GIS-1

LOWER COLUMBIA RIVER BI-STATE WATER QUALITY PROGRAM FISH, WILDLIFE AND WETLANDS GIS HABITAT MAPPING

February 16, 1996

FINAL REPORT

Prepared by: U.S. Army Corps of Engineers,
Portland District
Geotechnical Engineering Branch
GIS, Survey and Mapping Section

ODEQ Contract Numbers: 081-95
082-95

INTRODUCTION

The Lower Columbia River is located on the border between the states of Oregon and Washington, and is defined as the reach of river extending from the mouth to Bonneville Dam (river mile 145), the maximum extent of tidal influence. The river has, since American settlement in the mid-19th century, experienced a variety of human impacts that have profoundly changed its physical, chemical and biological characteristics. Long term impacts to fish and wildlife habitats have resulted from urban development, hydropower production, industrial activity, recreation, agriculture, logging, and the effects of maintaining and improving navigation.

Aerial photography dating from 1948 to 1991 has been interpreted for a variety of generalized habitats and land cover categories, including wetlands, in an effort to measure this impact. Where the photographic coverage was more extensive, the interpretation extended out two miles from the shoreline of the river. The results of the interpretation have been digitized into a GIS (geographic information system) and analyzed to determine the losses and gains of the interpreted habitat classes.

METHODOLOGY

Photography The Corps of Engineers has an extensive archive of aerial photographs dating back as far as 1929 for specific areas. The archives were researched to develop a listing of aerial photographic dates that provided the best comprehensive coverage of the study area. This list was provided to the study team, consisting of representatives from several federal, state, and regional agencies. Also provided was a historical compilation of significant events affecting the physical evolution of the lower Columbia River (see attached Appendix B). The study team used this data to select five aerial photographic dates from which habitats and land cover classifications would be interpreted. The dates ultimately selected were 1948, 1961, 1973, 1983, and 1991. (See Table 1).

It must be noted that many factors affect the interpretation of aerial photographs. Factors inherent in the photography itself are film type used (black and white, color infrared, natural color), scale, film processing and focal length of the lens. Temporal conditions that affect the interpretation are season, time of day, light conditions, vegetative conditions, tides, and hydrologic conditions. All of these factors vary during the five dates of photography listed below. For example, the diurnal tidal fluctuation averages ± 4.2 feet at Astoria, which could have a significant effect on wetland / marsh area exposed. Even for a given year, the aerial photography was acquired over a period several days or weeks, and at various times of the day. Therefore, tidal affects are very difficult to determine. This is an important consideration in the interpretation of the statistical output from the analysis.

Table 1. Aerial Photographs Used for Habitat Delineations

DATE	FILM	SCALE	# Photos	COMMENTS
1948 (Sept/Oct)	Black &White	1:12,000 1:24,000	352	Post-Flood. Receded
1961 (Nov.)	Black & White	1:20,400	235	Does not cover two miles inland
1973 (Aug/Sept)	Black & White	1:24,000	270	
1983 (Sept)	Color Infrared	1:48,000	134	
1991(Sept/Oct)	Black & White	1:48,000	172	

Classification System The classification scheme developed is a simplified hybrid of two existing classification systems. The study team suggested using the classification scheme developed for the U.S. Army Corps of Engineers study entitled **Inventory of Riparian Habitats and Associated Wildlife Along the Columbia and Snake Rivers**, U.S. Army Corps of Engineers, North Pacific Division, 1976. This study is based on vegetative cover, interpreted from aerial photos taken in 1973 ranging in scale from 1:10,000 to 1:24,000. The 30 month study identified vegetative complexes up to four mix types according to the composition of the overstory. The photographic interpretation was verified by field surveys and intensive sampling of 82 areas. The Lower Columbia River Bi-State Water Quality Program Study Team requested that this classification system be coordinated with the Cowardin classification system, which is based on physiographic and hydrologic characteristics, used for the National Wetland Inventory maps produced by the U.S. Fish and Wildlife Service. Therefore, the most general categories of the Corps of Engineers study were used in conjunction with a simplified form of the Cowardin classification system to create the following hybrid classification system:

1 barren land (unvegetated sandy beaches, quarries, dunes, rock lands, etc.-95% barren)

2 open water (at least 2 meters deep)

Possible classifications are:

2Ms Open water, marine subtidal

2Mi Open water, marine intertidal

2Es Open water, estuarine subtidal

2Ei Open water, estuarine intertidal

2Rt Open water, riverine tidal

2Rl Open water, riverine lower perennial

2Ru Open water, riverine upper perennial

2Ll Open water, lacustrine limnetic

2Lt Open water, lacustrine littoral

2P Open water palustrine

3 grassland (95% grassland)

4 wetland/marsh (tidal and non-tidal, cattail, sedge, grass, salt or freshwater marsh, and water shallow enough to support emergent marsh vegetation-[less than 2 meters deep])

Possible classifications are:

4Ms Wetland / marsh, marine subtidal

4Mi Wetland / marsh, marine intertidal

4Es Wetland / marsh, estuarine subtidal

4Ei Wetland / marsh, estuarine intertidal

4Rt Wetland / marsh, riverine tidal

4Rl Wetland / marsh, riverine lower perennial

4Ru Wetland / marsh, riverine upper perennial

4Ll Wetland / marsh, lacustrine limnetic

4Lt Wetland / marsh, lacustrine littoral

4P Wetland / marsh palustrine

5 shrub / scrub (95% shrub / scrub)

6 savanna-like (grassland with less than 25% scattered trees)

7L coniferous forest, low [26-70% cover] **forest density**

7H coniferous forest, high [>70% cover] **forest density**

8L broadleaf forest, low [26-70% cover] **forest density**

8H broadleaf forest, high [>70% cover] **forest density**

9L mixed forest (>20% mixed) **, low** [26-70% cover] **forest density**

9H mixed forest (>20% mixed) , **high** [>70% cover] **forest density**

10 agricultural land (field crops, orchards, pasture)

11 urban / developed (residential, industrial, transportation, etc.)

12 forested wetland (palustrine)

Two of the wetland classes of the above classification scheme (**2 open water, 4 wetland/marsh**) were coordinated with the Cowardin classification system to the 'Subsystem' level in the hierarchy. No wetland determination was made to the class and subclass level. Only classes 2,4 and 12 are wetland catagories. All others classes are not wetland in nature. The following are descriptions of the attributes added to each polygon that was determined to be one of the wetland classes (2 or 4):

Marine (M) From the open ocean (continental shelf) shoreward. Limits include:

1) to the landward splash zone of breaking waves;

2) to the seaward limit of emergent vegetation

Marine subtidal (Ms) Continuously submerged

Marine intertidal (Mi) Exposed and flooded by tides

Estuarine (E) Tidal deepwater and wetlands that are semi-enclosed by land with access to the open ocean. Limits include:

1) upstream and landward to where ocean salts measure less than .5%;

2) seaward to a line closing the mouth;

3) to the seaward limit of the wetland

Estuarine subtidal (Es) Continuously submerged

Estuarine intertidal (Ei) Exposed and flooded by tides

CORPS OF ENGINEERS

U.S. ARMY

FIGURE 1

PACIFIC CO.

WAHKIAKUM CO.

CLATSOP CO.

COWLITZ CO.

COLUMBIA CO.

LOWER UNIT
MILES 0 – 46.5

MIDDLE UNIT
MILES 46.5 – 105.5

WASHINGTON
OREGON

Columbia River

Skamokawa

Cathlamet

Astoria

Kelso

Longview

Clatskanie

Rainier

Match Line A

Match Line B

LEGEND

RIVER MILES x75

COUNTY BOUNDARY

STATE BOUNDARY

ORIGINAL AREA OF ANALYSIS

EXPANDED AREA OF ANALYSIS

MAJOR HIGHWAYS

N

11000 0 11000 22000

SCALE IN FEET

U.S. ARMY ENGINEER DISTRICT, PORTLAND

COLUMBIA RIVER
MILE 0 TO MILE 73
OREGON-WASHINGTON

LOWER COLUMBIA RIVER BI-STATE WATER QUALITY STUDY

Habitat Mapping-Study Area Limits

SUBMITTED	DESIGNED	DRAWN	CHECKED
JOHN W. SAGER, RPG	GMB	GMB	RCP

DATE	SHEET	REVISED
15 Sept. 1995	1	

CORPS OF ENGINEERS

U.S. ARMY

FIGURE 2

Match Line B

Kalama

COWLITZ CO.

COLUMBIA CO.

St. Helens

MIDDLE UNIT
MILES 46.5 – 105.5

Scappoose

Sauvie Island

Multnomah Channel

Willamette River

Lewis River

Bachelor Island

Lake River

Vancouver Lake

Match Line C

CLARK CO.

Vancouver

Portland

Beaverton

MULTNOMAH CO.

UPPER UNIT
MILES – 105.5 – 146.8

Match Line D

Government Island

Lady Island

McGuire Island

Sandy River

Reed Island

Hayden Island

Oregon Slough

Columbia River

Bonneville Dam

KLICKITAT CO.

N

11000 0 11000 22000

SCALE IN FEET

LEGEND

RIVER MILES x75

COUNTY BOUNDARY

STATE BOUNDARY

ORIGINAL AREA OF ANALYSIS

EXPANDED AREA OF ANALYSIS

MAJOR HIGHWAYS

U.S. ARMY ENGINEER DISTRICT, PORTLAND

COLUMBIA RIVER
MILE 73 TO MILE 147
OREGON-WASHINGTON

LOWER COLUMBIA RIVER BI-STATE WATER QUALITY STUDY

Habitat Mapping-Study Area Limits

DESIGNED	DRAWN	CHECKED
JOHN W. SAGER, RPG	GMB	GMB	RCP

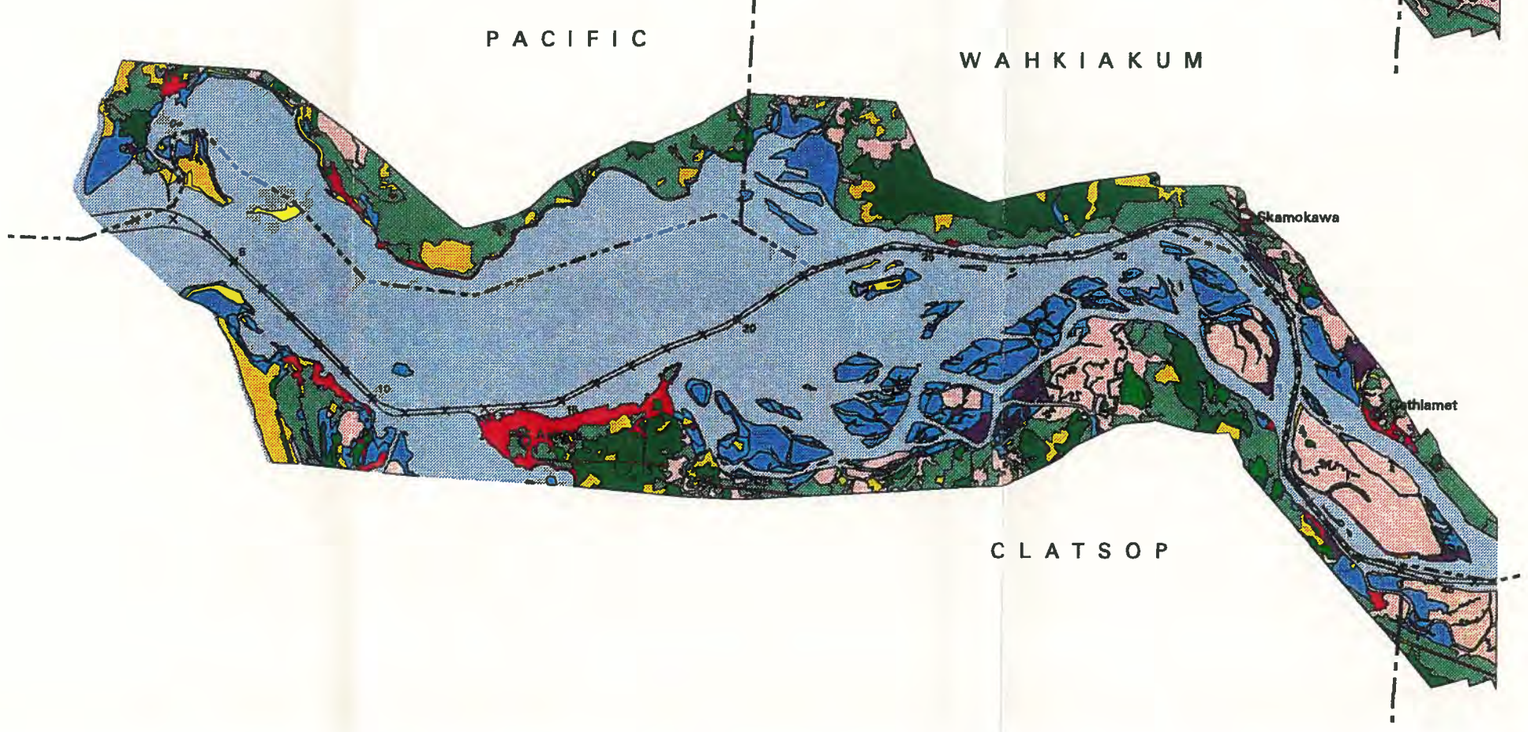
DATE: 15 Sept. 1995 | SHEET: 2 | VOLUME:

