring a variety of dredging options in order to minimize those costs. The following cost estimates are taken from the Master Plan and reflect estimates prepared in May, 1977. The estimate does not include the cost of engineering, administration, legal services and contingencies. Land acquisition costs and costs associated with park improvements or vegetative cover of dredged material have also not been included.

Dredging and Dike Construction for removal of 8,100,000 cubic yards of sediment -	$ 10,400,000
Dredging and Dike Construction for removal of 15,400,000 cubic yards of sediment -	$ 19,500,000
Flushing Channel Construction	430,000
Culvert Construction	520,000
TOTAL	$ 11,350,000 --$ 20,450,000

The Port of Vancouver and Regional Planning Council of Clark County have proposed the above package of work elements in order to restore Vancouver Lake to public use by improving its water quality. The proposal presented by these two agencies requires dredging of approximately 12-15 million cubic yards of lake bottom sediments. The entire package of aquatic improvments, including dredging of 12-15 million cubic yards of material, are included within Alternative 2A and represent the project sponsor's proposed project. The impacts discussion included within Alternative 2A will evaluate the total package of proposed improvements.

In order to fully evaluate the proposed project, the Environmental Protection Agency selected two alternatives which would affect the scale of the entire development. Alternative 2B will evaluate the dredging of 8-10 million cubic yards of material, while Alternative 2C will evaluate the dredging of under 6 million cubic yards. Other project features will remain the same for each of these alternatives; therefore, the effects discussion will be limited to the impacts of decreasing the quantity of material to be dredged and disposed.

ALTERNATIVE 2A - DREDGING OF 12-15 MILLION CUBIC YARDS

Alternative 2A represents the dredging of 12-15 million cubic yards of bottom sediments from Vancouver Lake. This is the amount of dredging that would provide for the sailing course while maximizing water quality benefits. The remainder of the project features are as discussed in the previous pages. The effects of this alternative are discussed below.

Air Quality

Short Term

The air effluents created by the dredging machinery would have a negligible effect on the Vancouver Lake airshed. No significant adverse impacts are anticipated; however, specific projections cannot be made until the machinery and methods to be used have been identified.

Long Term

Secondary impacts would occur primarily due to an increase in vehicular traffic around the lake. The dredging of the lake would significantly increase the recreational use of the lake, particularly for sailboating and swimming, thus bringing more vehicles into the area. However, projected increases in vehicular traffic are not expected to significantly decrease current air quality conditions. Industrial development in Clark County, specifically as it affects particulate levels, will be closely monitored by the Southwest Air Pollution Control Authority. Guidelines have been adopted by that body which will require that any new industrial developments be thoroughly analyzed to determine their short and long term effects on the regional airshed.

Topography

The disposal of dredged materials would alter present topographic conditions along the lake shore. Proposed disposal sites may experience an elevation increase of from 10 feet to 22 feet. The maximum total increase proposed would bring the Mean Sea Level elevation up to 32 feet, from a present 20 feet. This change in topography may have effects on certain upland vegetation types, but any such effects are expected to be negligible.

The configuration of the lake bottom would be that portrayed in Figure 12 if the study plan of 15.4 million cubic yards were to be dredged. Configuration for 12 million cubic yards would be depths lessened by one foot throughout the lake bed. The differential configuration described in the previous section would be maintained to assist with the flushing characteristics.

Construction of the proposed flushing channel would create a 4,300 foot long, 15 foot deep and 100 foot wide channel through presently level ground. In addition a 100 foot wide cross dike would extend outward from the inland portions of these channels. Although the construction of the flushing channel would change the land configuration, no adverse impacts would be expected.

The Clark County Park and Recreation Department hopes to use some of the dredged materials to create topographical variety within the proposed park areas, providing a range of park and recreation experiences and vistas.

Soils

Short Term

Soils would be affected when they are either removed, or covered over by land disposal activity. The dredged materials would take up to a year to dewater and settle, thus making the dispoal sites unusable during that time period. The structure of the underlying soils would be sufficient to handle the disposal materials and local soils could be used for diking purposes for disposal cells. If existing soils were not removed (particularly the top 4 to 6 inches of organics), good top soil would be permanently lost. If they were removed from the site, either for relocation or eventual return to the site, the impact would be temporary.

Long Term

The long term effects that may occur at the disposal sites would depend upon the re-use of the lake soils. Lake soils are of a substandard quality, both for building purposes and agricultural purposes. The physical and chemical characteristics of the lake soils must be enhanced and properly managed before the soil characteristics could attain existing dry land soil conditions. If the lake soils were placed on the land and were not conditioned and enhanced, the soil would experience shifting and settling, and could not support traffic or a diverse vegetation for a few years. If the soil were conditioned to attain uniform dewatering, settling, and compaction, the site could be developed for vehicular and certain structural functions. The re-use of the soils for agricultural purposes would require enhancement with fertilizers and other amendments.

Revegetation of disposal sites as soon as is practicable would alleviate any long-term increase in erosion potential.

Hydrology and Flood Hazard

The implementation of Alternative 2A would result in significant changes in the hydrology of Vancouver Lake, through the combination of dredging to change the lake circulation patterns and construction of the flushing channel to allow an inflow of Columbia River water.

During low flow periods the flushing channel would introduce approximately 500 cfs into Vancouver Lake from Columbia River. The flushing flow would be one-directional into the lake since the flap gates would prevent reverse flow back into Columbia River. During the summer, Lake River would continue to flow in both directions, although the flow to the north would be increased by about 35 percent. The circulation model prepared by Dames and Moore in the Master Plan indicates that during the summer a tidal amplitude of approximately 0.7 foot would occur in the lake. Although this variation is several times the present amplitude, it is still quite low. In it's present state, Vancouver Lake responds to elevation changes in Lake River. With the flushing connection, lake levels would also be influenced by the Columbia River at River Mile 101, resulting in a slight increase in water elevation (0.2 to 0.3 foot) (85).

During low water nonsteady-state periods, the existing flow in Lake River is two-directional with approximately the same flow rate in each direction. The introduction of flushing flow would reduce the southerly flow of Lake River and increase the northerly flow. The decrease in the level of inflow is expected to be about 65 percent of the preflushing flow, while the increase in the outflow is expected to be 140 percent of the preflushing flow.

During high flow periods in Columbia River, the flow in Lake River would be essentially one-directional to the north. At the southern extreme, the rate of flow would be essentially the same as the flushing channel inflow. During high flow periods, the average water level in the lake would be increased about 0.5 foot over present levels, while during low flow periods it would be increased about 0.2 foot (86).

In the past, rapid flooding in the Columbia River has resulted in southward progressing flood surges in Lake River. The construction of the flushing channel should lessen the impact of this surge due to the northward progressing flow through the flushing system (87).

The circulation and velocity model cited in the Master Plan for the Rehabilitation of Vancouver Lake indicates that the proposed dredging plan would result in increased water circulation throughout the lake. Of primary importance is the flushing action that would increase the flow along the park beach, placing Columbia River water in close proximity to the shoreline, and the channel along the east shoreline which will divert Burnt Bridge Creek water directly to Lake River.

The 500-700 cfs flushed from Columbia River through Vancouver Lake represents approximately .3 percent of the average Columbia River flow.

Private property owners around the lake have encouraged the Corps of Engineers to proceed with the proposed diking improvements in order to remove additional lands from the floodplain. Agricultural lands may be available for placement of dredged materials if diking and flood control is provided. Specific placement of the proposed dikes has not yet been established, awaiting the outcome of EPA's on-going Wetlands Classification Study.

The proposed project is not expected to have any effects on the downstream floodplains of Columbia River and Lake River. During extensive flooding conditions, the flow from Columbia River into Vancouver Lake can be controlled so as not to increase the flow in Lake River above existing flood levels.

Since the Corps of Engineers has not mapped the Vancouver Lake floodplain, it is not currently possible to assess the effects of future lake flooding on the disposal sites or the future recreation facilities. Dikes surrounding the disposal sites would be built to sufficient height to provide the necessary flood protection.

Water Quality

A variety of techniques have been employed to improve water quality in lakes. Nutrient removal or diversion, dredging or flushing have sometimes proven effective in reducing algal growth and associated water quality problems (88). In the case of Vancouver Lake, three separate alterations in the lake and its drainage basin are included within the proposed lake rehabilitation program.

1. Land use patterns and sewage handling practices are expected to change, which will have an impact on the quality of water and the amounts of algal nutrients and other contaminants transported into the lake.

2. The proposed dredging program would increase the mean depth of the lake and might alter the character of the sediments at the sediment-water interface.

3. The proposed diversion of Columbia River water would alter the residence time and circulation pattern of water in the lake, and would change the concentration of algal nutrients in the lake.

Each of these modifications is considered separately in the following discussion, and finally all are considered simultaneously (since there is some interaction among them) in an attempt to anticipate their potential impact on water quality. It is not possible to predict precisely what the consequences of each of these actions might be. However, the application of selected theoretical models and comparisons with other lakes, makes it reasonable to predict the general pattern of response to be expected.

208 Wastewater Management Program

The water quality of Vancouver Lake is directly influenced by the pattern of land use in its drainage basin. Extensive urbanization in the Burnt Bridge Creek drainage basin has led to the creek transporting increasingly greater amounts of sediment, algal nutrients, and other materials into Vancouver Lake, In addition, agricultural use of land around the lake also produces sediment and algal nutrients which are transported to the lake.

The goal of the proposed 208 program in Burnt Bridge Creek is to bring the water quality within the accepted state and federal water quality standards. In order to achieve this, a variety of management and land use control techniques have been proposed. Studies prepared during the 208 program indicated high phosphorus, septic tank intrusion and heavy metal levels reached the stream due to surface storm runoff (89). In response to that, the 208 Program proposes that the "first flush" storm runoff should be diverted to the sanitary sewer system to alleviate that source of stream contamination. In addition, a variety of land use, septic tank, construction and erosion control measures have been proposed to further assist in the attainment of existing state and federal water quality standards. Until the proposed Burnt Bridge Creek Drainage Management Plan has been implemented, the specific increases in water quality levels cannot be evaluated. It is doubtful, however, that the proposed measures will totally eliminate the deleterious effects of urban runoff on water quality in Vancouver Lake. For that reason, proposed circulation within the lake has been designed to move Burnt Bridge Creek water directly to Lake River, allowing it only marginal contact with the remaining water in the lake.

It is expected that implementation of the Burnt Bridge Creek Drainage Management Plan, and the yet to be completed non-point source control measures, will result in a decrease in the level of nutrients reaching Vancouver Lake from those sources. Whether these nutrient sources will be too low to support further algal growth is unknown.

Dredging and Removal of Bottom Sediments

Dredging would increase the mean depth of the lake and should improve the character of the sediments exposed at the sediment-water interface. The increase in mean depth resulting from dredging would be less than three feet; however, the depth would not be uniform throughout the lake. This increase in mean depth would reduce the tendency for wave action to resuspend bottom sediment. At times, Vancouver Lake is noticeably discolored by fine turbidity, probably largely derived from resuspended fine sediment. Since wave induced turbulence declines exponentially with depth, the proposed dredging may cause a considerable reduction in the resuspension of sediment (90).

An increase in mean depth would also reduce the average amount of light available for algal growth throughout the water column. However, it is very doubtful that an increase in mean depth of less than three feet could have a significant impact on algal growth. The lake would still be very shallow, and in addition, any decrease in turbidity would increase light availability.

Deepening the lake should, to some extent, alter the character of the sediment exposed at the sediment-water interface. Sediment can, in some instances, provide a source of nutrients to the overlying water, and the leakage of phosphorus from the sediment can be considerable in shallow lakes (91). However, it does not appear that the nutrient supply in Vancouver Lake sediment is particularly high. The sediment is described as blue or grey clay, silt and sand and, at least for agricultural purposes, low in nitrogen and very low in phosphorus (92).

There is some evidence, however, that at least the surface layer of sediment currently supports algal growth (93). Removing this surface layer could reduce the availability of nutrients from the sediment. Nonetheless, supplies of nutrients already in the water from the drainage basin are more than adequate to support algal blooms, so that removing sediment bound nutrients could have little impact. In addition, the soil exploration program carried out during the preparation of the Master Plan indicated that while the upper few inches of sediment "do generally contain higher levels of nutrients than lower sediments, there is little variability in nutrient levels below the upper active layer, and the levels of nutrients in the lower zone are still significant (94)". The Master Plan goes on to conclude that "because the levels of nutrients in the underlying sediments are significant and because the flushing water itself is expected to contain substantial amounts of nutrients, it is our opinion that dredging only to remove the interface soil would be of little lasting water quality benefit (95)." Based on that conclusion the Master Plan presented a dredging plan designed to improve lake circulation and to maximize recreational use of the lake.

There have been very few studies of the effectiveness of dredging on water quality in lakes, although there is some evidence that dredging can improve water quality in certain instances (96). However, the lack of any extensive literature and the lack of sufficient data on Vancouver Lake make it impossible to anticipate precisely what the impact of dredging Vancouver Lake might be.

The Pilot Dredge Study and Master Plan for Rehabilitation of Vancouver Lake evaluated the short-term effects of dredging on the water quality in Vancouver Lake. The following discussion is based on the findings presented in those reports (97). Dredging may affect surface water quality at the point of excavation and in the area were discharge from the disposal site returns to the lake. Generally, only minor effects limited to short-term increased turbidity, occur at the dredge head. A monitoring program was carried out during the pilot dredging of Vancouver Lake to determine the effects of dredging discharge on the lake. Mercury was found to occur in significant quantities (0.6-1.1 ug/L) in the dredge disposal effluent. Subsequent bioassays of specimen fish, including bottom feeders found very little incorporation of mercury, however. The mercury would probably settle to the lake bottom within a relatively short radius of the effluent discharge from the retention point (98).

Zinc and copper were also detected in significant quantities in the disposal pond effluent; however, subsequent fish specimen bioassays indicated that the residues of these metals were comparable to or less than concentrations found in a limited sampling of the same species from other parts of the country. Like mercury, zinc and copper are expected to absorb onto particulate matter in the disposal pond effluent to a great extent, hence settling within a short distance of the discharge (99).

Diversion of Columbia River Water Into Vancouver Lake

Diversion of Columbia River into Vancouver Lake could be expected to significantly alter the limnological conditions of the lake. The mineral composition of the lake could be expected to improve and to closely resemble Columbia River water, since the volume of flow being considered for flushing (600 cfs) would greatly exceed the present flow through the lake (approximately 50 cfs from a combination of stream flow, groundwater flow and precipitation.) Flushing water introduced from Columbia River would tend to deposit coarser sediments as the flow entered Vancouver Lake. As a consequence the proposed sediment traps located at the inlet of the flushing channel to the lake would gradually become shallower. Analysis by Dames and Moore indicated that about 35,000 cubic yards of suspended sediment would enter the lake annually. They further estimated that this sediment would accumulate in the sediment trap to a thickness of about 2 feet within ten years. This rate of sediment accumulation could be reduced by excluding flushing water from the lake during periods of high sediment content in Columbia River (100).

The benefits of flushing in reducing the tendency for a lake to become excessively eutrophic or to produce excessive algal growth stem from two separate influences. First, if the water used to dilute a lake is low in nutrients, the concentration of nutrients will be lowered, which can lead directly to reduced algal growth rates (101). Second, if the flushing rate is great enough, algae may simply be so rapidly washed out that they are unable to develop significant populations (102).

The diversion of Columbia River water into Vancouver Lake can assist in reducing, to some extent, eutrophic conditions in the lake. Nutrient dilution has been shown to be an effective technique for Green Lake, Seattle, Washington and to be of some benefit for Moses Lake, Washington, where Columbia River was used as dilution water (103). However, the Columbia River at Vancouver, Washington, at times carries relatively high concentrations of algal nutrients (78 ug P/l for average total phosphorus, and 254 g NO_3-N and 70 ug NH_3-N/l average nitrate and ammonia nitrogen). These amounts of nutrients are sufficient to promote rapid algal growth. Any nitrogen and phosphorus derived from the drainage basin or bottom sediment would only add to the nutrient supply. The Control Plan for the basin will work towards minimizing these supplies.

As shown in Table 15 the nutrient content of Columbia River varies seasonally, thus flow into the lake could be regulated to minimize the entry of sediment into Vancouver Lake. The total phosphorus category is the most relevant to this analysis since it is the most widely used measure of nutrient enrichment. Recent sources have stated that it is therefore more relevant to the question of increasing algal productivity to view the phosphorus concentrations in terms of total phosphorus, since most of the phosphorus is bound in the particulate components at any given time (104)." The majority of the recent models also use total phosphorus as the major nutrient indicator. Although nitrogen levels can also be used as an indication of potential algal productivity, significant nitrogen-fixing algae currently exist in Vancouver Lake indicating that the presence of high levels of nitrogen are not necesseary for algal production.