GENERALIZED HABITATS AND LAND COVER

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1948

1961



Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

Scale 1:250,000

LOWER UNIT
Miles 0 - 46.5

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

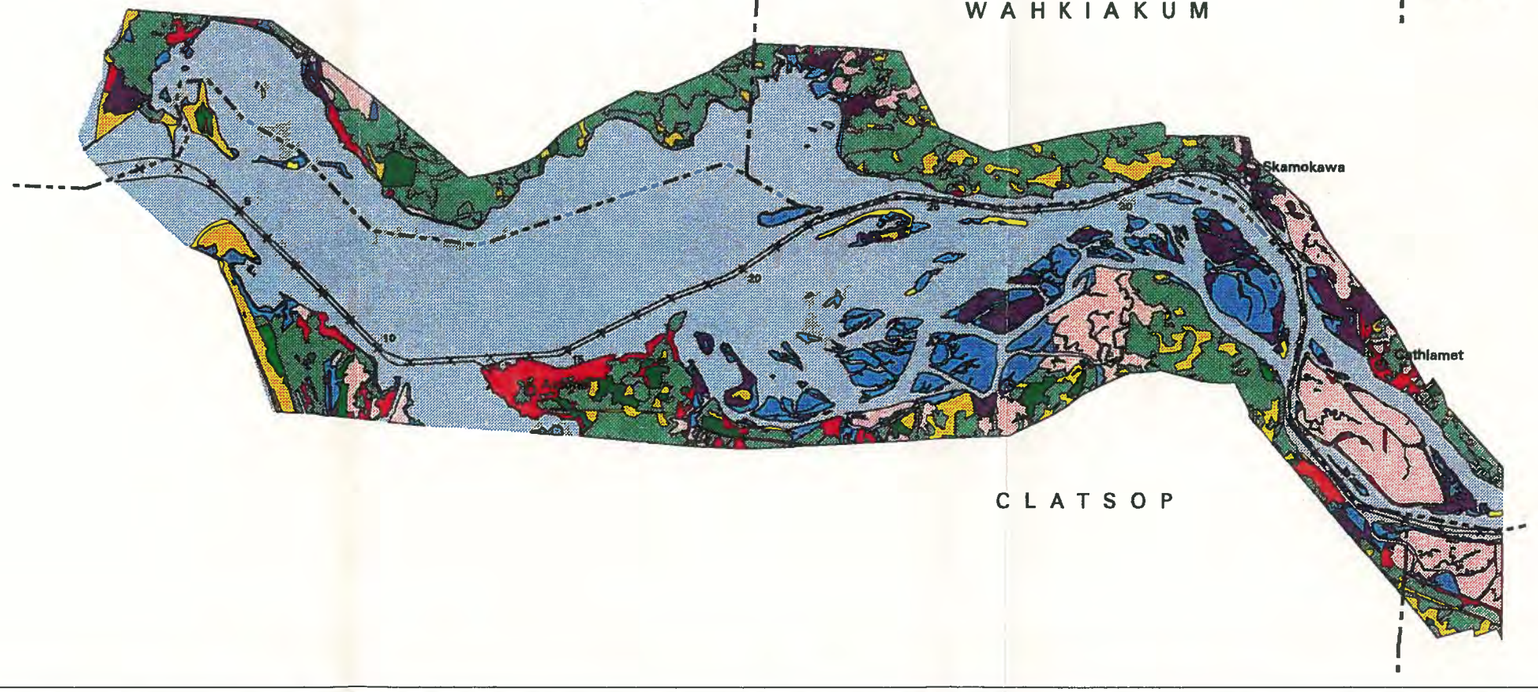
February 1996

GENERALIZED HABITATS AND LAND COVER

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1973

1983



Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

LOWER UNIT
Miles 0 - 46.5

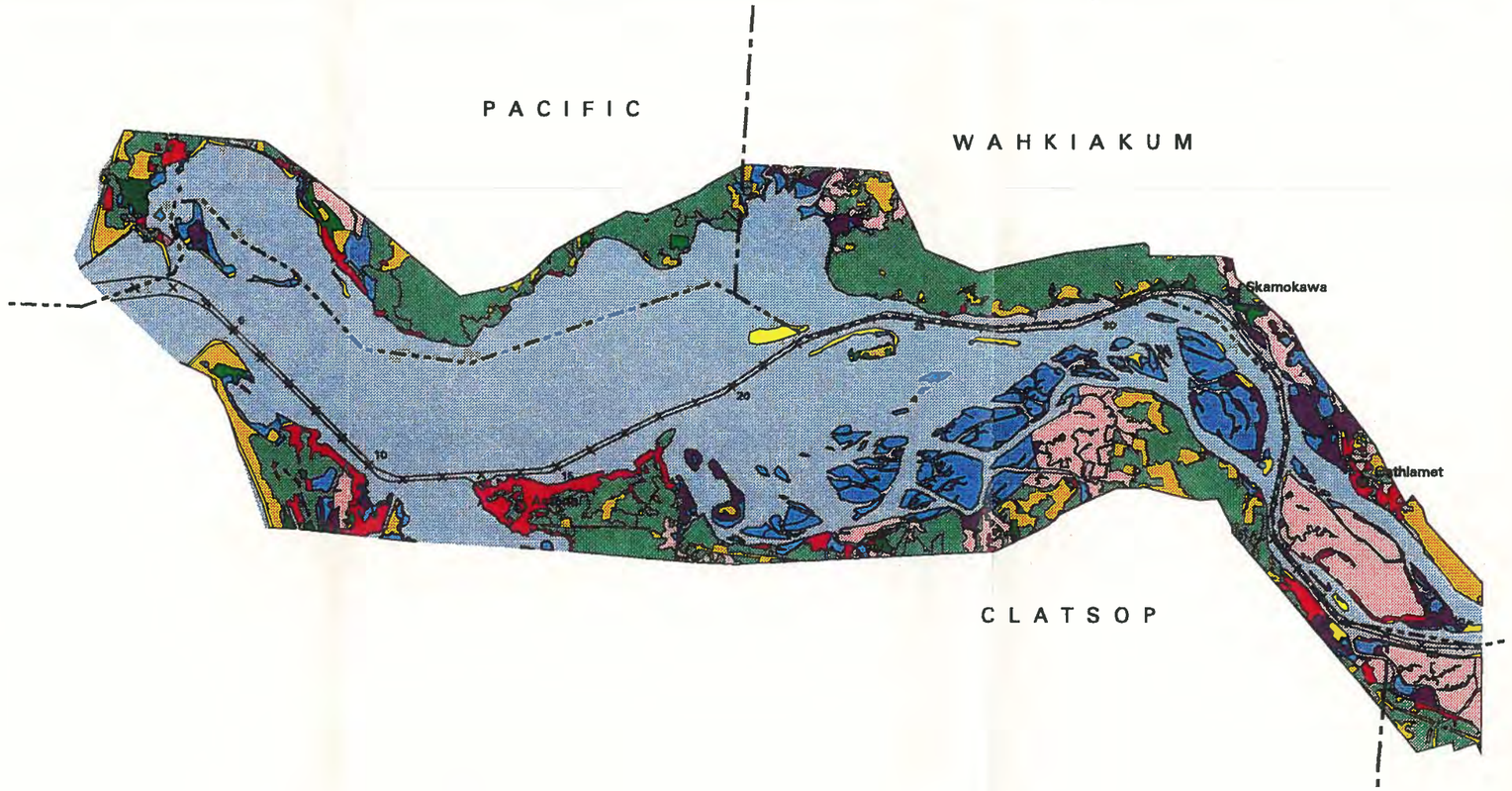
Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

GENERALIZED HABITATS AND LAND COVER

1991

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)



Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

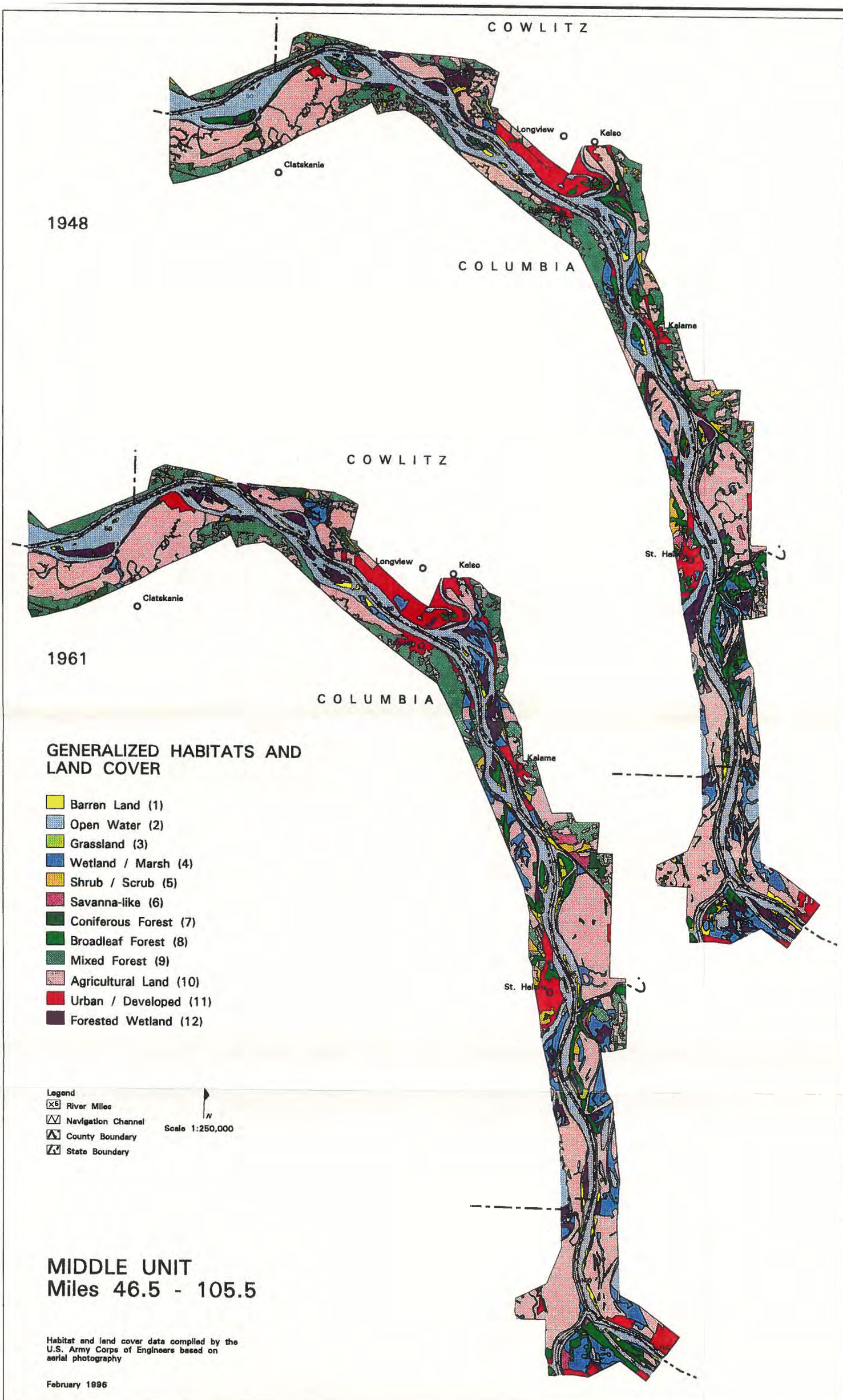
N

Scale 1:250,000

LOWER UNIT
Miles 0 - 46.5

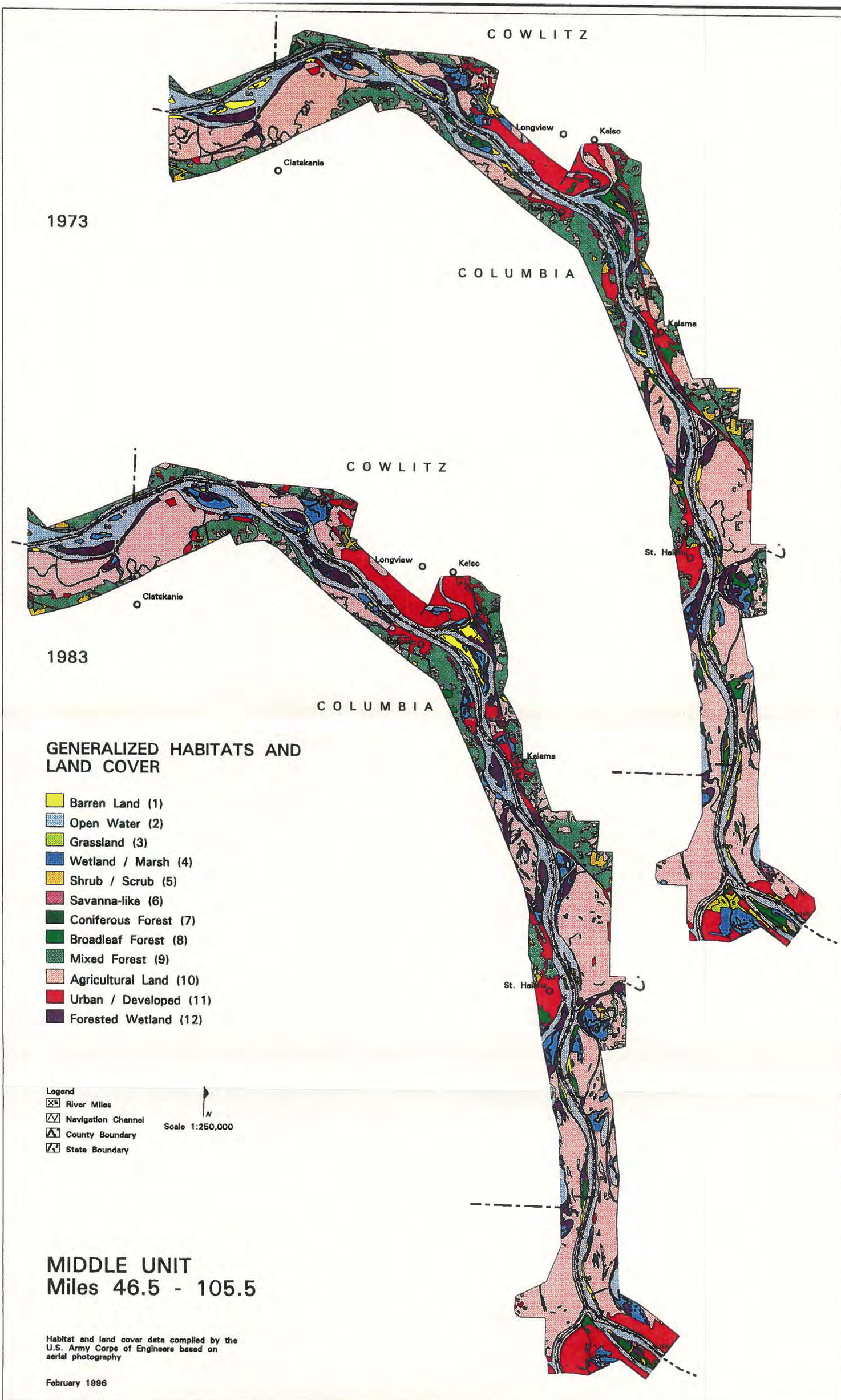
Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996



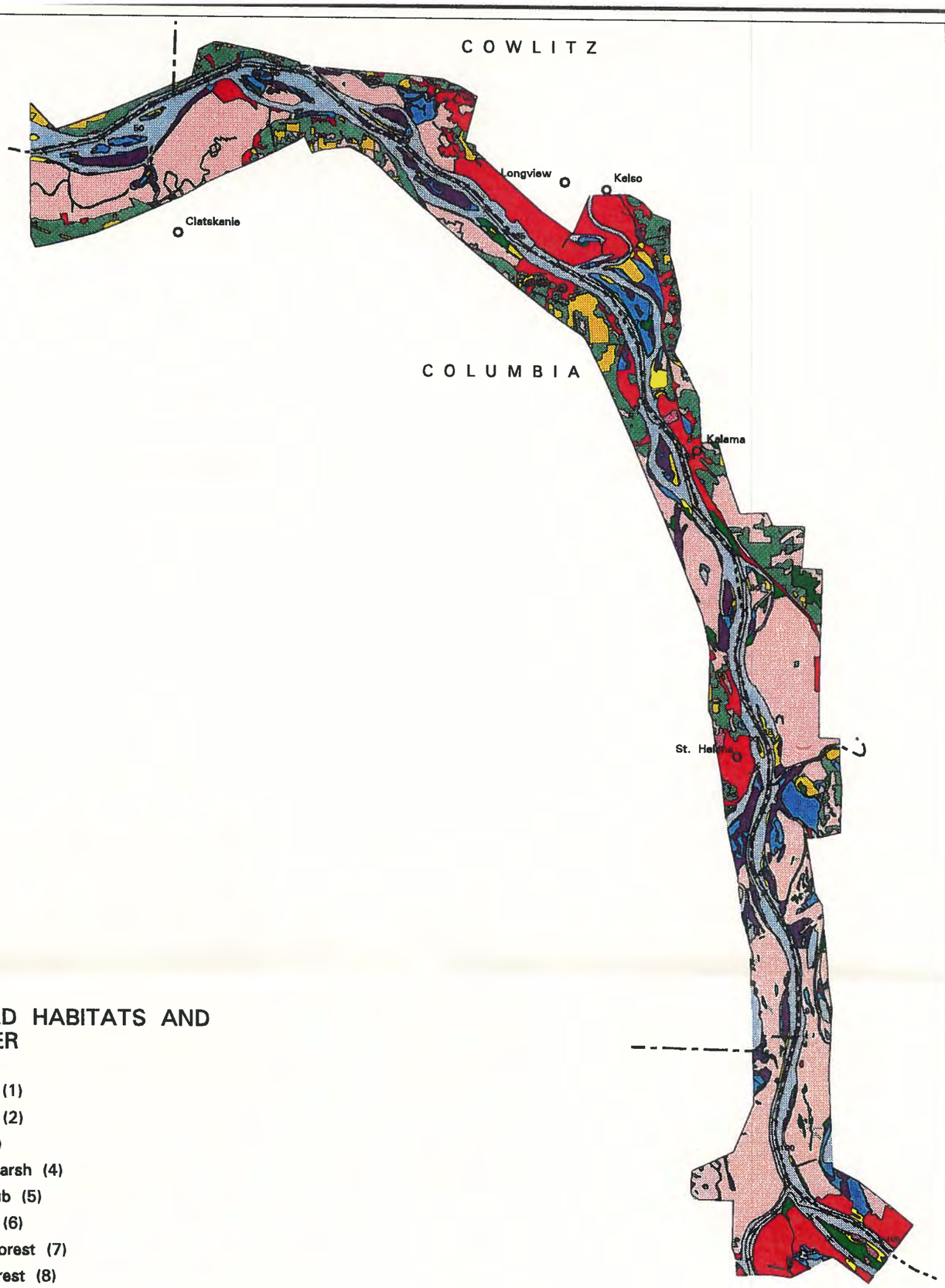
FISH, WILDLIFE AND WETLANDS GIS HABITAT MAPPING
Prepared by: U.S. Army Corps of Engineers

FIGURE 6
LOWER COLUMBIA RIVER BI-STATE WATER QUALITY PROGRAM



FISH, WILDLIFE AND WETLANDS GIS HABITAT MAPPING
Prepared by: U.S. Army Corps of Engineers

FIGURE 7
LOWER COLUMBIA RIVER BI-STATE WATER QUALITY PROGRAM



GENERALIZED HABITATS AND LAND COVER

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

MIDDLE UNIT
Miles 46.5 - 105.5

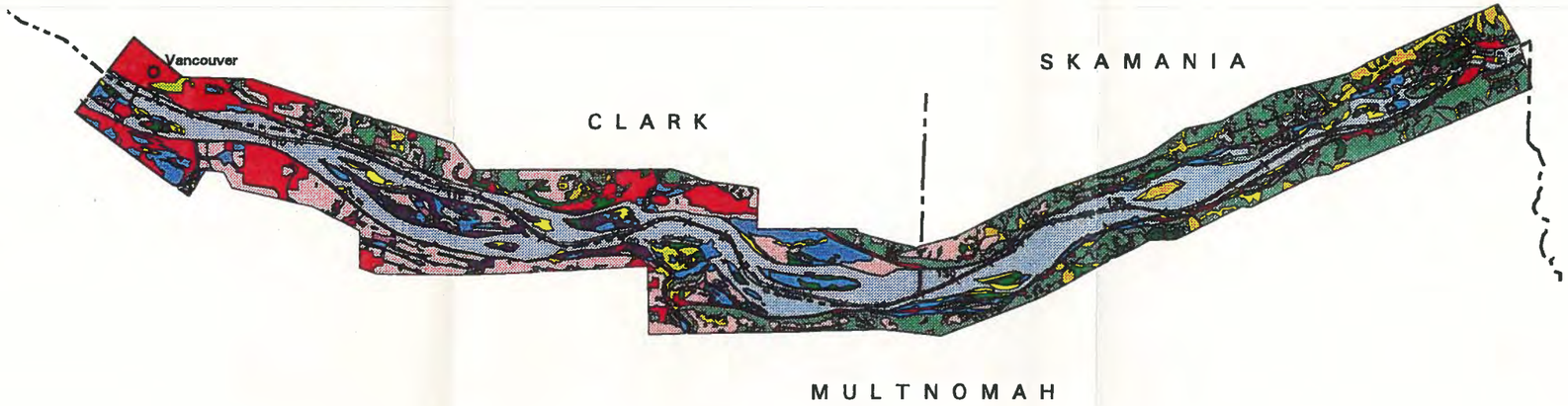
Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

GENERALIZED HABITATS AND LAND COVER

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1948

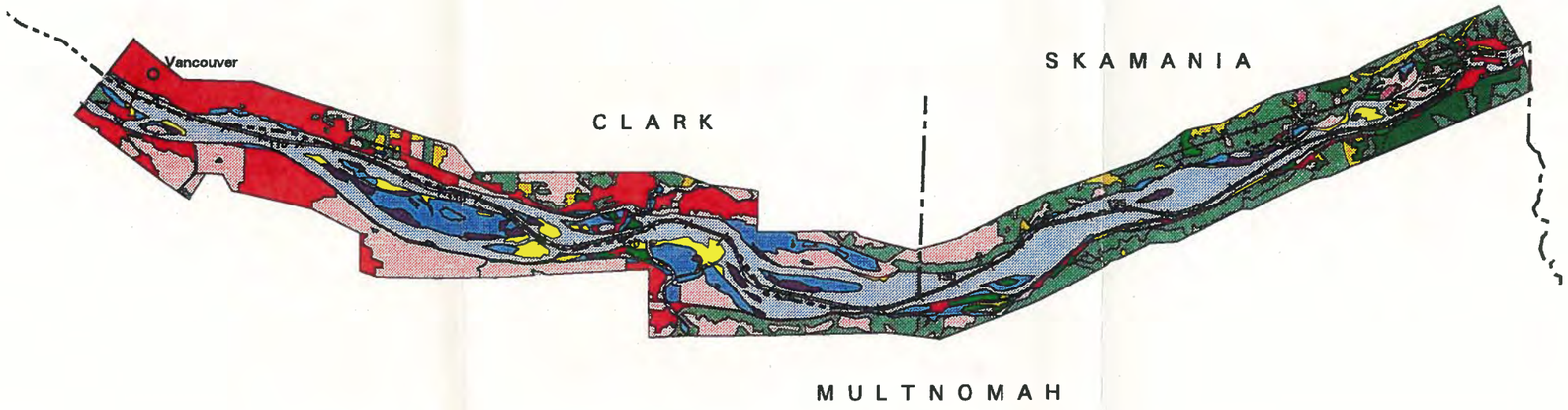


Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

1961



UPPER UNIT
Miles 105.5 - 146.8

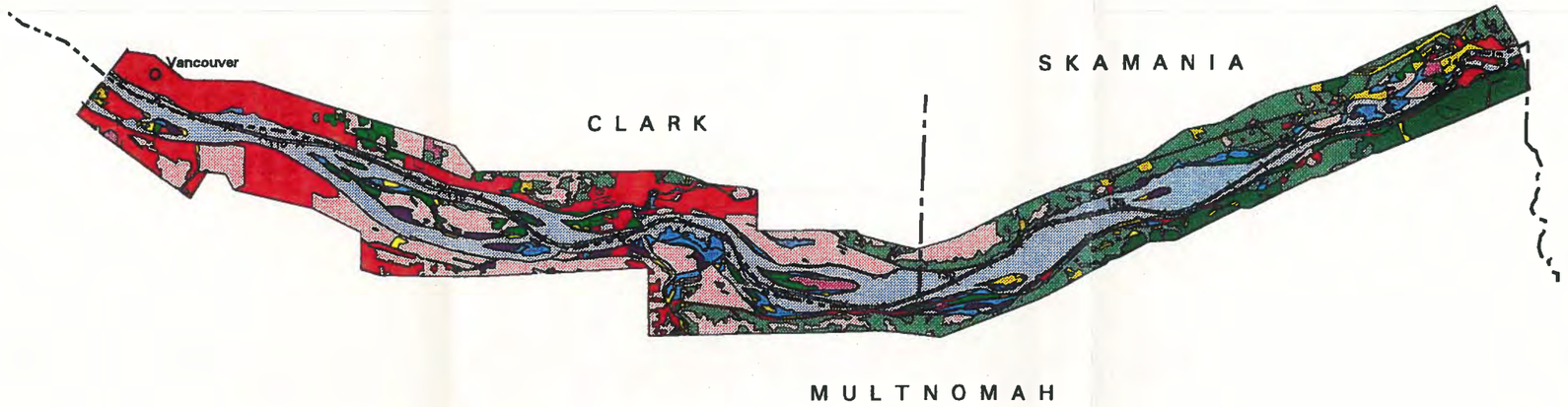
Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

GENERALIZED HABITATS AND LAND COVER

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1973

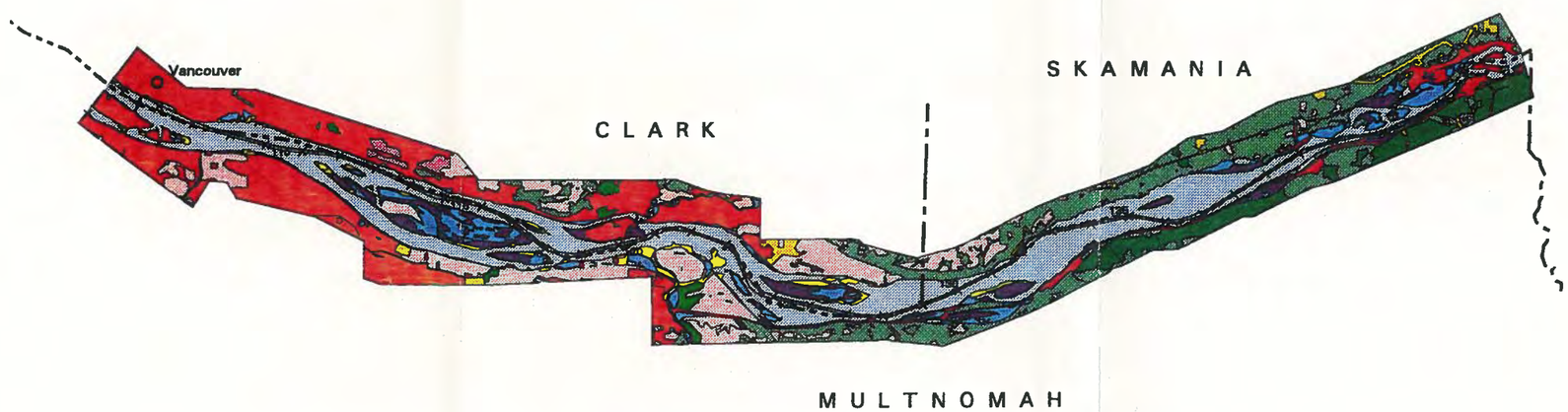


Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

1983



UPPER UNIT
Miles 105.5 - 146.8

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

GENERALIZED HABITATS AND LAND COVER

1991

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
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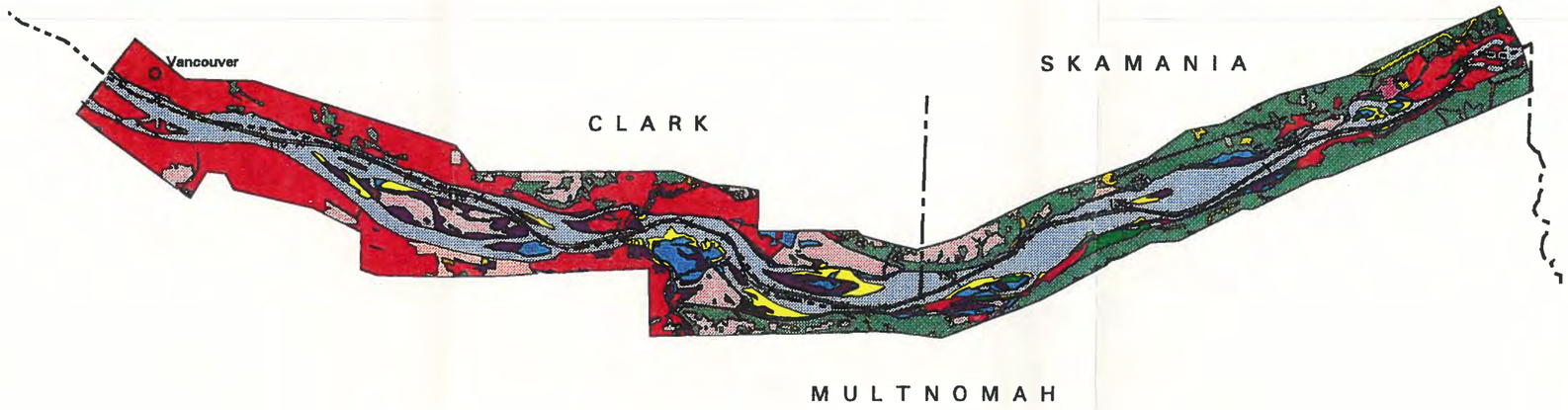


Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

UPPER UNIT
Miles 105.5 - 146.8

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

Riverine (R) All wetlands and deepwaters contained within a channel and are upstream of the saline (7.5%) estuarine environment. Persistent emergents indicate the classification to be other than riverine.

Riverine tidal (Rt) Low gradient. The water velocity fluctuates under the tidal influence

Riverine lower perennial (Rl) Low gradient. The water velocity is not influenced by tides, and some water flows throughout the year.

Upper perennial (Ru) High gradient. Velocity is fast and not influenced by tides, and some water flows throughout the year.

Lacustrine (L) All wetlands and deepwaters that include the following characteristics (typically lacustrine refers to lakes):

1) situated in a topographic depression

2) lacking persistent emergents (at least 70% of the water must be too deep to support emergents)

3) total area must exceed 20 acres; (however, if the lacustrine system under 20 acres is very deep [2 meters] and it does not support emergents, then the system is still classifed as lacustrine)

Lacustrine limnetic (Ll) all deepwaters within the lacustrine system

Lacustrine littoral (Lt) the shallow wetlands (<2 meters) which extend from the shore to the non-persistent emergent deepwaters; typically found along the shoreline.

Palustrine (P) All non-tidal wetlands documented by persistent emergents, trees, or shrubs; examples may include backwaters, ox-bows, and ponds and also includes the following characteristics:

1) areas less than 20 acres with emergents

2) areas in which the water depth is shallow (< 2 meters); if emergents persist (marshes and swamps) may include areas which are greater than 20 acres.

Delineations Due to the extremely short time frame to complete the project, work was divided into two major tasks to be handled concurrently. Consultation and technical support services for the first task, aerial photography interpretation, were provided by Bohica Enterprises and by the Oregon State University Department of Geosciences. A team of eight to ten interpreters worked on consecutive photographic dates, completing one date before beginning another. This process assured consistency across all five aerial photographic dates. The interpretation was accomplished by overlaying the photographs with a mylar overlay and delineating the habitat classes. Stereopairs were viewed to differentiate between various classes that are elevation dependent, such as tidally influenced wetlands. The polygons were classified according to the above system. The mylar overlays were then transferred to USGS 7.5' quad overlays using a zoom transfer scope. Quality control was performed for each step to assure the accuracy of delineations, classifications, and edge matching (See Figures 1 through 11).

The second major task included digitizing the 200 mylar overlays, editing, attributing, and analyses. As much as possible, the work was performed concurrent with the interpretation. Each set of forty overlays was digitized into a single file using an Intergraph system. The files are based on Oregon North Zone State Plane coordinate system, NAD 27, and were converted to Arc/Info coverages where they were attributed. A pulldown menu was used in the attribution process, to prevent errors in keying in polygon attributes, and to expedite the process. Each date averaged 3281.4 polygons for a total of 16407 polygons, and averaged 576,701 acres interpreted for a total of 2,883,504 acres.