TABLE 15
Columbia River Nutrient Content

	Nitrogen	mg/l Ortho Phosphate	Total Phosphorus
At Bonneville (above Vancouver)			
May - October	0.080	0.029	0.074
Nov. - April	0.363	0.034	0.084
At Longview Bridge (below Vancouver)			
May - October	0.163	0.011	0.122
Nov. - April	0.530	0.060	0.417

Control of algal growth conditions by displacement would require very high rates of dilution. Algal growth rates can easily exceed one doubling every two days; therefore, control of algal growth by washout is effective only when the entire volume of a lake is replaced in two or three days (105).

It would require a flushing flow in excess of 1500 cfs to replace the entire volume of Vancouver Lake in three days at minimum lake volume (mean depth of four feet).

It has been suggested that diversion of Columbia River water into Vancouver Lake would drastically reduce algal growth in the lake (106). Since the Columbia River supports a considerable population of algae, such a prediction is questionable (107). In addition, algal growth in Columbia River is believed to be largely determined by light availability (108). The much shallower depth of Vancouver Lake would prevent the light limitation evident in the Columbia River, and it is expected that algal production within the lake would continue.

Combined Effects of Dredging & Diversion of Columbia River Water

Since 1966 a variety of studies have been performed to determine the most feasible method to clean up Vancouver Lake and make it available for public use and enjoyment. The first full scale study was prepared by the College of Engineering Research at Washington State University and recommended three major steps to restore lake water quality: 1) control of pollution entering the lake, 2) dredging of the lake to remove nutrient rich bottom sediments and increase recreational potential, and 3) introduce flushing flow of Columbia River water into the lake. A subsequent study prepared by Stevens, Thompson and Runyan further refined these recommendations and suggested that dredging the lake could also serve to enhance circulation within the lake (109). The most recent study, Master Plan for the Rehabilitation of Vancouver Lake was recently completed by Dames and Moore. This report suggests that the same three steps be taken to enhance lake water quality, but that the major purpose of dredging be to allow more extensive recreational use and to improve water circulation within the lake (110).

None of these reports suggests that the combined restoration efforts would convert Vancouver Lake into a pristine, clear body of water, but they all project that the water quality within the lake would be improved to the extent that increased recreational use would be possible.

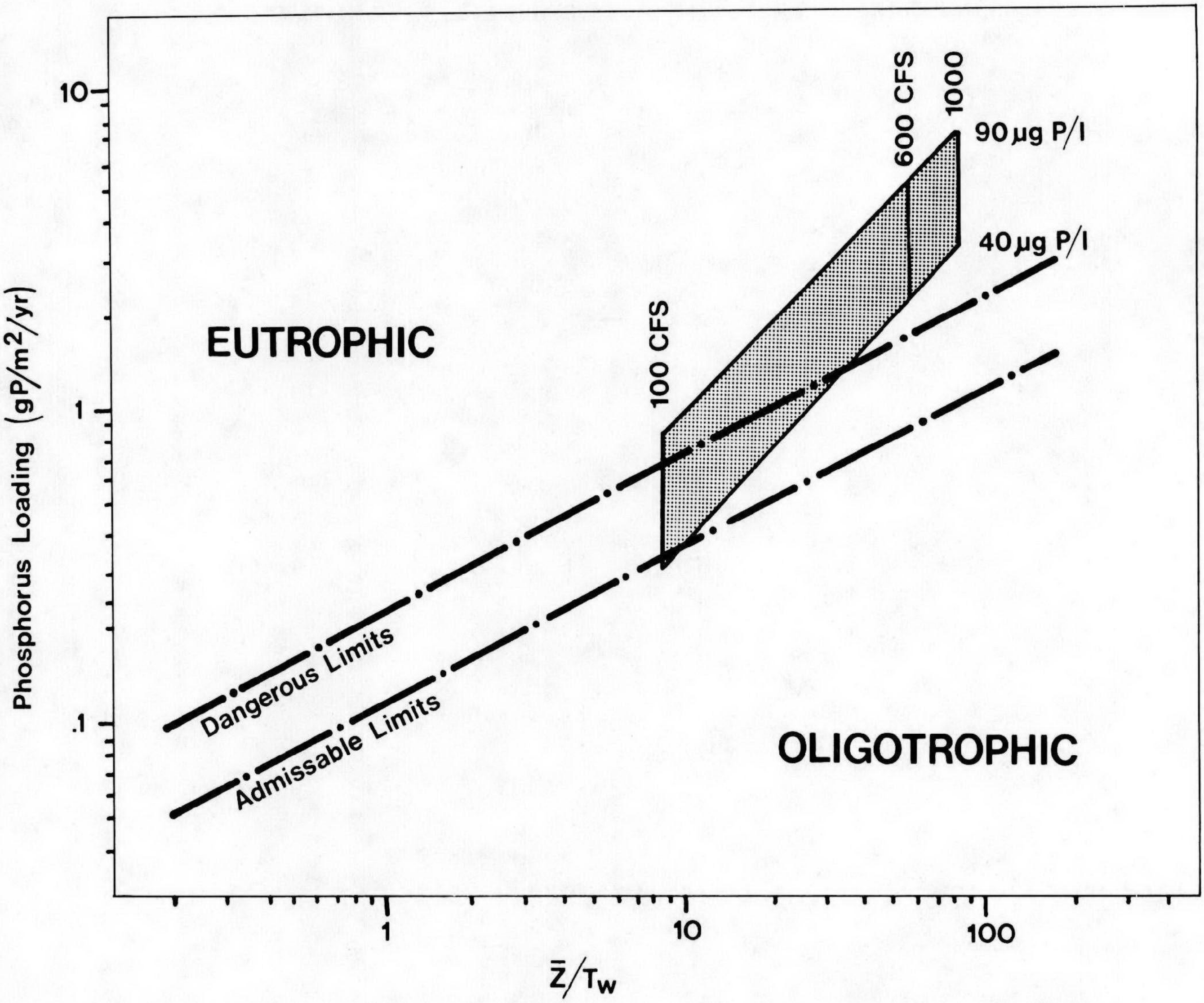
Dredging Vancouver Lake would increase both the mean depth of the lake, and the hydraulic residence time. Diversion of Columbia River water into the lake via the proposed channel would, in turn, decrease the hydraulic residence time and introduce additional supplies of algal nutrients, although at substantially lower concentrations. All of these alternatives can be considered simultaneously using the "Nutrient Loading Concept" developed by R. A. Vollenweider and his co-workers (111). In developing the parameters of this model, a range of conditions are considered in order to assess the predicted impact of a variety of alternative procedures. These alternatives are outlined in the following Tables 16 and 17 and then presented graphically in Figure 13 to compare with Vollenweider's model.

TABLE 16

PHOSPHORUS LOADING FROM COLUMBIA RIVER

	Added Flow from Columbia River	Phosphorus Loading (gP/m^2/yr)
Assumed phosphorus concentration in inflow of 40 ug P/L*	100 cfs	0.339
	600 cfs	2.035
	1,000 cfs	3.395
Assumed phosphorus concentration in inflow of 90 ug P/L*	100 cfs	0.764
	600 cfs	4.578
	1,000 cfs	7.640

*Representative values for high and low concentrations of phosphorus observed in Columbia River (Beak 1977).



13 Annual Phosphorus Loading to Vancouver Lake using Columbia River water for flushing at various rates. (Adapted from Vollenweider and Dillon 1974).

TABLE 17

RELATIONSHIP OF MEAN DEPTH AND RESIDENCE TIME

	Added Flow From Columbia River (cfs)	Residence Time (Year)	Depth/Residence Time
Mean Depth Before Dredging 1 Meter	100	0.118	8.5
	600	0.0193	51.8
	1,000	0.0118	85.5
Mean Depth After Dredging 3 Meters	100	0.353	8.5
	600	0.0589	50.9
	1,000	0.0353	84.8

Volume at one meter depth = 1.052×10^7 m^3

Volume at three meter depth = 3.156×10^7 m^3

The results of these calculations are presented in Figure 13, which includes lines indicating admissible and dangerous levels of phosphorus loading. The shaded area in the figure represents the expected status of the lake due to nutrient loading from the proposed addition of Columbia River water alone. It is clear from this graph that the greater the addition of Columbia River water, the more eutrophic the lake may be expected to become. When existing sources of phosphorus loading (from the existing drainage basin and from sediment in the lake) are included in the nutrient budget, the Vollenweider model predicts that Vancouver Lake would remain a eutrophic lake, with or without dredging, and with or without the addition of flushing water.