ANALYSIS

To make meaningful comparisons between the photo dates, the coverages had to be limited geographically to analyze only that area common to all five coverages (see map sheets 1 and 2). Each of the five dates was then queried to determine the acreages of the various habitat classes. To aid in the interpretation of the figures, the study area was divided into three main units. The lower unit extends from the mouth of the Columbia River to river mile 46.5, which is the same study area as the Columbia River Estuary Data Development Program (CREDDP). The middle unit covers the area from river mile 46.5 to river mile 105.5, the upper limit of the U. S. Army Corps of Engineers Dredged Material Management Study (DMMS). The upper unit completes the study area to River mile 146.8, just above Bonneville Dam.

Tables 2 through 4 list the various habitat classes for each date by unit and their respective acreages. Tables 5 through 8 list the changes in habitat acreages by habitat class between 1948 and 1991.

Table 2 Acreage Statistics by Habitat Class and Year, Lower Unit Mouth to River mile 46.5 (Figures 3 to 5)

Code	Habitat Type	1948	1961	1973	1983	1991
1	Barren Land	770.73	1020.23	2817.43	904.86	1722.20
2Ms	Open Water	273.88	0.00	241.73	315.84	109.04
2Mi		320.20	238.70	220.52	291.32	496.98
2Es		52286.04	55251.29	55745.58	57251.15	57649.32
2Ei		49.04	0.00	5.98	163.56	0.00
2Rt		43920.68	38435.92	36105.42	38618.80	39631.78
2Rl		250.15	742.94	643.91	395.11	338.36
2Ru		0.00	79.44	0.00	0.00	0.00
2Ll		79.15	113.65	141.84	99.96	104.33
2Lt		2.01	0.00	0.00	0.00	0.00
2P		15.18	0.00	0.00	0.00	0.00
3	Grassland	33.98	148.40	225.78	29.27	28.44
4Ms	Wetland/Marsh	0.00	0.00	0.00	0.00	0.00
4Mi		0.00	0.00	0.00	0.00	0.00
4Es		0.00	0.00	0.00	80.91	0.00
4Ei		3118.95	3631.85	1517.01	1141.17	993.89
4Rt		7426.79	2814.85	1802.70	1593.71	1965.18
4Rl		55.19	0.00	4.24	77.62	8.38
4Ru		0.00	0.00	0.00	0.00	0.00
4Ll		5.27	0.00	0.00	0.00	0.00
4Lt		143.28	14.93	38.86	43.33	5.31
4P		4035.66	12282.70	12711.47	10892.68	11424.41
5	Shrub/Scrub	4166.68	6033.33	12840.22	6671.49	8061.47
6	Savana-Like	206.39	113.13	0.00	0.00	54.19
7L	Coniferous Forest	6.73	93.91	1266.30	0.00	198.08
7H		5991.58	10000.55	6437.35	2070.49	689.23
8L	Broadleaf Forest	334.81	891.67	149.55	311.62	235.09
8H		406.44	1267.84	197.68	483.66	670.39
9L	Mixed Forest	7683.95	8652.16	7249.76	7787.68	21416.19
9H		23657.20	14918.94	14302.71	23724.49	9562.49
10	Agricultural Land	16288.74	15031.66	14504.55	13750.33	12815.12
11	Urban/Developed	3486.80	4025.59	5426.47	5119.15	5538.08
12	Forested Wetland	2738.33	2016.30	3297.49	6082.22	4165.24

Table 3 Acreage Statistics by Habitat Class and Year, Middle Unit River Mile 46.5 to River Mile 105.5 (Figures 6 to 8)

Code	Habitat Type	1948	1961	1973	1983	1991
1	Barren Land	1252.59	1841.24	2238.46	1681.15	1398.69
2Ms	Open Water	0.00	0.00	0.00	0.00	0.00
2Mi		0.00	0.00	0.00	0.00	0.00
2Es		0.00	0.00	0.00	0.00	0.00
2Ei		0.00	0.00	0.00	0.00	0.00
2Rt		30383.60	27964.39	27846.86	28087.98	27068.29
2Rl		1134.49	1898.21	862.26	537.64	817.75
2Ru		9.70	0.00	0.00	0.00	0.00
2Ll		2565.42	1318.69	1349.93	1939.17	1414.36
2Lt		406.56	209.95	0.00	13.54	0.00
2P		87.25	0.00	0.00	0.00	0.00
3	Grassland	334.30	387.64	594.58	88.96	71.14
4Ms	Wetland/Marsh	0.00	0.00	0.00	0.00	0.00
4Mi		0.00	0.00	0.00	0.00	0.00
4Es		0.00	0.00	0.00	0.00	0.00
4Ei		0.00	0.00	0.00	0.00	0.00
4Rt		1041.31	546.30	629.26	618.84	1246.17
4Rl		253.18	47.80	26.92	25.58	0.00
4Ru		0.00	0.00	0.00	0.00	0.00
4Ll		6.27	71.14	13.75	0.00	0.00
4Lt		1297.94	1032.49	743.92	993.28	983.30
4P		7280.42	9601.75	4647.61	6500.16	4883.93
5	Shrub/Scrub	1164.39	1435.79	2025.63	1299.20	3909.82
6	Savana-Like	1350.14	1168.71	570.63	78.85	420.38
7L	Coniferous Forest	0.00	368.82	89.13	15.82	476.59
7H		4.98	1117.90	137.02	283.48	101.83
8L	Broadleaf Forest	5875.09	1950.37	3234.35	1092.02	804.54
8H		3006.32	2928.20	1336.04	739.80	1208.07
9L	Mixed Forest	4754.09	5476.29	3138.31	3433.23	4809.36
9H		10477.43	8946.89	13472.70	12896.31	9132.98
10	Agricultural Land	37572.30	39073.96	42299.68	41248.70	40634.58
11	Urban/Developed	6819.16	8670.69	11297.92	13375.54	15970.43
12	Forested Wetland	4493.47	5409.85	5016.09	6657.00	6251.49

Table 4 Acreage Statistics by Habitat Class and Year, Upper Unit
River Mile 105.5 to River Mile 146.8 (Figrues 9 to 11)

Code	Habitat Type	1948	1961	1973	1983	1991
1	Barren Land	1537.16	1615.95	825.94	1250.43	1826.73
2Ms	Open Water	0.00	0.00	0.00	0.00	0.00
2Mi		0.00	0.00	0.00	0.00	0.00
2Es		0.00	0.00	0.00	0.00	0.00
2Ei		0.00	0.00	0.00	0.00	0.00
2Rt		21.45	0.00	29.89	26.61	27.53
2Rl		19373.06	18928.83	18346.12	19009.13	18055.05
2Ru		0.00	0.00	0.00	4.37	0.00
2Ll		244.46	335.10	179.73	265.04	192.99
2Lt		150.11	3.00	10.56	12.19	7.25
2P		13.21	0.00	0.00	0.00	0.00
3	Grassland	947.78	231.97	67.55	29.89	64.81
4Ms	Wetland/Marsh	0.00	0.00	0.00	0.00	0.00
4Mi		0.00	0.00	0.00	0.00	0.00
4Es		0.00	0.00	0.00	0.00	0.00
4Ei		0.00	0.00	0.00	0.00	0.00
4Rt		1.90	0.00	54.53	0.00	0.00
4Rl		983.18	185.27	989.03	508.57	212.39
4Ru		0.00	0.00	0.00	29.27	0.00
4Ll		7.57	3.87	13.06	12.67	0.00
4Lt		146.17	187.84	180.46	76.46	26.85
4P		5119.79	5601.51	2418.13	3497.79	2341.33
5	Shrub/Scrub	2663.04	1499.17	1602.13	1080.95	752.69
6	Savana-Like	632.23	164.51	592.98	398.38	214.24
7L	Coniferous Forest	315.60	1164.95	188.74	413.69	0.00
7H		623.26	774.15	2924.47	2897.19	222.70
8L	Broadleaf Forest	816.43	419.07	1391.56	281.76	100.27
8H		833.25	622.37	1049.57	340.69	585.51
9L	Mixed Forest	3499.61	8507.17	5453.25	7860.78	1450.92
9H		10392.85	4070.22	5364.52	3244.93	12847.11
10	Agricultural Land	9620.07	11436.72	12766.58	8001.76	6785.13
11	Urban/Developed	7869.27	10219.43	11625.26	15275.98	18166.47
12	Forested Wetland	1447.48	1263.59	1069.76	2756.06	3395.67

Table 5. Change in Habitat Acreage, 1948-1991- Lower Unit, River Miles 0 to 46.5.

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	770.73	0.43%	1722.20	0.97%	951.47	0.53%
2	Open Water	97196.33	54.68%	98329.81	55.28%	1133.48	0.64%
3	Grassland	33.98	0.02%	28.44	0.02%	-5.54	0.00%
4	Wetlands/Marsh	14785.14	8.32%	14397.17	8.09%	-387.97	-0.22%
5	Shrub/Scrub	4166.68	2.34%	8061.47	4.53%	3894.79	2.19%
6	Savanna-Like	206.39	0.12%	54.19	0.03%	-152.20	-0.09%
7	Coniferous Forest	5998.31	3.37%	887.31	0.50%	-5111.00	-2.87%
8	Broadleaf Forest	741.25	0.42%	905.48	0.51%	164.23	0.09%
9	Mixed Forest	31341.15	17.63%	30978.68	17.42%	-362.47	-0.20%
10	Agricultural Land	16288.74	9.16%	12815.12	7.20%	-3473.62	-1.95%
11	Urban/Developed	3486.80	1.96%	5538.08	3.11%	2051.28	1.15%
12	Forested Wetland	2738.33	1.54%	4165.24	2.34%	1426.91	0.80%

Table 6. Change in Habitat Acreage, 1948-1991- Middle Unit, River Miles 46.5 to 105.5.

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	1252.59	1.03%	1398.69	1.15%	146.10	0.12%
2	Open Water	34587.02	28.45%	29300.40	24.09%	-5286.62	-4.35%
3	Grassland	334.30	0.27%	71.14	0.06%	-263.16	-0.22%
4	Wetlands/Marsh	9879.12	8.13%	7113.40	5.85%	-2765.72	-2.27%
5	Shrub/Scrub	1164.39	0.96%	3909.82	3.22%	2745.43	2.26%
6	Savanna-Like	1350.14	1.11%	420.38	0.35%	-929.76	-0.76%
7	Coniferous Forest	4.98	0.00%	578.42	0.48%	573.44	0.47%
8	Broadleaf Forest	8881.41	7.31%	2012.61	1.66%	-6868.80	-5.65%
9	Mixed Forest	15231.52	12.53%	13942.34	11.47%	-1289.18	-1.06%
10	Agricultural Land	37572.30	30.91%	40634.58	33.42%	3062.28	2.52%
11	Urban/Developed	6819.16	5.61%	15970.43	13.13%	9151.27	7.53%
12	Forested Wetland	4493.47	3.70%	6251.49	5.14%	1758.02	1.45%

Table 7. Change in Habitat Acreage, 1948-1991- Upper Unit, River Miles 105.5 to 146.8..

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	1537.16	2.29%	1826.73	2.72%	289.57	0.43%
2	Open Water	19802.29	29.44%	18282.82	27.18%	-1519.47	-2.26%
3	Grassland	947.78	1.41%	64.81	0.10%	-882.97	-1.31%
4	Wetlands/Marsh	6258.61	9.31%	2580.57	3.84%	-3678.04	-5.47%
5	Shrub/Scrub	2663.04	3.96%	752.69	1.12%	-1910.35	-2.84%
6	Savanna-Like	632.23	0.94%	214.24	0.32%	-417.99	-0.62%
7	Coniferous Forest	938.86	1.40%	222.70	0.33%	-716.16	-1.06%
8	Broadleaf Forest	1649.68	2.45%	685.78	1.02%	-963.90	-1.43%
9	Mixed Forest	13892.46	20.66%	14298.03	21.25%	405.57	0.60%
10	Agricultural Land	9620.07	14.30%	6785.13	10.09%	-2834.94	-4.21%
11	Urban/Developed	7869.27	11.70%	18166.47	27.00%	10297.20	15.31%
12	Forested Wetland	1447.48	2.15%	3395.67	5.05%	1948.19	2.90%

Table 8. Change in Habitat Acreage, 1948-1991-All Units, River Miles 0 to 146.8.

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	3560.48	0.97%	4947.62	1.35%	1387.14	0.38%
2	Open Water	151585.64	41.35%	145913.03	39.78%	-5672.61	-1.55%
3	Grassland	1316.06	0.36%	164.39	0.04%	-1151.67	-0.31%
4	Wetlands/Marsh	30922.87	8.44%	24091.14	6.57%	-6831.73	-1.86%
5	Shrub/Scrub	7994.11	2.18%	12723.98	3.47%	4729.87	1.29%
6	Savanna-Like	2188.76	0.60%	688.81	0.19%	-1499.95	-0.41%
7	Coniferous Forest	6942.15	1.89%	1688.43	0.46%	-5253.72	-1.43%
8	Broadleaf Forest	11272.34	3.07%	3603.87	0.98%	-7668.47	-2.09%
9	Mixed Forest	60465.13	16.49%	59219.05	16.15%	-1246.08	-0.34%
10	Agricultural Land	63481.11	17.32%	60234.83	16.42%	-3246.28	-0.89%
11	Urban/Developed	18175.23	4.96%	39674.98	10.82%	21499.75	5.86%
12	Forested Wetland	8679.28	2.37%	13812.40	3.77%	5133.12	1.40%

In addition to the above, it was suggested that an analysis be performed that was limited to the comparison of only the 1948 and 1991 photography. This would result in the inclusion of some significant wetland areas that were not covered by intermediate photo dates. Therefore, the area of analysis was expanded to cover that area common to the 1948 and 1991 photography. Tables 10 through 12 summarize the analysis of the expanded study area. See map sheets one and two for the expanded study area limits outlined in red, and the original study area limits outlines in black. Figures 16, 17, and 18 show the habitats of the expanded study areas.

Table 10. Expanded Study Area, Habitat Acreages - Lower Unit - Mouth to River Mile 46.5

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	825.95	0.38%	1801.19	0.84%	975.24	0.45%
2Ms	Open Water	9147.05	4.26%	7966.26	3.71%	-1180.79	-0.55%
2Ml		412.53	0.19%	837.89	0.39%	425.36	0.20%
2Es		52565.50	24.50%	58580.06	27.30%	6014.56	2.80%
2Ei		49.04	0.02%	0.00	0.00%	-49.04	-0.02%
2Rt		44032.65	20.52%	39744.45	18.52%	-4288.20	-2.00%
2Rl		277.72	0.13%	342.00	0.16%	64.28	0.03%
2Ru		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Ll		84.04	0.04%	105.04	0.05%	21.00	0.01%
2Lt		2.01	0.00%	0.00	0.00%	-2.01	0.00%
2P		15.18	0.01%	0.00	0.00%	-15.18	-0.01%
3	Grassland	54.02	0.03%	28.44	0.01%	-25.58	-0.01%
4Ms	Wetland/Marsh	0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ml		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Es		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ei		3151.57	1.47%	995.14	0.46%	-2156.43	-1.01%
4Rt		7426.79	3.46%	1965.30	0.92%	-5461.49	-2.55%
4Rl		55.19	0.03%	8.38	0.00%	-46.81	-0.02%
4Ru		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ll		5.27	0.00%	0.00	0.00%	-5.27	0.00%
4Lt		143.28	0.07%	4.81	0.00%	-138.47	-0.06%
4P		4388.15	2.05%	11521.56	5.37%	7133.41	3.32%
5	Shrub/Scrub	6493.19	3.03%	15020.35	7.00%	8527.16	3.97%
6	Savana-Like	220.28	0.10%	54.15	0.03%	-166.13	-0.08%
7L	Coniferous Forest	215.91	0.10%	255.09	0.12%	39.18	0.02%
7H		16634.73	7.75%	1120.78	0.52%	-15513.95	-7.23%
8L	Broadleaf Forest	334.81	0.16%	234.85	0.11%	-99.96	-0.05%
8H		406.00	0.19%	730.46	0.34%	324.46	0.15%
9L	Mixed Forest	8757.35	4.08%	34244.71	15.96%	25487.36	11.88%
9H		34409.12	16.04%	13869.48	6.46%	-20539.64	-9.57%
10	Agricultural Land	18137.98	8.45%	14981.28	6.98%	-3156.70	-1.47%
11	Urban/Developed	3558.70	1.66%	5742.64	2.68%	2183.94	1.02%
12	Forested Wetland	2740.76	1.28%	4394.79	2.05%	1654.03	0.77%
		214544.77	100.00%	214549.10	100.00%		

Table 11. Expanded Study Area, Habitat Acreages - Middle Unit - River Mile 46.5 to 105.5

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	1273.01	0.69%	1398.69	0.75%	125.68	0.07%
2Ms	Open Water	0.00	0.00%	0.00	0.00%	0.00	0.00%
2Mi		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Es		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Ei		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Rt		31614.37	17.03%	28159.14	15.17%	-3455.23	-1.86%
2Rl		1618.45	0.87%	1018.08	0.55%	-600.37	-0.32%
2Ru		9.70	0.01%	0.00	0.00%	-9.70	-0.01%
2Ll		8140.81	4.38%	5706.96	3.07%	-2433.85	-1.31%
2Lt		500.11	0.27%	0.00	0.00%	-500.11	-0.27%
2P		103.31	0.06%	0.00	0.00%	-103.31	-0.06%
3	Grassland	501.63	0.27%	126.52	0.07%	-375.11	-0.20%
4Ms	Wetland/Marsh	0.00	0.00%	0.00	0.00%	0.00	0.00%
4Mi		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Es		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ei		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Rt		1239.16	0.67%	1475.34	0.79%	236.18	0.13%
4Rl		258.39	0.14%	0.00	0.00%	-258.39	-0.14%
4Ru		64.54	0.03%	0.00	0.00%	-64.54	-0.03%
4Ll		41.73	0.02%	0.00	0.00%	-41.73	-0.02%
4Lt		2412.98	1.30%	2558.41	1.38%	145.43	0.08%
4P		10285.58	5.54%	7357.94	3.96%	-2927.64	-1.58%
5	Shrub/Scrub	3225.94	1.74%	10027.94	5.40%	6802.00	3.66%
6	Savana-Like	2708.45	1.46%	499.66	0.27%	-2208.79	-1.19%
7L	Coniferous Forest	0.00	0.00%	488.78	0.26%	488.78	0.26%
7H		27.01	0.01%	906.08	0.49%	879.07	0.47%
8L	Broadleaf Forest	7713.30	4.15%	1073.90	0.58%	-6639.40	-3.58%
8H		3754.11	2.02%	1650.86	0.89%	-2103.25	-1.13%
9L	Mixed Forest	12822.94	6.91%	7884.20	4.25%	-4938.74	-2.66%
9H		21682.19	11.68%	22661.94	12.21%	979.75	0.53%
10	Agricultural Land	59593.51	32.10%	58589.16	31.56%	-1004.35	-0.54%
11	Urban/Developed	10260.01	5.53%	26200.87	14.11%	15940.86	8.59%
12	Forested Wetland	5806.61	3.13%	7878.23	4.24%	2071.62	1.12%
		185657.84	100.00%	185662.70	100.00%		

Table 12. Expanded Study Area, Habitat Acreages - Upper Unit - River Miles 105.5 to 146.8

Code	Habitat Type	1948	%	1991	%	Acreage +/-	% Change
1	Barren Land	1598.97	1.85%	1827.60	2.12%	228.63	0.27%
2Ms	Open Water	0.00	0.00%	0.00	0.00%	0.00	0.00%
2Mi		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Es		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Ei		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Rt		21.45	0.02%	27.53	0.03%	6.08	0.01%
2Rl		19731.60	22.88%	18251.29	21.16%	-1480.31	-1.72%
2Ru		0.00	0.00%	0.00	0.00%	0.00	0.00%
2Ll		371.06	0.43%	362.84	0.42%	-8.22	-0.01%
2Lt		151.00	0.18%	7.26	0.01%	-143.74	-0.17%
2P		22.11	0.03%	0.00	0.00%	-22.11	-0.03%
3	Grassland	1081.83	1.25%	64.81	0.08%	-1017.02	-1.18%
4Ms	Wetland/Marsh	0.00	0.00%	0.00	0.00%	0.00	0.00%
4Mi		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Es		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ei		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Rt		1.90	0.00%	0.00	0.00%	-1.90	0.00%
4Rl		1013.84	1.18%	212.40	0.25%	-801.44	-0.93%
4Ru		0.00	0.00%	0.00	0.00%	0.00	0.00%
4Ll		19.08	0.02%	0.00	0.00%	-19.08	-0.02%
4Lt		186.44	0.22%	40.67	0.05%	-145.77	-0.17%
4P		5955.19	6.91%	2387.62	2.77%	-3567.57	-4.14%
5	Shrub/Scrub	3447.64	4.00%	981.84	1.14%	-2465.80	-2.86%
6	Savana-Like	795.68	0.92%	232.55	0.27%	-563.13	-0.65%
7L	Coniferous Forest	354.88	0.41%	22.68	0.03%	-332.20	-0.39%
7H		807.68	0.94%	265.46	0.31%	-542.22	-0.63%
8L	Broadleaf Forest	838.50	0.97%	122.28	0.14%	-716.22	-0.83%
8H		871.00	1.01%	617.18	0.72%	-253.82	-0.29%
9L	Mixed Forest	4624.40	5.36%	2415.29	2.80%	-2209.11	-2.56%
9H		12152.18	14.09%	15869.36	18.40%	3717.18	4.31%
10	Agricultural Land	18888.04	21.90%	10763.33	12.48%	-8124.71	-9.42%
11	Urban/Developed	11760.09	13.64%	28229.34	32.74%	16469.25	19.10%
12	Forested Wetland	1539.43	1.79%	3534.35	4.10%	1994.92	2.31%
		86233.99	100.00%	86235.68	100.00%		

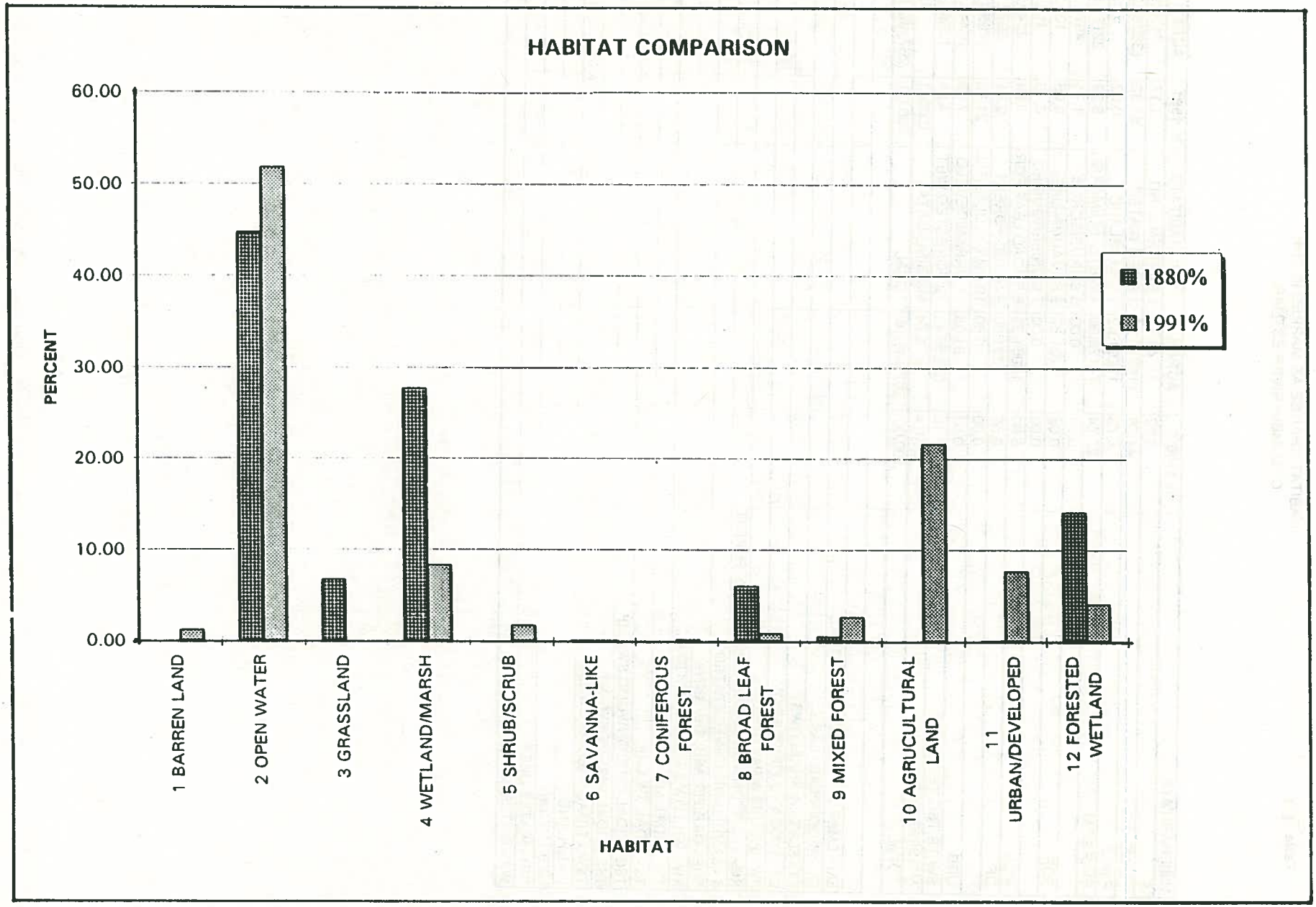
Table 13

HABITAT CHANGE AS MAPPED IN THE
COLUMBIA RIVER ESTUARY

1880 HABITATS	% 1880'S	ACRES	1991 HABITATS	% 1991	ACRES	% CHANGE
S	0.02	44.71	1 BARREN LAND	1.17	3128.33	1.15
FL,WD,WS	44.76	119713.27	2 OPEN WATER	51.82	138589.29	7.06
PW,U	6.73	17991.62	3 GRASSLAND	0.02	61.37	-6.70
EM,FS,TM	27.74	74178.30	4 WETLAND/MARSH	8.29	22181.00	-19.44
	0.00	0.00	5 SHRUB/SCRUB	1.71	4575.17	1.71
SOF	0.08	201.57	6 SAVANNA-LIKE	0.05	135.27	-0.02
	0.00	0.00	7 CONIFEROUS FO	0.16	415.50	0.16
RCA	6.00	16051.39	8 BROAD LEAF FOR	0.84	2240.20	-5.16
OF	0.50	1331.80	9 MIXED FOREST	2.61	6972.12	2.11
	0.00	0.00	10 AGRUCULTURAL	21.63	57856.43	21.63
URB	0.03	81.08	11 URBAN/DEVELO	7.65	20446.97	7.61
SW,TS,TSC,TSS,TSW	14.15	37855.42	12 FORESTED WET	4.06	10851.04	-10.10
MISSING DATA	0.0014	3.74	MISSING DATA	0.0001	0.17	0.00
TOTAL	100.00	267,449.16	TOTAL	100.00	267,452.86	

EM - EMERGENT MARSH NOT TIDAL
FL - FLOODPLAIN LAKE
FS - FLATS & SHALLOWS
OF - OAK AND FIR FOREST
PW - PRARIE & PASTURE
RCA - COTTONWOOD AND ASH RIPARIAN FOREST
S - SAND BANK UNVEGETATED
SOF - OAK,FIR ASH, SAVANNA
SW - WILLOW SWAMP NOT TIDAL
TM - TIDAL MARSH
TS - TIDAL SWAMP
TSC - TIDAL COTTONWOOD SWAMP
TSS - TIDAL SPRUCE SWAMP
TSW - TIDAL WILLOW SWAMP
U - UPLAND
URB - URBAN
WD - WATER DEEP
WS - WATER SHALLOW

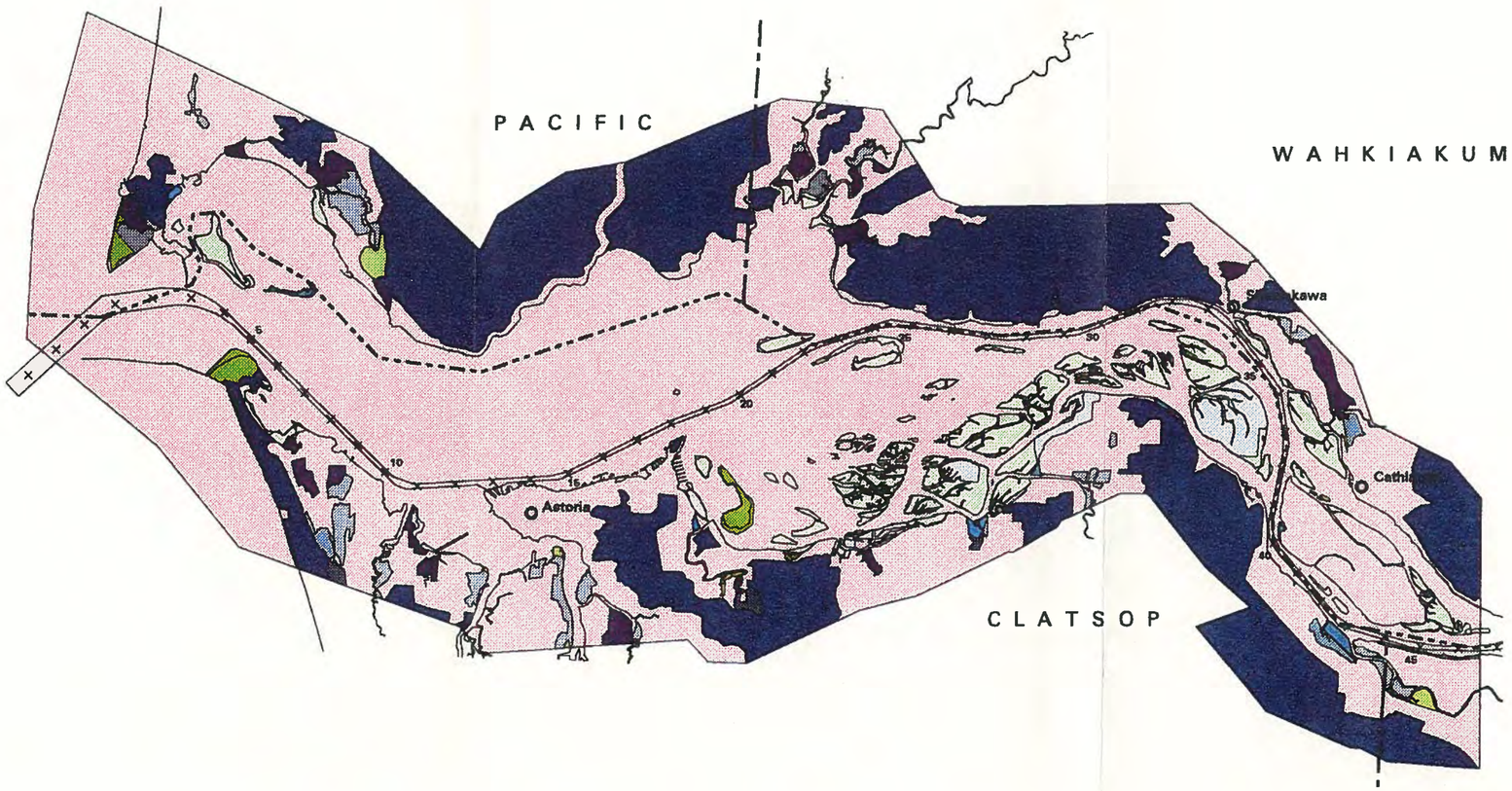
COMPARISON BETWEEN
1880 AND 1991 HABITAT USING 1991 HABITAT
CLASSES



SIGNIFICANT HABITATS
1991

Habitat Classification

- Minimally Disturbed Areas: Riparian or Wetlands (A1)
- Minimally Disturbed Areas: Riparian or Wetlands (A2)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A3)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A4)
- Minimally Disturbed Areas: Largely Uplands (Forest, Savanna, Grassland) (A5)
- Potentially Rehabilitated or Enhanced Habitat (B1)
- Potentially Rehabilitated or Enhanced Habitat (B2)
- Potentially Rehabilitated or Enhanced Habitat (B3)
- Potentially Rehabilitated or Enhanced Habitat (B4)
- Potentially Rehabilitated or Enhanced Habitat (B5)
- Potentially Rehabilitated or Enhanced Habitat (B6)
- Potentially Rehabilitated or Enhanced Habitat (B7)
- Potentially Rehabilitated or Enhanced Habitat (B8)
- Potentially Rehabilitated or Enhanced Habitat: Largely Uplands (B9)
- Severly Disturbed, Little Potential for Recovery; Deep Water; or Open Water (C)