The pattern of dredging and the position of the proposed flushing channel are designed to promote "short circuiting" of the flow from Burnt Bridge Creek directly to the outflow, Lake River, and also to provide a flushing current of Columbia River water along the swimming beach at the park. This flow pattern would help reduce bacteria populations in the rest of the lake and provide the cleanest possible water along the swimming beach. The Master Plan indicates, however, that in order to increase water quality to the level required for water contact sports, it may be necessary to provide a supply of cleaner water (preferably from a groundwater source) along the swimming beach (112). The reduced residence time of water in the lake could prevent the accumulation of a large standing population of algal. Since the inflowing Columbia River water would be somewhat cooler, it would tend to flow into the lake on the bottom and could displace or prevent major surface accumulations of algae out of the lake. Thus, although nutrient supplies would support rapid algal growth, the additional flow could reduce any deleterious impacts.

Vancouver Lake can be expected to remain a eutrophic body of water after dredging and with the addition of Columbia River water because there would be a sufficient supply of nutrients, sufficient residence time (15-20 days) and sufficient light availability to ensure significant algal production. However, the shorter residence time of water in the lake would reduce the tendancy for large standing crops of algae to develop. Although the lake would still be considered eutrophic (30-100 ug P/l), the proposed restoration procedures would halt its movement towards a hypereutrophic condition (in excess of 100 ug P/l). As Columbia River water quality is improved and nutrient sources from the watershed are eliminated, the nutrient levels are expected to continue to decline.

It is important to note that neither eutrophic conditions, nor the presence of algae render a lake unusable for recreation purposes. In fact, many of the most widely used recreational lakes in both Washington and Oregon are characterized by both conditions.

The State of Washington has not established specific standards of coliform levels for water contact recreation. However, within the State's Lake classification total coliform levels are not to exceed 240/100 ml with 20 percent not to be greater than 1,000/100 ml if fecal coliform is present (113). Present conditions in Vancouver Lake indicate that maximum coliform levels approximate 100,000/100 ml total coliform, while 10-40 percent of the total coliforms are fecal coliforms. The coliform bacteria counts in the Columbia River, while far better than the existing conditions in Vancouver Lake, sometimes approach marginal levels for water contact recreation (mean is 2,600-1,000/100 ml) (114). On the basis of those estimates, the <u>Master Plan for Rehabilitation of Vancouver Lake</u> recommends that water quality in the vicinity of the swimming beach be enhanced during swimming season by the discharge of ground water to the swimming area (115). The Master Plan estimates that a single well with a capacity of about 1,000 gallons per minute (gpm) could be used to pump water to the surface where it could be directed to two discharge points along the beach. "The flow of well water would act both to dilute and displace the lake water. Since the well water should have very low concentrations of coliform bacteria, it should significantly increase the quality of water at the beach (116)." Water quality and coliform levels along the beach would be monitored and groundwater would be diverted to the beach as necessary.

Fisheries

Short Term

The construction of the flushing channel would cause considerable turbidity both at Columbia River and Vancouver Lake. The increased turbidity could adversely affect Columbia River fish runs and nearby downstream fishing. However, these effects would be temporary and the extent of the impacts would be dependent upon the time of year of the construction activities. Maintenance dredging of the flushing channel sediment trap within the lake would be required every 10 years (117). No estimates have been prepared for maintenance dredging within the flushing channel itself.

In-lake impacts would occur where the dredging takes place (at the pipeline head) and at certain disposal sites. The effects of the actual dredging are expected to be slight, although the spread of turbidity would be greatly affected by specific wind and current conditions. The disposal of dredged materials in Mulligan Slough, the south embayment and along the northeast shore would have adverse impacts upon the fisheries. Disposal in these areas would destroy feeding and spawning areas. If disposal in wetland areas of Mulligan Slough occurred in spring or early summer, it would destroy considerable numbers of fish.

Return waters from the dewatering process would have a short term impact on the lake fish, but this is expected to be minimal. Removal of the lake bottom sediments would eliminate certain toxics from the fish environment which should have a favorable impact on local populations.

Washington State University conducted surveys in 1967-68 that involved bottom sampling in various parts of the lake. The benthic organisms collected included Naididae, Chironomid and Nematoma worms. No other epifaunal or infaunal organisms were collected. The most common organisms were worms of the family Naididae which characteristically inhabit shallow and turbulent waters. Dredging would eliminate such organisms from specific areas of the lake during the short-term. Repopulation would be expected.

Columbia River water is expected to warm at the rate of approximately $1^{o}C$. per day upon entering Vancouver Lake. Thus in six days time, the water is expected to warm $6^{o}C$. ($10^{o}F$.). It is anticipated that this warming factor would be sufficient to increase the Columbia River waters to meet the spawning needs of the spiny-rayed fishes in the lake.

Long Term

The flushing channel could permanently alter nearby Columbia River shore contours, which may affect immediate area fisheries. This effect should be minimal, however. The Washington State Department of Fisheries believes that the flushing channel may lure migrating salmonids, which would disrupt their natural migration processes. Juvenile salmonids, if allowed to enter the lake, would probably fall prey to resident spiny-rayed fishes. The Department of Fisheries has indicated that screening of the flushing channel would probably be necessary in order to prevent juvenile salmonids from entering the lake during their fall downstream migration. Screening criteria for water diversions typically require that screen openings should not exceed 1/8 inch in the narrow direction, and approach velocities should not exceed 0.5 feet per second as measured at the gross area of the screen. These screens would be placed at the entrance to the flushing channel, where the Columbia River water entered the channel. The construction of these fish screens would entail considerable engineering design, impacts or costs of which cannot now be determined. The possibility also exists of closing the culvert gates at key times during the salmon runs in order to prevent their entry into the lake.

The deepening of the lake may enhance the over-all fish habitat, increasing the carrying capacity of the lake and diversifying available niches. Where a pilot dredge study hole was dredged in the southwest corner of the lake, it was found that a marked number of lake fishes soon moved into the deeper waters. Deeper waters, thus an increased total environment, may encourage an increase in size of resident fishes.

If the spiny-ray fish population in Vancouver Lake were enhanced due to lake rehabilitation, the Washington State Department of Fisheries believes that an adverse impact upon the salmon fisheries of Lake River could occur (118). During the spring season juvenile salmon migrate down Salmon Creek and through Lake River on their way to the Columbia River. These small fingerlings would be susceptible to predation by larger spiny-ray fishes, primarily bass. An increased spiny-ray population in Vancouver Lake could result in an increased spiny-ray population in Lake River (119).

The placement of dredged materials in Mulligan Slough or its surrounding wetland areas, would have a significant adverse impact on the lake fisheries. Disposal in these areas would permanently destroy the most important spawning areas of the entire lake. There are few areas in Vancouver Lake, Lake River, or Burnt Bridge Creek that have comparable conditions, and none offer so large an area. The specific role played by Mulligan Slough will be more evident after completion of the on-going wetlands inventory.

Vegetation and Wildlife

Short Term

Alternative 2A would have varying effects on the local vegetation and wildlife. The construction of the flushing channel would destroy vegetation and habitat, but should not cause significant losses. The channel would primarily cut through pastureland and open areas. Vegetation loss would be minimal, and though some mammals would be lost, most of them could easily relocate.

The dredging of the lake should cause minimal effects on waterfowl, given that dredging activities were not undertaken by several dredges at once. The lake is large enough for visiting waterfowl to stay away from, and thus not be disturbed by, the dredging.

The disposal of dredged materials in Mulligan Slough and other recognized important wildlife areas would cause immediate disturbance to local wildlife species. The destruction of nesting and feeding areas would seriously impact waterfowl and songbirds, as these species would be forced to relocate. Limited nesting areas are available to such waterfowl as woodducks, thus the destruction of any nesting areas could severely impact area populations. Raptors and mammals would be affected by loss of habitat, but relocation would be possible for predator/prey relationships. Most invertebrates in the area would be lost, as would all wetland vegetation communities in the areas of disposal.

Long Term

The flushing channel may affect seasonal mammalian movements in the area, as the channel would present a very real barrier to certain species. The channel would be too great for small mammals to circumvent (mice, squirrels, oppossums, rabbits, skunks, and possibly raccoons). Although deer should be able to swim the flushing channel, its presence would create a barrier restricting their habitat.

The dredging of the lake should cause no significant problems for waterfowl, except that feeding may be restricted for the "dabblers". Since the pond ducks (dabblers) do not diver, they are restricted in the depth of water available to them for feeding purposes. However, the deepening of the lake may prove to be advantageous to the diving ducks, as they prefer deeper waters in which they can actually dive for invertebrates and small fish. Available feeding areas for the great blue heron would be reduced, but adequate feeding would still be present along the entire shoreline of the lake.