LOWER UNIT
Miles 0 - 46.5

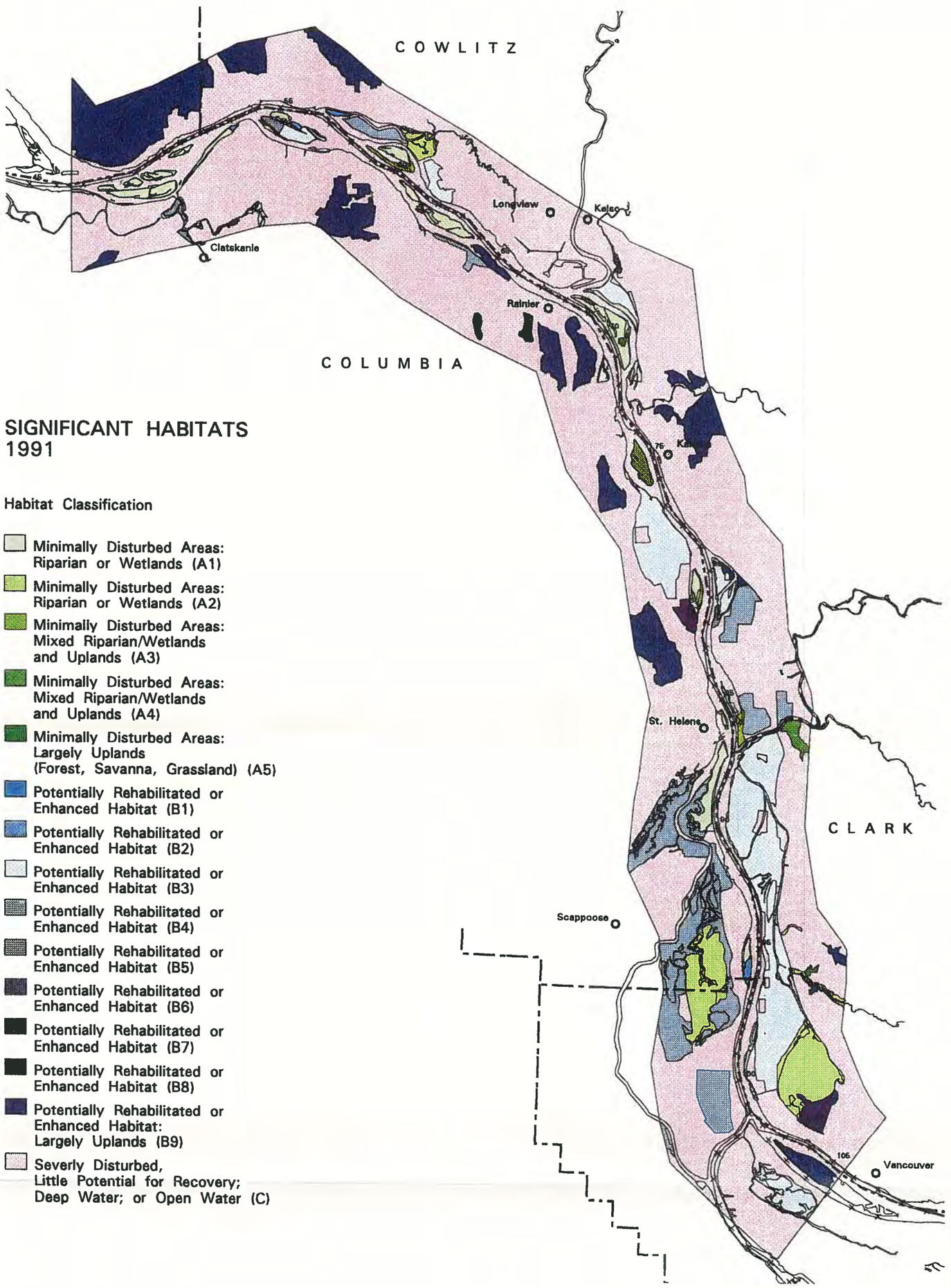
Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996



SIGNIFICANT HABITATS 1991

Habitat Classification

- Minimally Disturbed Areas: Riparian or Wetlands (A1)
- Minimally Disturbed Areas: Riparian or Wetlands (A2)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A3)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A4)
- Minimally Disturbed Areas: Largely Uplands (Forest, Savanna, Grassland) (A5)
- Potentially Rehabilitated or Enhanced Habitat (B1)
- Potentially Rehabilitated or Enhanced Habitat (B2)
- Potentially Rehabilitated or Enhanced Habitat (B3)
- Potentially Rehabilitated or Enhanced Habitat (B4)
- Potentially Rehabilitated or Enhanced Habitat (B5)
- Potentially Rehabilitated or Enhanced Habitat (B6)
- Potentially Rehabilitated or Enhanced Habitat (B7)
- Potentially Rehabilitated or Enhanced Habitat (B8)
- Potentially Rehabilitated or Enhanced Habitat: Largely Uplands (B9)
- Severly Disturbed, Little Potential for Recovery; Deep Water; or Open Water (C)

MIDDLE UNIT
Miles 46.5 - 105.5

Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

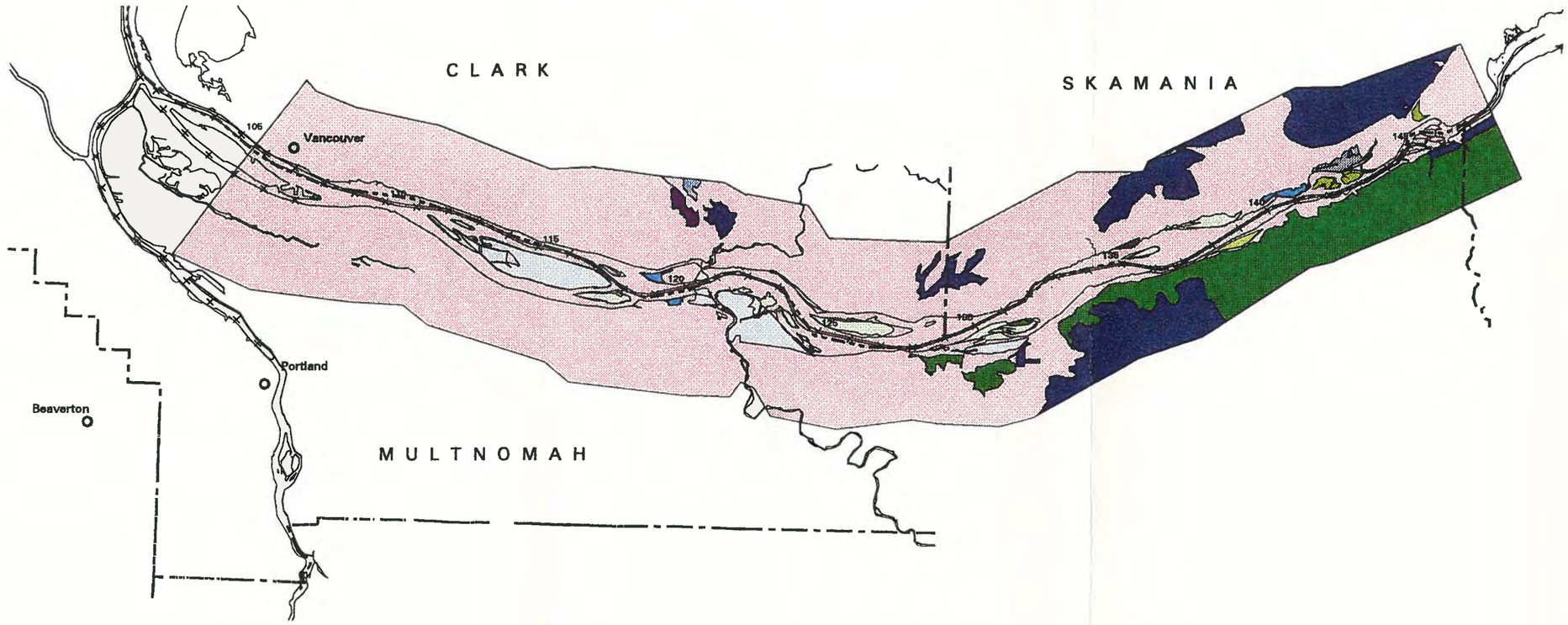
FISH, WILDLIFE AND WETLANDS GIS HABITAT MAPPING
Prepared by: U.S. Army Corps of Engineers

FIGURE 13
LOWER COLUMBIA RIVER BI-STATE WATER QUALITY PROGRAM

SIGNIFICANT HABITATS 1991

Habitat Classification

- Minimally Disturbed Areas: Riparian or Wetlands (A1)
- Minimally Disturbed Areas: Riparian or Wetlands (A2)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A3)
- Minimally Disturbed Areas: Mixed Riparian/Wetlands and Uplands (A4)
- Minimally Disturbed Areas: Largely Uplands (Forest, Savanna, Grassland) (A5)
- Potentially Rehabilitated or Enhanced Habitat (B1)
- Potentially Rehabilitated or Enhanced Habitat (B2)
- Potentially Rehabilitated or Enhanced Habitat (B3)
- Potentially Rehabilitated or Enhanced Habitat (B4)
- Potentially Rehabilitated or Enhanced Habitat (B5)
- Potentially Rehabilitated or Enhanced Habitat (B6)
- Potentially Rehabilitated or Enhanced Habitat (B7)
- Potentially Rehabilitated or Enhanced Habitat (B8)
- Potentially Rehabilitated or Enhanced Habitat: Largely Uplands (B9)
- Severly Disturbed, Little Potential for Recovery; Deep Water; or Open Water (C)



UPPER UNIT
Miles 105.5 - 146.8

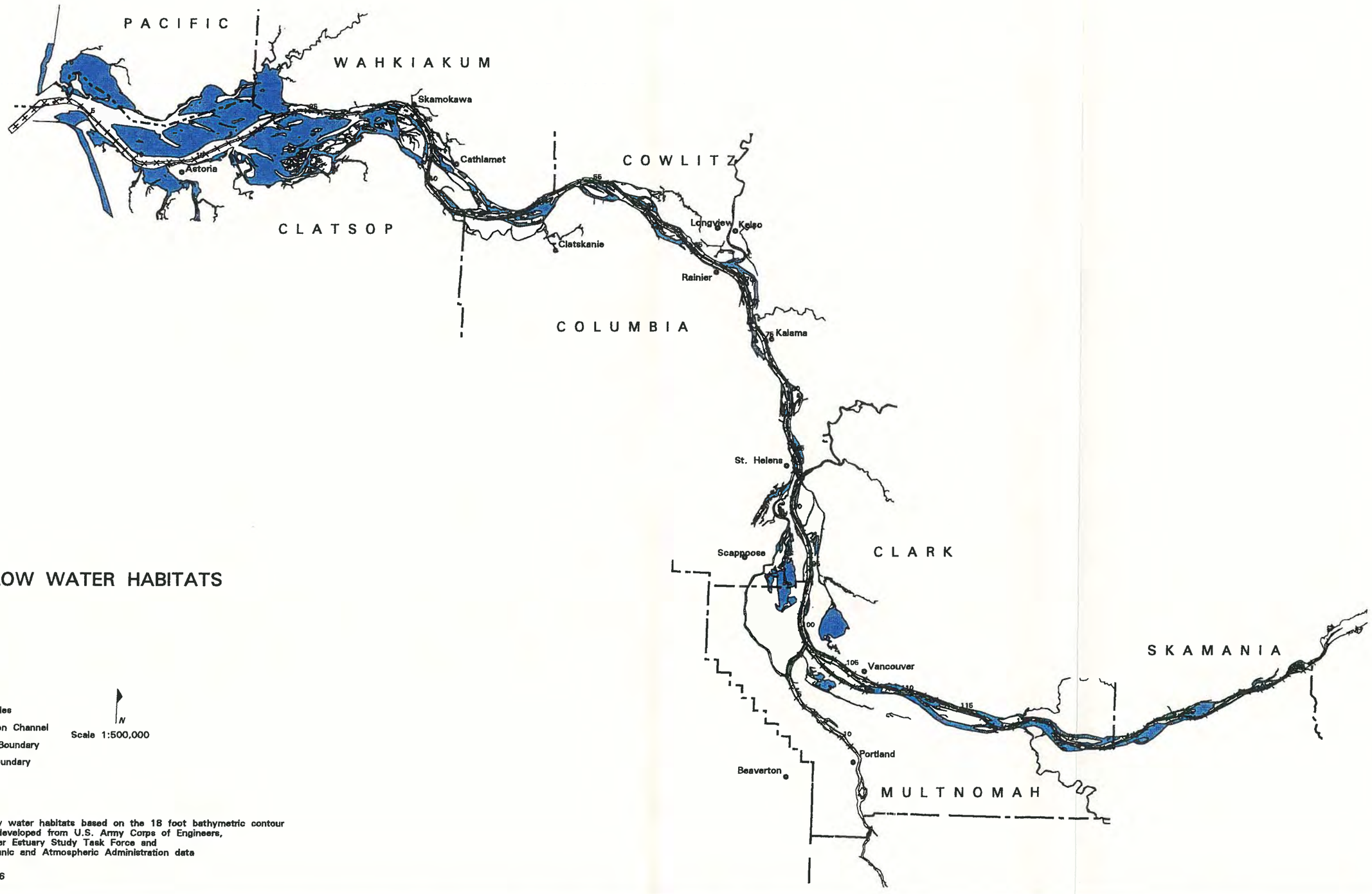
Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996



SHALLOW WATER HABITATS
1991

Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:500,000

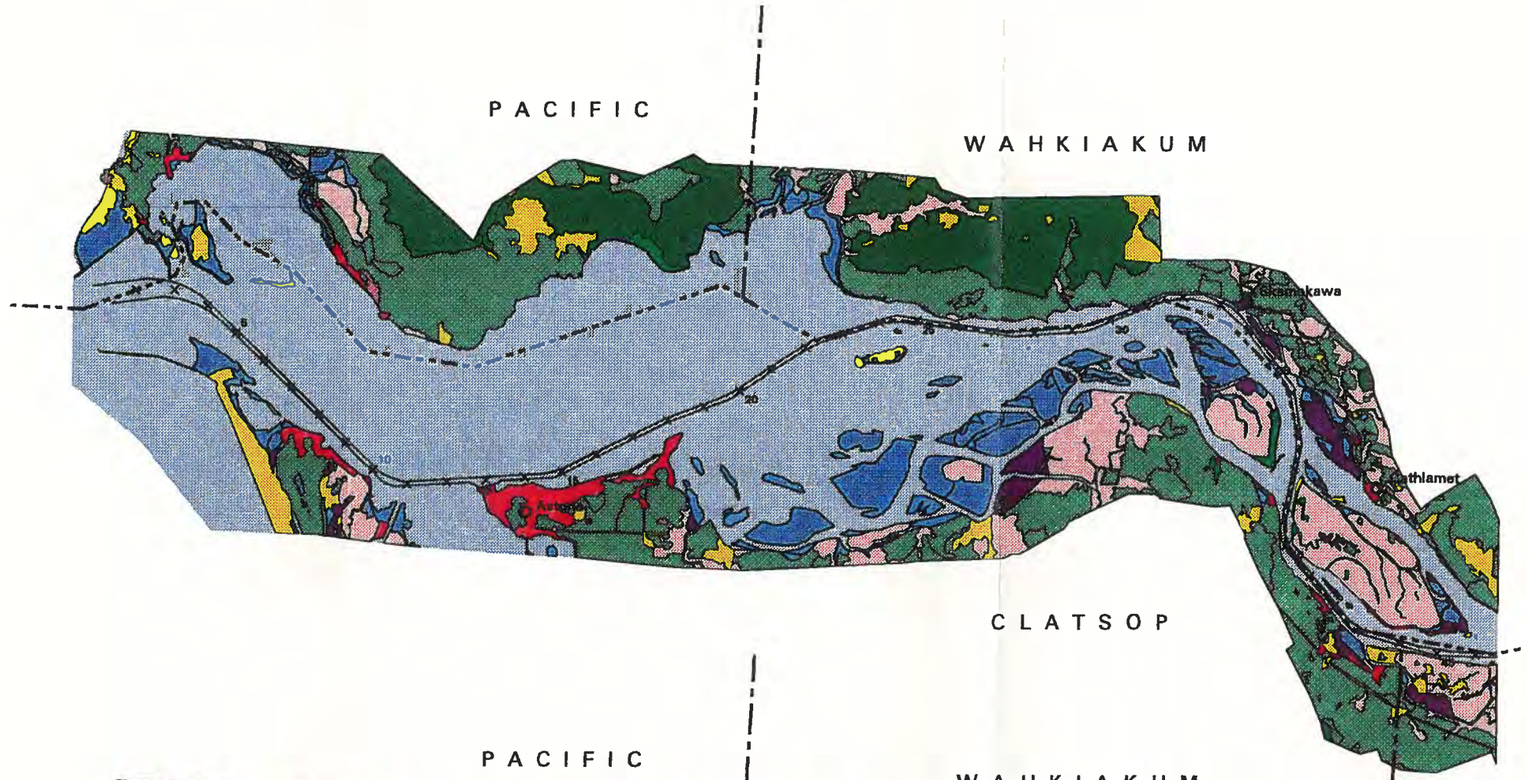
Note: Shallow water habitats based on the 18 foot bathymetric contour
Delineations developed from U.S. Army Corps of Engineers,
Columbia River Estuary Study Task Force and
National Oceanic and Atmospheric Administration data

February 1996

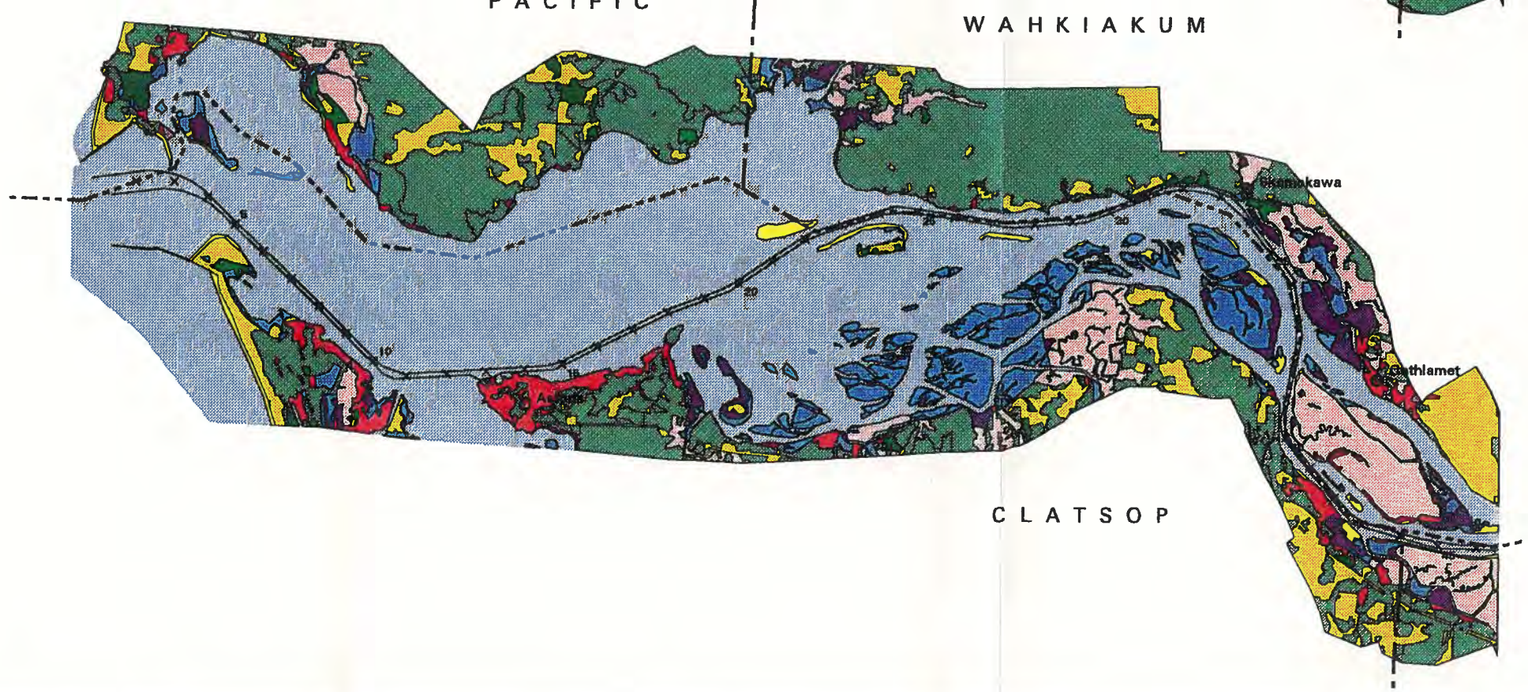
GENERALIZED HABITATS AND LAND COVER FOR EXPANDED AREA

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1948



1991



Legend
- River Miles
- Navigation Channel
- County Boundery
- State Boundary

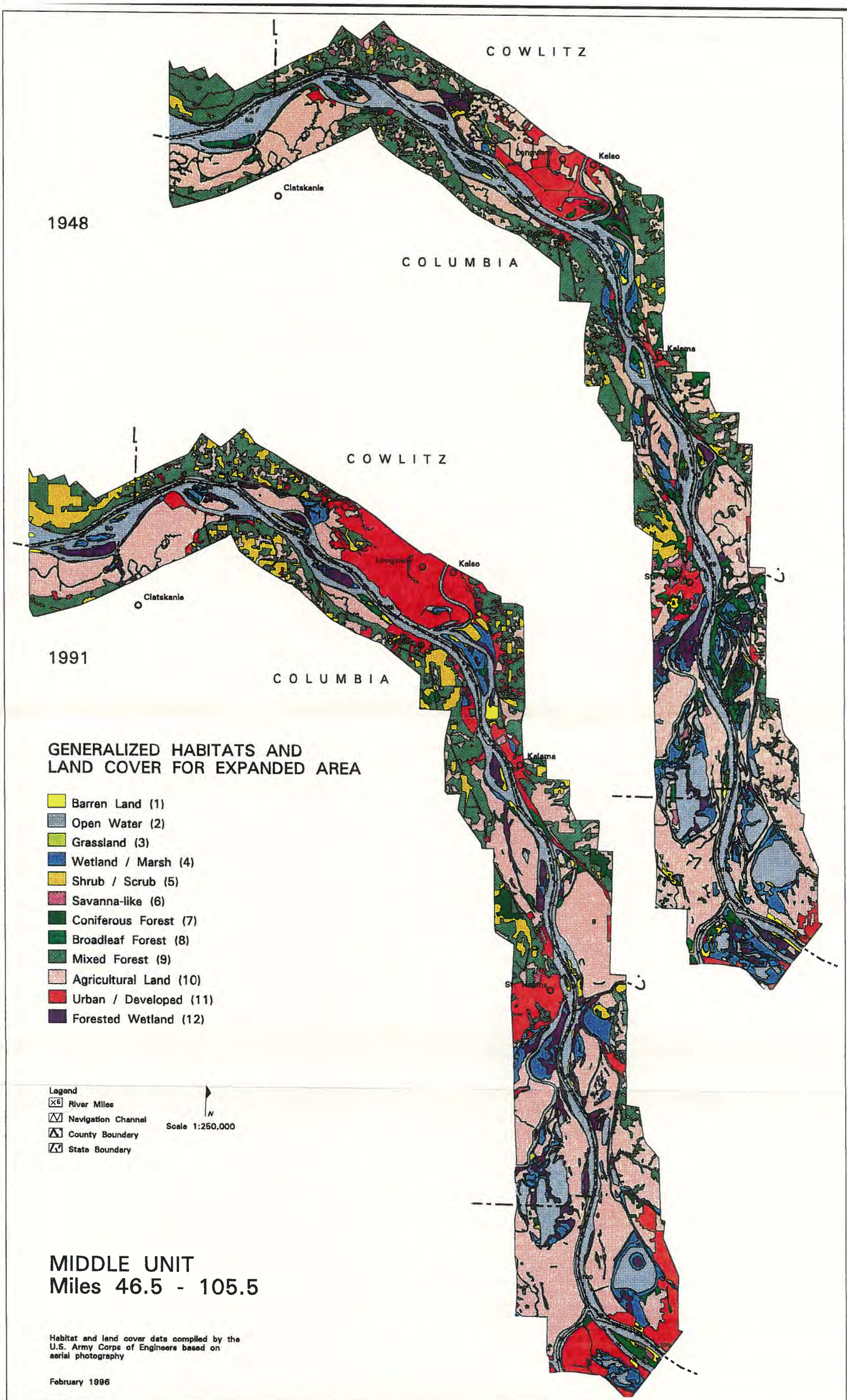
N

Scale 1:250,000

LOWER UNIT
Miles 0 - 46.5

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996



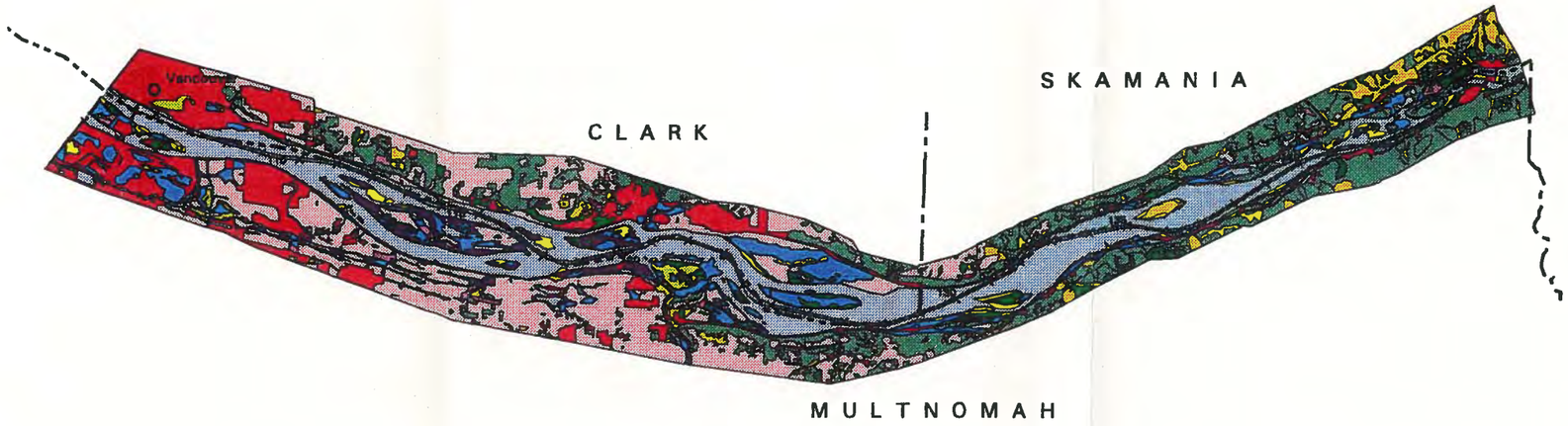
FISH, WILDLIFE AND WETLANDS GIS HABITAT MAPPING
Prepared by: U.S. Army Corps of Engineers

FIGURE 17
LOWER COLUMBIA RIVER BI-STATE WATER QUALITY PROGRAM

GENERALIZED HABITATS AND LAND COVER FOR EXPANDED AREA

- Barren Land (1)
- Open Water (2)
- Grassland (3)
- Wetland / Marsh (4)
- Shrub / Scrub (5)
- Savanna-like (6)
- Coniferous Forest (7)
- Broadleaf Forest (8)
- Mixed Forest (9)
- Agricultural Land (10)
- Urban / Developed (11)
- Forested Wetland (12)

1948

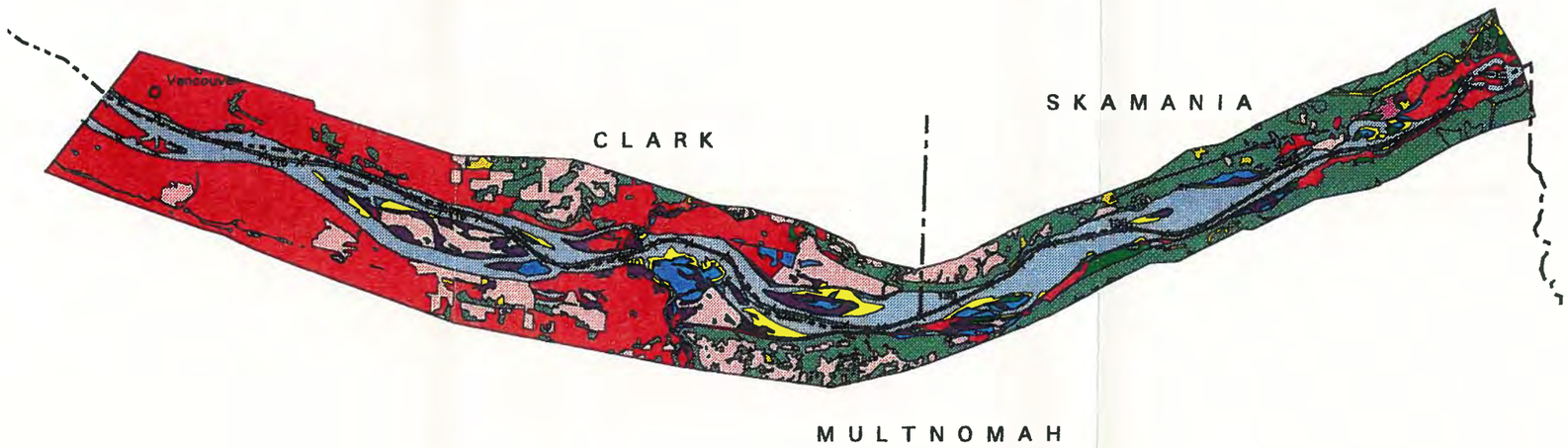


Legend
- River Miles
- Navigation Channel
- County Boundary
- State Boundary

N

Scale 1:250,000

1991



UPPER UNIT
Miles 105.5 - 146.8

Habitat and land cover data compiled by the U.S. Army Corps of Engineers based on aerial photography

February 1996

COMPARISON OF HISTORICAL 1880'S TO CURRENT 1991 HABITAT CHANGES

Table 13 identifies the habitat changes from the 1880's using the Columbia River Estuary Study Taskforce (CREST) data from their June 1995 publication "Historic Habitats of the Lower Columbia River", to 1991 for each comparable habitat type. CREST created two overlay maps that produced corresponding areas of coverage and acreage to calculate the percent habitat and acreage changes. The following bar chart presents this data in graphic format.