Increased recreational use of the lake, particularly in terms of boating, would have an adverse impact on wildlife usage of the lake. Waterfowl and waders would be more constantly disturbed by human activities, thus inhibiting their use of the lake.

The long-term effects of dredged material disposal would be most marked at Mulligan Slough, and on the west side of the lake. The inundation of these areas would permanently destroy wetland habitat, which is important to waterfowl, invertebrates, and certain flora. Nesting areas for wood ducks, teal, and mallards would be lost. Favorable habitat for swallows, warblers, vireos and flycatchers would be destroyed. These losses must be considered significant because similar habitat is rapidly decreasing in the urban regions. The diversity of the regional environment is commensurate with the stability of that environment. (Evaluation of the specific disposal sites is included within Alternative 3.)

Significant Wildlife Areas

Short Term

The construction of the flushing channel would result in short-term adverse effects on the nearby fishing areas of the Columbia River noted on the Significant Wildlife Areas Map, Figure 7. These areas, particularly the site immediately adjacent to the channel area, would experience excessive turbidity. These turbidity problems would occur until construction in the area was completed.

The dredging of the lake would cause some adverse impacts on the lake surface migration activity if dredging occurred during the migration season. As long as several dredges were not working concurrently, the impact should not be significant. The size of the lake should allow for adequate space between waterfowl and dredge to minimize disturbance.

The disposal of dredged materials would cause adverse impacts on certain areas of the lake shore. Mulligan Slough would be affected by the destruction of various invertebrates and some small mammals (shrews, moles, etc.). If disposal took place during the spring or early summer, significant numbers of spiny rayed fish would be destroyed while they were attempting to spawn or rear their young. Nesting songbirds and waterfowl would lose their nests, and the riparian and aquatic vegetation would be destroyed. The disposal of dredged materials in the Buckmire Slough area would also destroy songbird and waterfowl habitat, with the most adverse impacts occurring in the spring and early summer. Some spawning areas may be destroyed in the northern portion of Buckmire Slough.

Long Term

The deepening of the lake may change the migratory use of the lake by waterfowl, but not to a significant extent. Dabblers may do more feeding in the Shillapoo Lake area, because of difficulties in feeding in the deeper lake waters. Divers, on the other hand, may find the deeper waters more favorable.

The disposal of dredged materials in a portion of Mulligan Slough or adjacent wetlands would seriously impact the wildlife characteristics of the area. Spawning, nesting, and feeding for many and various species of vertebrates and invertebrates occurs within these wetland areas annually. The area must be considered the single most important eco-type within the entire project area. It is the most important spiny rayed fish spawning area and has the largest area of relatively undisturbed marshland and wetland. It contains the thickest belts of riparian vegetation, which provide important waterfowl and songbird nesting habitat. Also, the wetland habitat produces vast amounts of mico-flora and micro-fauna that ultimately plays an integral role in the life-processes of the entire lake eco-system. The filling of a portion of this area would destroy an irreplaceable biological resource of the Vancouver Lake environment.

Disposing of dredged materials adjacent to the Buckmire Slough area would destroy wood duck and teal nesting grounds, as well as songbird habitat and fish spawning areas. These areas are fairly heavily used by the wildlife groups because there are not many alternative areas available in the vicinity. The spawning grounds are primarily located in the northern part of Buckmire Slough. The avifauna habitats are shown on the Significant Wildlife Areas map.

Population Growth/Economic Base

The restoration of Vancouver Lake is not projected to have any significant long-term effects upon local population growth. Creation of a more pleasant lake environment could enhance the property values of those residential areas that either view the lake or are within walking distance. However, this would only result in a minor shift of population within the general western portion of Vancouver.

The creation of a widely used recreation facility in close proximity to the City of Vancouver could result in an increase in tourism to the area. Local gas stations, grocery stores and convenience restaurants would benefit from the recreationists visiting the lake during the summer months. The Olympic sailing course could also be expected to draw large numbers of spectators who would frequent local commercial enterprises.

By 1980 it is projected that approximately 1,705,000 recreation occasions would occur annually at Vancouver Lake Park if lake restoration efforts were undertaken. This would result in recreation benefits of approximately $4,000,000 (120). In addition, the construction of adjacent recreation facilities such as a marina, golfcourse or baseball/softball facility would expand the local economic base and generate additional revenues.

A previous plan for the flushing channel was designed to allow barge traffic and a barge loading facility, or marinas and other related activities along the channel. These plans have been abandoned and the present flushing channel design would not accommodate such uses.

Land Use Plans and Policies

Selection of the 2A Alternative is consistent both with the adopted Vancouver Lake Land Use Plan and the preliminary Clark County Comprehensive Plan Goals and Guidelines. Both documents have designated this area for a mix of high intensity recreational, agricultural and industrial activities. At the present time, the agricultural activities within the project area specialize in income-producing row and specialty crops. As long as these crops remain profitable, conversion to more intensive uses would probably not occur. Both the preliminary comprehensive plan and the Vancouver Lake Task Force report outline strategies to be instituted by the county for preservation of agricultural land. If these strategies are implemented, the intensification of recreational activity within the area should not adversely affect the maintenance of agricultural activities. Placement of dredged materials on currently productive agricultural land would be contrary to the Vancouver Lake Land Use Plan since it would remove that land from productive use for a period of time.

The sediments dredged from the lake are not expected to be of sufficient quali for use as structural fill material. Therefore, placement of materials on areas designated for future industrial use would render the land unusable for that purpose and would be in contradiction to the intent of the Vancouver Lake Land Use Plan.

208 Areawide Wastewater Management Program

Alternative 2A is the alternative recommended by the Regional Planning Council of Clark County in its 208 planning program. In combination with the control of non-point source pollution, they believe this alternative would best achiev Clark County's water quality and land use goals.

Recreation

The restoration activities outlined in Alternative 2A would support the recreation plans developed for Vancouver Lake by the Clark County Park and Recreation Department. These plans include construction of an Olympic sailing course in conjunction with the Vancouver Lake Sailing Club, as well as development of a number of facilities at Vancouver Lake Park including swimming, picnicking, play fields, nature areas and a youth camp. The park has been designed to provide a variety of both passive and active recreational options and it appears that the planned facilities recognize the value and limitations of the various habitats existing within the park boundaries.

Clark County Park and Recreation Department has indicated that they expect that the Port of Vancouver would be involved in the implementation of the park master plan, but that the county would be responsible for the operation and maintenance of the facilities once they were constructed.

Selection of the 2A Alternative would allow both shoreline and in-lake recreational activity. Dredging under this alternative would be sufficient to allow the establishment of an Olympic sailing course in the south central portion of the lake. The current county plans do not call for motor boat use of the lake, which, if it were to occur, would conflict with both sailing and fishing use of the lake, due to the lake's rather uniform shallow depths. Some conflict between sailing and fishing use of the lake could be expected to occur since the pilot dredge study indicated that the fish moved quickly into the deeper dredged areas of the lake. If the fishermen and sailing enthusiasts both wish to utilize the same areas of the lake, some conflicts could be expected. However, these could be minimized by the creation of use zones within the lake water areas.

Dredging of a deeper channel along the western shoreline and placement of sand materials in that area would create an adequate swimming beach for a large number of recreationists. Quiet water swimming areas are much in demand in the metropolitan area, and the easy access to Vancouver Lake should make it a popular warm weather picnicking and swimming area.

The Vancouver Lake Park Master Plan outlines recreation facilities capable of accommodating a large number of recreationists. The park's proximity to the Portland metropolitan area and the continually increasing demand for water-related recreation areas support those plans. If the case of Scoggins Reservoir is applicable to Vancouver Lake, then initial use may surpass early estimates. Park planners have been careful to provide parking facilities in a manner that may limit the chance of over use of the facility.

Historical and Archaeological Resources

Before the placement of dredged materials can occur, an archaeological inventory of the project area must be undertaken. Evidence of over

40 archaeological sites within the area was determined by the Washington Archaeological Research Center. The condition and significance of these sites is currently unknown. In addition to the disposal of dredged materials, increased recreational use and wave action along the shorelines could have adverse impacts upon these sites.

Mitigating Measure

Measures to mitigate the short-term effects on dredging and the disposal of the dredged material are discussed under Alternatives 3, 4 and 5. Placement of screens on the flushing channel culverts to prevent juvenile salmonids from entering the lake has been proposed by the Washington State Department of Fisheries.

Short-term Resource Use vs. Long-Term Productivity

Economic, social and environmental systems are seldom static, but can usually be viewed as a continuum moving from what they were in the past, to what they will be in the future. A significant concept in the evaluation of effects is: What effect does a potential project have upon those trends? Does the project slow down, or speed up the trend, or does it move the trend in another and different direction?

In the case of Vancouver Lake, we are faced with two distinct trends -- a natural system trend and a human trend. Over the past years Vancouver Lake has evolved from an integral part of the Columbia River system, to a highly eutrophic lake characterized by high levels of nutrients and bacteria. The lake has continued to become shallower and if left in its natural state would eventually infill to a greatly increased extent. Although extensive wildlife habitat is available in the wetlands and sloughs surrounding the lake, human use of the lake is very limited due to its poor water quality. The lake's eutrophication process has been encouraged by the extensive growth that has occurred within the Vancouver area over the past 20 years. Increasing construction activity, storm runoff and inadequate sewage disposal has added to the natural processes, resulting in a decreasing level of lake water quality. In addition, the population growth in Clark County and the Portland Metropolitan area has created a clear demand for increased public facilities, including recreation. Vancouver Lake's proximity to the urban area and underutilization has made it a focal point for future recreation plans.

The federal government through the implementation of the Environmental Protection Agency's Clean Lakes Program has determined that public monies should be expended to restore lakes such as Vancouver Lake. Thus federal policy actively supports changing the natural systems in some lakes, when those natural systems have been degraded by human activities, to improve their water quality and, hence, their usability. In the short-term, the restoration of the lake would result in localized decreases in water quality as a result of the proposed dredging activity. Short-term losses of productivity and wildlife habitat use would also be associated with the placement of dredged materials on the lands surrounding the lake.

The proposed restoration program and its maintenance would increase the future usability of the lake for local and metropolitan area residents. By decreasing the lake's long-term production of nutrients and its coliform levels, future recreation uses can be greatly enhanced. The only major, long-term adverse effect of the proposed project would result from the destruction of significant wetland habitat through inundation with dredged materials. The results of an on-going study are intended to identify Class I and other significant wetland areas. Placement of dredged materials on those lands would not support the President's Executive Order concerning wetlands, as well as to EPA's wetlands policy.

The selection process for determining specific dredged material disposal sites would be closely tied to a direct understanding of the tradeoffs and relative values associated with a variety of land uses. Placement of materials on Class I wetlands would not be supported by federal policy, while placement of materials on productive farmlands or designated industrial land would not be supported by the Vancouver Lake Land Use Plan.

Irreversible and Irretrievable Resource Commitments

The major resource commitments involved in lake restoration would be the inundation of the disposal sites with lake bottom sediments and the funds spent during the dredging and construction activities. If wetland areas were covered with dredged materials, a significant habitat area would be lost to the local and regional ecosystem. The placement of dredged materials on other lands around the lake would result in short-term losses of productivity and use, until the soils were settled and prepared for a new use. The commitment of the approximate $15,000,000 necessary to complete the proposed project must be weighed against the benefits in both enhanced water quality and recreation opportunities that would result from the proposed program.

ALTERNATIVE 2B - DREDGING OF 8-10 MILLION CUBIC YARDS

Alternative 2B suggests that 8-10 million cubic yards of material be dredged from Vancouver Lake, as opposed to the 12-15 million cubic yards outlined in Alternative 2A. This dredging plan would allow maximum dredging for circulation, but would not include dredging of the Olympic sailing course, which would result in decreased spoils disposal near Site 5 and 6. The remainder of the dredging and spoils disposal would occur as outlined in Alternative 2A. Only those areas in which impacts would differ between Alternatives 2A and 2B are discussed below. The estimated cost of Alternative 2B would be approximately $12,500,000.

Air Quality

The dredging of 8-10 million cubic yards of lake bottom sediments would have the same general impacts as would occur if the project involved the dredging of 12-15 million cubic yards. The total emissions would be slightly less, due to less operating time required by the dredge machinery, and possibly less vehicular traffic due to the elimination of the sailing race course. However, these differences would probably be negligible.

Topography

The dredging of 8-10 million cubic yards would lessen the total amount of fill material that would be deposited on Sites 5 and 6. Thus, the topographic change from existing conditions to post-disposal conditions would be less marked. No significant effects should be anticipated.

Soils

The same relative effects could be expected from Alternative 2B as were outlined in Alternative 2A. Where the native soils were buried, they would be permanently lost. If scraped to the side for reuse or relocation, the impact would be temporary.

Hydrology and Flood Hazards

The general hydrological effects that are discussed in Alternative 2A would apply under selection of this alternative.

There would be no impacts on the flood hazard potential.

Water Quality

Because the hydrologic conditions within the lake would remain as they were with Alternative 2A, no change would be expected from those predicted for that alternative. Sufficient sediments would still be removed from the lake to possibly decrease the existing nutrient load, and the channels along both shorelines would provide increased circulation.

Due to lessening the volume of water in the lake, it is possible that the residence time would be shortened somewhat. However, it is doubtful if the shortened residence time would be sufficient to provide any noticeable effects.

Fisheries

There would be very little difference in the impacts experienced between this alternative and alternative 2A. A little less deep water habitat would be available to the fishes and the water could remain slightly warmer. However, these changes would not be expected to be significant.

Vegetation and Wildlife

Alternative 2B would have less impact upon the vegetation and wildlife than Alternative 2A due to the reduction by 3-7 million cubic yards in the amount of lake bottom materials to be dredged and disposed. This smaller quantity of dredged material would result in the destruction of less vegetation and wildlife, particularly in Sites 5 and 6. Since Site 5 and 6 both contain signficant wetland habitats, disposal of less material on these sites would greatly decrease any adverse effects that could result from the destruction of wetland habitat.

Significant Wildlife Areas

Decreased recreational use of the lake, particularly in the southern portion, would increase the use of the lake by migratory waterfowl. The large, shallow area in the south central portion of the lake would provide suitable habitat for migrating waterfowl to use for loafing and feeding.

If Alternative 2B would eliminate the need to fill significant wetland areas within Sites 5 and 6, any adverse impacts related to project construction would be significantly lessened. (A discussion of specific dredged material disposal effects relating to the individual sites can be found in Alternative 3.)

208 Areawide Wastewater Management Program

Selection of Alternative 2B would allow implementation of the lake rehabilitation portion of Clark County's 208 program. Although the recreation benefits would be decreased over those to be realized in Alternative 2A, the water quality benefits for both alternatives would remain the same.

Recreation

Selection of Alternative 2B would result in elimination of the Olympic sailing course at Vancouver Lake. No projections have been prepared to determine what portion of the recreation visits would be affected by elimination of that use. Selection of this alternative would not affect any other planned uses at Vancouver Lake Park.

Archaeological and Historical Resources

Selection of Alternative 2B would result in significant reductions in the amount of dredged materials to be placed along the southern shore. This would substantially decrease any potential adverse effects upon archaeological sites in that portion of the shoreline.

Mitigating Measures

Measure to mitigate the short-term effects of dredging and the disposal of the dredged materials are discussed under Alternatives 3, 4 and 5. Placement of screens on the flushing channel is discussed under Alternative 2A.

Short-term Resource Use vs. Long-term Productivity

Alternative 2B would maximize water quality benefits, but decrease by 25% the amount of dredged materials requiring disposal. This could, potentially, result in a substantial decrease in the amount of land to be covered by dredged materials. Selection of this alternative would decrease the long-term recreation potential of the lake by prohibiting the construction of the Olympic sailing course, which was projected to draw a large number of participants and observers.

Irreversible and Irretrievable Resource Commitments

The selection of Alternative 2B over Alternative 2A would result in a decrease in the resources that would be committed to the proposed project. Elimination of dredging in the south central portion of the lake would substantially decrease the amount of dredged materials to be placed in the vicinity of Mulligans Slough and the south embayment (Sites 6 and 5). These areas are believed to contain significant wetland habitats, preservation of which is strongly encouraged in federal policy.

ALTERNATIVE 2C - DREDGING OF 6 MILLION CUBIC YARDS AND UNDER

Selection of Alternative 2C would result in the dredging of only 6 or less million cubic yards of material from Vancouver Lake, a reduction of 50-75 percent of the amount proposed in Alternative 2A. No hydrologic, engineering or recreation studies have been prepared to indicate where the dredging would occur, or what types of recreation facilities would correspond to this level of dredging activity. For the purposes of this analysis it is assumed that the highest priority for dredging would be the channels along both shorelines to promote adequate flushing of the swimming beach area and short-circuiting of flows from Burnt Bridge Creek. Only those impacts which would be substantially different from the impacts expected for Alternatives 2A and 2B are discussed below.

Hydrology

In the Master Plan for Rehabilitation of Vancouver Lake, Dames and Moore indicated that 8.1 million cubic yards would be the minimum amount of dredging that would achieve the circulation and flow objectives they established (121). Therefore, it is believed that dredging 6 million cubic yards or less would not be adequate to promote flushing of the swimming beach and the short-circuiting of the flow from Burnt Bridge Creek. The exact hydrologic and circulation changes that would occur as a result of that dredging level are not known, but they would not be sufficient to achieve the water quality benefits that comprise the project objectives.

Water Quality

If hydrologic flow conditions within the lake were not altered by implementation of this alternative, no change in the eutrophic processes of the lake would be expected to occur. This alternative would not provide for removal of bottom sediments, other than those immediately adjacent to the west and east shorelines. Therefore, it would be expected that substantial nutrient sources would remain in the lake. If Alternative 2C were selected, it is questionable whether any long-term changes in Vancouver Lake water quality would occur.

Fisheries

Alternative 2C would represent a shallower lake, and thus a smaller aquatic environment available to the fishes.

Vegetation and Wildlife

Selection of Alternative 2C represents a significant reduction in the amount of land necessary for the disposal of dredged material, and hence a significant reduction in the amount of vegetation and wildlife to be destroyed by the activity. The specific effects would be determined by the location of the dredged disposal sites.

Significant Wildlife Areas

Impacts of the selection of Alternative 2C would be dependent upon the areas used for the disposal of dredged materials. If the materials were placed in areas outlined on the Significant Wildlife Areas map then the impacts would be similar to those discussed in the Alternative 2A impacts discussion. However, if other sites were utilized, then adverse impacts would be significantly reduced.

Short-term Resource Use vs. Long-term Productivity

Since the dredging of 6 million cubic yards would not provide significant water quality benefits, it is questionable whether the long-term quality and use of the lake would be enhanced. The Dames and Moore Master Plan believes that dredging is necessary in addition to the construction of the flushing channel in order to meet the water quality and recreation objectives. Selection of Alternative 2C would probably not contribute to the achievement of those objectives.

Irreversible and Irretrievable Resource Commitments

The funding costs of Alternative 2C have not been calculated, but are estimated to be approximately $8,000,000 - $9,000,000. The commitment of funds necessary to complete this level of development must be weighed against the benefits to be gained, if any. Any wetland areas covered by dredged materials would be irretrievably lost to that habitat use.

ALTERNATIVE 3 - DISPOSAL MATERIAL PLACEMENT

The Master Plan for the Rehabilitation of Vancouver Lake proposes the use of seven general disposal sites. Each of these sites is described on pages 50-52 of this section. These disposal areas are very general in nature since negotiations for use of the sites have not been undertaken. The choice of a project alternative (Alternative 2A, 2B or 2C) would determine the size and location of the necessary disposal sites. The sites proposed within the Master Plan are a combination of upland, wetland, shoreline and in-water sites. The comparative effects of using such sites are described below.

Alternative 3A - Land Disposal

Land disposal sites comprise both upland and wetland sites. The specific lands that would be covered by dredged materials are not currently known. However, the effect of placing materials on general sites can be addressed. The amount of land to be covered with dredged material is dependent upon the amount of material to be dredged and the time frame over which dredging would occur.

Land disposal of the dredged materials could result in increases of land elevations of up to 22 feet. The depth of the disposal material would be primarily dependent upon the topography of the specific disposal site, and the length of time over which the dredging occurred. If the dredging were to occur in increments over 5 to 10 years, it is possible that disposal depths could be increased, due to compaction of the disposal material. In other words, a given disposal site can accomodate more dredged materials if the materials are placed incrementally on the site so that compaction can occur between placements. Disposal of dredged materials on the upland, floodplain and wetland areas adjacent to Vancouver Lake would markedly alter the visual aspects of the land. Due to the future recreation uses planned for the area, particularly on Sites 1, 2, 3 and 7, it is expected that these topographic changes would be scaled to achieve a pleasing aesthetic environment.

Land disposal will significantly alter the existing soils conditions, especially where those existing soils are buried. Impacts would be lessened in those areas where the topsoil was removed and stockpiled until it could later be returned to the site. Lake bottom soils consist primarily of clayey silt, sandy silt and silty fine sand. They are considered from poor to fair for use as structural fill and from fair to good for use as non-structural fill and agricultural fill.. However, they are of poorer quality than the soils on adjacent agricultural land.

Lake sediments have poor soil structure and would be characterized by poor internal drainage. In order to be acceptable for agricultural uses, the soils must be enhanced for root penetration, drainage and nutrient content. For structural uses, the soils would require compaction for the full depth of the soil and appropriate drying to within the recommended compaction standards. Moderate strength and moderate compressibility could be expected from these soils if property compacted.

Intended uses and locations must be examined in detail with consideration given to both the characteristics of the lake soils and the underlying soils. Where heavy loads are planned in the future, this examination is of particular importance.

Sites 1 and 2 are primarily in upland pasture usage and do not receive significant wildlife use. Site 2 is a part of Vancouver Lake Park, planned for future park development. Placement of dredged materials on these two sites would be expected to have no long-term adverse effects. Site 1 could be returned to pasturage after the proper compaction and soil reconditioning occurred. The site would be non-productive during the short-term, but should return to productive use within 3 to 4 years after the completion of disposal activities. Dredged materials placed on Site 2 would be used to create a varied landscape to accomodate recreation activities and enhance the park setting.

Site 3 is currently used for pasture and is predominantly an upland site. Numerous low lying areas occur throughout the site which will be studied for wetland classification. The property is owned by Alcoa and could eventually be rezoned for industrial use. However, the Clark County Regional Planning Council staff believes that such rezoning may not be feasible due to the site's close proximity to Vancouver Lake Park. The site's pasture production is not considered to be as important as other areas around the lake; therefore, short-term effects during the disposal and compaction processes would not be significant.

Site 4 is characterized by two distinct wetland areas which provide water fowl habitat. The class and role of these wetland areas will be determined during the on-going wetlands classification program. If these wetlands are determined to be Class I wetlands or to play a significant habitat role, filling of the site would have long-term adverse effects and would be in contradiction with EPA wetlands policy and Presidential directives. The land is currently zoned for industrial use and the property owner may not wish to have dredged materials placed on the site due to their inadequacy for structural use.

Site 5 includes a willow swamp, grassy marsh and open meadow. The extent of wetlands in the site will be determined during the current wetlands study. Wetland habitat would be lost if the area were to be filled. The site would be allowed to revegetate naturally after disposal and future use would be limited to nature trails and view points.

Site 6 includes a large portion of Mulligan's Slough and productive farmlands. This 650 acre area is zoned for agricultural and open space uses. If the Corps of Engineers diking improvements are constructed as presently designed, a portion of the wetland areas would be cut off from their major water source. The extent and importance of the wetlands within this site are currently being studied. It is believed that this area contains some of the most significant wetland and marsh habitat in the Vancouver area and plays a significant role in the local ecosystem.

If that is the case, filling of portions of Mulligan Slough would result in significant long term adverse effects. Future agricultural use would be curtailed until adequate compaction and soil conditioning had occurred.

The chemical state of the heavy metals and pesticides found in the dredged material sediments has not yet been fully determined. The Soil Conservation Service, in conjunction with Dames and Moore, intend to perform experimental plantings on the existing dredged materials to better determine any retardation or crop limitations that the spoils may inflict upon various plant types.

Alternative 3B - Shoreline/In-Water Disposal

The disposal of materials on the shoreline or in-water would eliminate fish habitat and possible waterfowl habitat. Lakeshore vegetation would be lost, with Site 7 experiencing minimal such losses. Waterfowl habitat loss should be minimal at Site 7 and loss of fishery habitat is not expected to be significant. The area outlined within Site 7 is not known as an important spawning area, although migrating salmonids move through that portion of the lake towards Burnt Bridge Creek. However, these migration patterns can be easily altered.

The embayment included within Site 5 is currently a spiny-rayed spawning area. Filling of the embayment would convert a water-habitat to an upland habitat, and would thus represent a loss in total aquatic habitat.

In total, shoreline and in-water disposal within Sites 5 and 7 would allow substantially increased recreational and public access to those portions of the lake shoreline. In the area of Site 7, the width of the shoreline would be increased by several hundred feet.

Mitigating Measures

Proposed use of shoreline disposal sites must take into consideration the biological seasons, as in-water diking projects and outfall may have significant effects on spawning and migration.

Dike construction must be durable and consist of relatively clean materials. The cleanest sands and gravels available from Columbia River dredging operations exemplify such possible material. Subsequent diking stages can consist of dredged materials, depending upon specific conditions and needs.

Dames and Moore and the Regional Planning Council of Clark County studied the entire area in and around Vancouver Lake for possible deposition of dredged material. The objectives in reviewing each site were: 1) to minimize dredging cost, 2) to complement future planned use for the site, and 3) to minimize adverse environmental impacts. The sites discussed above were selected as the most feasible based on those three criteria. Many sites were considered and discarded because they were characterized by wetland and other valuable wildlife habitats, highly productive crop growing soils or were planned for future industrial use. The Regional Planning Council believes that the potential sites listed above are the most feasible for disposal use.

ALTERNATIVE 4 - DREDGING METHODS

At the present time Vancouver Lake cannot be used for diversified recreational purposes due to its shallow depths and poor water quality. To deepen the lake, thus enhance its recreational functions and appeal to a broader spectrum of citizens, the lake sediments must be removed. Based on current technology, dredging appears to be the most viable method to achieve that goal. This would involve removal of lake sediments by means of one of a variety of dredging methods.

The Dames and Moore Pilot Dredge Study explored various possible methods of dredging that could be applied to the Vancouver Lake conditions. Excavating type dredges, such as power shovels, drag lines and clam shells (bucket-type equipment) were considered. The major advantage in the use of this type of equipment is the minimized amount of time necessary for dewatering. However, these methods cause excessive turbidity, and would be very costly since the materials would have to be loaded on barges to be transported to shore.

New types of dredging equipment were considered, particularly the oozer and the pneuma pump systems. These methods are especially beneficial when highly contaminated material is to be dredged. The bottom sediments are forced into small cylinders, then pumped or sucked up a pipeline and piped to the disposal site. These methods achieve a relatively high ratio of solids to water, thus reducing the decanting process (which in turn reduces the amount of turbidity and pollutants in the outfall process). If the lake sediments were found to be more chemically polluted than expected, these systems would probably offer the least amount of pollution re-circulation. Although these two methods are more expensive to utilize than is hydraulic pipeline dredging, their use could result in decreased land acquisition costs since they achieve a higher ratio of solids to water, resulting in more rapid compaction. The oozer system in particular, is still being considered for use by the Port of Vancouver.

The hydraulic suction dredge was determined by Dames and Moore to be the most suitable method for dredging in Vancouver Lake and they used it during the Pilot Dredge Study. This method consists of a pipeline which scans the bottom of the lake, sucking up the nearby sediments and piping the material to the disposal site. An eight-inch (eight-inch diameter at head of pipeline) hydraulic dredge was used in the Pilot Dredge Study, though larger dredges are available. The dredge used draws 28 inches, requires about that much depth for proper operation, and can pump the material 3,500 feet horizontally. Booster pumps can increase the possible pumping distances, but at considerable cost.

Hydraulic dredging results in two primary impacts. First, the dredge causes increased turbidity in the water during operation. As the pipeline cuts and scans the bottom, fine material becomes suspended in the near vicinity. Wind and wave action can spread this turbidity beyond the actual dredging area. This increased turbidity would be short term and is discussed in the Water Qualtiy effects portion of Alternative 2A. It would cause temporary problems for localized fish and invertebrates, but the impact should be minimal. Curtains could be used to minimize the spread of the suspended materials, if that became a serious problems. The second major short-term effect of dredging occurs at the disposal site. During the dredging process, the hydraulic pipeline draws in considerable quantities of water along with the bottom sediments. During the Pilot Dredge Study the ratio of solids to water was measured at approximately 17 percent by weight. Thus, large amounts of water must be removed from the dredged materials, causing pollution recycling, turbidity and extended decanting times. Lake sediments must be disposed of carefully, so that the materials would be properly contained and the dewatering process be managed to minimize pollution recycling and turbidity. If well managed, the effects on water quality and fisheries should be minimal.

Due to the condition of the materials that would be dredged from the lake, considerable enhancement would be necessary for future economic use of the materials (agricultural, structural, etc.). This would require dewatering of the material to levels applicable for the various intended uses. The clam shells, drag lines and power shovels would require the least amount of dewatering (thus less time, less return flow, and reduced water quality problems at the disposal area.) The pneuma and oozer methods would be more efficient than the excavators at the dredge site, but less efficient at the disposal site. These methods would require more time to decant than the excavators, but would be more efficient than the hydraulic system (50 percent solids versus 17 percent solids.) The hydraulic system would take the longest time before serious efforts of enhancement of the dredged materials could take place. The re-use of the materials for structural or agricultural purposes would take more than a year. Given enough time and work with the dredged materials, they could be used for agricultural and various structural purposes.

Mitigating Measures

The Master Plan for the Rehabilitation of Vancouver Lake suggests a variety of mitigating measures that could be used to decrease the short term effects of dredging on water quality. These include avoidance of hot weather dredging, lengthening retention periods to allow for minimum 3 day water detention time, creating numerous cells within the storage areas, use of chemical flocculants, limiting decantation and increasing aeration.

Dikes are necessary for containment purposes, for settling purposes to improve the quality of the outfall water, and for material reclamation projects. Dikes may be constructed from local soils, imported materials, and sometimes from dredged materials. Native soils are preferred for construction of initial dikes when the site is on land. Dikes constructed in water (as would be the case for Sites 5 and 7) typically function best if constructed of foreign materials with specified characteristics.

A weir is a simple structure built into the disposal cell, or disposal pond, that will allow the excess water to drain out (the outfall). The weir should be designed to allow only that water which is the least turbid to enter the outfall, thus causing minimal water quality problems in the return flow to the lake. The design of the weir should be site specific to accomodate existing conditions, with minimal return flow pollution the major objective.

The construction of the dikes would cause the primary impacts on the environment. Soils and existing vegetation would be at least temporarily lost. Wildlife losses would depend upon the diversity and depth of the habitat. If it is a particularly complex, or extensive habitat, the environmental impact must be considered to be significant. If the habitat is small and fairly common, wildlife can presumably relocate without irretrievable losses. Vegetation and wildlife can be re-established within three to seven years, depending upon specific conditions.

If the disposal materials were not physically conditioned for enhancement purposes, the material would probably require a year's time before it could support light traffic. The structure of the lake soils would not support agricultural activities, unless they were conditioned. Thus, it is expected that natural revegetation would be retarded. Therefore, to reduce the environmental impact of dredged material disposal, the disposal materials should be conditioned to improve their reuse capabilities.

"Casual" uses, such as parkland, playfields, beaches and landscaping, would require minimal lake soils improvements and care. Such reuse potentials should not be difficult, given proper planning and a good understanding of the soil limitations. Reuse for structural purposes (roads, buildings, etc.) would require significant preparation.

Compaction of the material, after proper dewatering, would be necessary for the full depth of the dredged soil. Such activity would require a detailed examination of the specific soil characteristics not only of the dredged material, but also of the underlying soil as well. Impacts of structural reuse of the materials would depend primarily upon the specific reuse.

For agricultural reuse, the dredged materials would require soil structure conditioning to improve drainage characteristics and root develop ment potential. This preparation might be likened to the opening up of a new plot of land for agricultural use, in that six months to a year would be spend preparing and enriching the soils. What impact this would have on the land would depend upon the prior use. If this action were not undertaken within the wildlife areas or thick vegetation zones as mapped in Section II, the effects would either be minimal or advantageous.

Any in-water or shoreline disposal as in Sites 5 and 7 would be an irreversible commitment of a natural resource. Site 7 could possibly be replaced, through the development of more water area for the lake. Sites 5 and 6 would be irretrievable commitments of the natural resources, as the replacement of such habitat types would not be possible. Both areas are used extensively for mating, spawning and nesting by various wildlife species.

If the dredged materials were used for structural purposes, then the land would be committed to long-term or permanent structural use. If agriculture is to be the re-use, then it is an addition to the local natural resources.

To significantly reduce the adverse environmental impacts of the disposal of dredged material, alternative sites should be found for Sites 5 and 6. These areas are vital to the biological mechanics of the lake environment. Important wildlife areas that occur on the west shore should be avoided as well.

Construction of the dikes and cells should occur during dry weather to minimize the impact of the heavy machinery on the wet soils. Construction activity during the Pilot Dredge Study occurred during wet periods, and the machinery caused considerable disturbance to the soils and local vegetation.

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