SIGNIFICANT HABITAT AREAS

The second part of the analysis provided for identifying significant habitat areas. These are areas that:

1. are undisturbed; habitat areas that have no apparent human impacts, such as roads, trails, fills, excavations, or development.
2. may be rehabilitated or enhanced to improve their value as habitat.

The term 'undisturbed', or 'untouched' are somewhat vague and narrow. Taken at face value, very little area on Lower Columbia River could be described as such. Therefore the following criteria were developed and applied by Oregon State University, Department of Geosciences, to identify undisturbed areas from the 1991 date of photography (See table 1 above for a description of the 1991 photos).

1. Undisturbed refers to human impacts, not natural impacts.
2. The total land area for each identifiable habitat must be at least 0.2 square miles. This is necessary due to photo resolution at 1:48,000 scale. Species diversity is another concern. Smaller habitats are greatly affected by surrounding land uses, resulting in a decrease in species and habitat diversity. The natural functions of habitats smaller than 0.2 square miles (128 acres) are assumed to be disturbed.
3. Habitats must display no or minimal impact. Cultural influences must be less than one percent of these natural lands.
4. Habitats and surface processes are naturally functioning.
5. There can be no evidence of human settlement.
6. Forested areas must contain a majority of trees that have not been cut in approximately the past forty years.

Habitats that have returned to their natural state following human disturbance will be included.

Similarly, the following criteria were developed to delineate areas to be considered for rehabilitation:

1. **The total land area for each identifiable habitat must be at least 250 acres.**

2. **The disturbance upon the habitat and associated land unit cannot be so severe that recovery would be severely inhibited. Such lands may include:**

   a) **Urban areas**
   b) **Paved roads**
   c) **Mines**
   d) **All homes or buildings which are either occupied or in use**

3. **Habitats must be able to recover naturally or with minimal human intervention. Habitats that are allowed to recover by simply removing the anthropogenic agent are favorable (i.e. the removal of cattle from a parcel of land). Minimal human intervention must occur at a similar scale as in the following examples:**

   a) **Dike excavation or small scale removal (e.g. removal of less than 100 feet of dike to restore natural flow**
   b) **Blockade of road and trail access**
   c) **Culvert placement beneath road mounds (this would allow for the reconnection natural flows)**
   d) **Removal of abandoned structures**

Using the above criteria, the 1991 photographs were interpreted using the following classification system (the area of analysis was not geographically limited, but extended to the maximum coverage of the 1991 aerial photography);

A1 Minimally disturbed areas that

- **Have riparian or wetland characteristics**
- **Are adjacent to the Columbia River or Bay**

A2 Minimally disturbed areas that

- Have riparian or wetland characteristics
- Are linked to the Columbia River via tributary or canal, or are in the active floodplain, or are palustrine

A3 Minimally disturbed areas that

- Have mixed riparian / wetland and upland characteristics
- Are adjacent to the river

A4 Minimally disturbed areas that

- Have mixed riparian / wetland and upland characteristics
- Are linked to the Columbia River via tributary or canal, or is in the active or historic floodplain, or are palustrine

A5 Minimally disturbed areas that

- Largely upland characteristics (forest, savanna, grassland)

B1 Potentially Rehabilitated or Enhanced Habitats

- Where rehabilitation will naturally occur
- That have riparian or wetland characteristics, or have historical indications of riparian or wetland conditions
- That are adjacent to the Columbia River

B2 Potentially Rehabilitated or Enhanced Habitats

- Where rehabilitation will naturally occur
- That have riparian or wetland characteristics or have historical indications of riparian or wetland conditions
- That are linked to the Columbia River via tributary or canal, or are in the active or historic floodplain, or is palustrine

B3 Potentially Rehabilitated or Enhanced Habitats that

- Will be rehabilitated with minimal human intervention
- Have riparian or wetland characteristics, or have historical indications of riparian or wetland conditions
- Are adjacent to the River

B4 Potentially Rehabilitated or Enhanced Habitats

- Will be rehabilitated with minimal human intervention
- Have riparian or wetland characteristics, or have historical indications of riparian or wetland conditions
- Are linked to the Columbia River via tributary or canal, or are in the active or historic floodplain, or are palustrine

B5 Potentially Rehabilitated or Enhanced Habitats

- Where rehabilitation will naturally occur
- That have mixed riparian / wetland and upland characteristics
- That are adjacent to the River

B6 Potentially Rehabilitated or Enhanced Habitats

- Where rehabilitation will naturally occur
- That have mixed riparian / wetland and upland characteristics
- That are linked to the Columbia River via tributary or canal, or is in the active or historic floodplain, or are palustrine

B7 Potentially Rehabilitated or Enhanced Habitats that

- Will be rehabilitated with minimal human intervention
- Have mixed riparian / wetland and upland characteristics
- Are adjacent to the River

B8 Potentially Rehabilitated or Enhanced Habitats that

- Will be rehabilitated with minimal human intervention
- Have mixed riparian / wetland and upland characteristics
- Are linked to the Columbia River via tributary or canal, or is in the active or historic floodplain, or are palustrine

B9 Potentially Rehabilitated or Enhanced Habitats

- Where rehabilitation will naturally occur
- With largely upland characteristics

C Other habitats that

- Have been severely disturbed and have little potential for recovery
- Are largely upland in character

This interpretation resulted in the production of 40 additional mylar overlays. The mylars were digitized, attributed, and queried for acreage totals per habitat code (see table 14).

Table 14 - Significant Habitats - Based on 1991 Aerial Photography

Habitat Code	Acreage	Percentage
A1	19,077.92	3.0
A2	7,677.76	1.0
A3	1,997.72	.5
A4	860.86	.5
A5	14,320.03	2.0
B1	1,312.69	.5
B2	1,082.45	.5
B3	24,978.51	3.5
B4	17,799.87	2.5
B5	1,266.15	.5
B6	549.19	.5
B7	765.30	.5
B8	4,391.46	.5
B9	98,673.65	15.0
C	458,684.22	69.0
Total Acreage	653,437.78	100.0

COMPLETE GIS DATA FOR DMMS STUDY AREA, PORTLAND TO BONNEVILLE DAM

The Columbia River Dredged Material Management Study (DMMS) is an ongoing study of the lower Columbia River from the mouth to river mile 105.5. The Bi-State study team determined that some of the data produced for the DMMS would be valuable for inclusion in the GIS for the Bi-State Water Quality Program. However, completion of the additional 40 miles of study area is necessary. Funding was provided to the Corps of Engineers to append a shallow water habitat map, originally produced for the DMMS. This map delineates areas that are less than or equal to 18' in depth, which is important habitat for juvenile salmonids. This map was produced utilizing recent Corps of Engineers hydrographic surveys, supplemented by data from NOAA charts. The map, originally compiled on an Intergraph workstation, has been converted to an Arc/Info coverage.

Other data themes completed for the Bi-State study area include the federally authorized navigation channel, river mile markers, hydrography (1:24,000 scale), political boundaries, major roads and rail lines, and state parks. This data has not yet been converted to Arc/Info coverages.

INVESTIGATION OF CURRENT / HISTORICAL EXISTING MAPPED DATA

An effort was made to investigate the availability of existing wetlands, fish and wildlife habitat data, and site specific habitat and species data. This investigation was done before any data compilation was performed by the Corps of Engineers, to ensure there would not be redundancy with data collection efforts. Contacted agencies included:

Bonneville Power Administration	Environmental Protection Agency	US Fish and Wildlife Service
National Biological Service	NW Power Planning Council	OR Div. Of State Lands
OR Dept. Of Fish and Wildlife	OR Dept. Of Land Cons. And Dev.	OR Water Res. Dept.
National Marine Fisheries Serv.	OR State Service Center for GIS	The Nature Conservancy
WA Dept. Of Fish and Wildlife	WA Dept. Of Natural Resources	WA Dept. Of Energy

It is not within the scope of this report to detail the specific geographic information available at each agency . However, it must be noted that no agency indicated the availability of data similar to that being produced for the Bi-State Water Quality Program, either in a spatial or historical context.

Funding was not provided to acquire or incorporate any other GIS data into the Bi-State study. However, all available National Wetland Inventory maps were acquired in digital form directly from the US Fish and Wildlife Service on the Internet, and converted to Arc/Info coverages with funding provided by the Corps of Engineers Dredged Material Management Study (DMMS). Approximately 75% of the Bi-State study area is covered by 31 coverages. All coverages are available in UTM or State Plane coordinate systems. This data, as well as all other GIS data produced by the Corps of Engineers for the Columbia River Dredged Material Management Study or the Bi-State Water Quality Program is available for distribution.

Recommendations for Potential Future Work Tasks

The following is a list of potential data layers and work items that the Bi-State Water Quality Study Team may consider for the future.

- **Bank-to-bank hydrographic surveys (bathymetry)**
- **Orthophotography / topography**
- **Dredging related information - Existing, approved, and proposed dredged material disposal sites, site capacities, shoaling areas**
- **Near shore soils classification**
- **Continuation of habitat mapping using newly acquired 1995 color infrared aerial photography**
- **Digital image processing of satellite or fixed-wing aircraft multi-spectral imagery**
- **Acquisition of aerial videography**
- **Acquisition of relevant data available at various agencies**

APPENDIX A
RESPONSE TO COMMENTS

COMMENT: The Corps of Engineers report should be integrated with the report by CREST, based on historic maps for the LCR based on 19th century survey maps.
RESPONSE: This was accomplished with the most recent draft revision. An effort was made to coordinate the classification systems between the two projects, so that comparisons could be made between the mapping developed from historic 19th century surveys and the historic aerial photo interpretation.

COMMENT: The habitat types delineated appear to be more land cover types than true habitat types. Perhaps this can be resolved through fine tuning of the classification by state and federal resource managers.
RESPONSE: The classification system was chosen and approved by Oregon DEQ and Washington Dept. Of Ecology previous to the mapping effort. The system is based on a 1976 Corps of Engineers study, with additional emphasis on wetlands. The wetland catagories are based on the National Wetland Inventory classification system, as directed by Oregon DEQ. Any modifications to the classification system would result in changes in the photo interpreted delineations. This is essentially reworking the entire project.

COMMENT: Some appropriate level of ground truth based validation of the digital habitat maps should be undertaken.
RESPONSE: The scope of work was developed to keep costs within the allocated funding and to accomplish the project within a very limited timeframe. While it is agreed that the methodology would include field work under ideal circumstances, ground truthing at any level was not possible given the level of funding provided and the sceduling requirements.

COMMENT: The areas of coverage for the two GIS efforts differ (Corps versus CREST). Apparently the CREST and Corps mapping boundaries were constrained or determined by the coverage of available historic photos and survey maps. The boundaries of the mapped areas could not be determined on the basis of consistent criteria such as extent of floodplain area or some other hydrographic or natural factors. It appears that the artificial map boundaries cut off large areas of wetlands and other riparian habitats within

the historic floodplain that are or were very important. It cleary under estimates the total existing and historic habitat and very likely underestimates habitat loss. The map boundary limitations were unavoidable, but ways to correct this limitation could be explored.

RESPONSE: The mapping efforts were directed to extend out two miles from the shoreline of the Columbia River. No other hydrographic or natural criteria were specified. The extent of coverage was often reduced by the limited coverage of aerial photos and surveys. As stated, this was unavoidable. No other source of historic aerial photos or surveys is known to exist that would add to the coverage. The analysis of habitat loss for the Corps mapping was limited to the area common to all five photo dates. This did artifically reduce the study area and eliminate some important wetland areas from consideration. Therefore, the final report is appended with an analysis that compares the habitats for only two photo dates, 1948 and 1991. This expanded the study area to include some significant areas, such as Sauvie Island.

COMMENT: For future work recommendations, it is suggested that future digital maps should include coverages for land use and incorporate refinement of habitat classifications. I also recommend in addition to the remote sensing techniques proposed by the Corps, that aerial videography be considered.

RESPONSE: Any modifications to the classifications for future work should be coordinated with the existing work, so that comparisons may be made. The proposal for aerial videography have been added to the recommendations future work.

COMMENT: Some reviewers expressed concern for the section on significant habitat areas. These are the areas that were identified as undisturbed or as having a potential for rehabilitation. Catagory C may be too general and miss some potential restoration sites.

RESPONSE: Few criteria were specified as to how these areas are defined and therefore identified. This leaves much open to subjective interpretation. However, if the presence of occupied structures and paved roads are not a deterent to rehabilitation, then catagory C could be modified, resulting in much of the lands currently within that catagory to be reclassified. If funding is available in the future, this interpretation could be refined with input from various agencies.

Many other minor comments were made that were incorporated into this report.

APPENDIX B

Chronology of important events affecting the physical evolution of the Columbia River Estuary

1792	Captain George Vancouver commanding sent Lt. Broughton to chart river and mouth: single entrance channel, controlling depth 8 m (27 ft); Robert Gray prepared harbor sketch.
1805	Lewis and Clark expedition arrived.
1811	Fort Astoria constructed by Pacific Fur Company.
1839	Sir Edward Belcher survey: two entrance channels, controlling depth 8 m (27 ft).
1840's	Irrigation began in Columbia River basin.
1841	Wilkes survey.
1844 to present	Log and lumber exports.
1849	Large June freshet.
1849 -1850	First USCGS bathymetric survey (Lt. Commander McArthur).
1850's	First salmon canneries.
1863	June freshet >26,900 m^3s^{-1} (950,000 cfs).
1867 -1877	USCGS survey of estuary and river.
1867	Dredging begun in Willamette River.
1868	First dikes in place in Youngs Bay.
1873 -1874	Dredging of the Hogsback bar, Cordell Channel.
1876	June freshet >27,180 m^3s^{-1} (960,000 cfs).
1877	Navigation channel from mouth to Vancouver/Portland approved by Congress.
1878	First current observations.
1880	June freshet >26,050 m^3s^{-1} (920,000 cfs); first scrape-dredging on bar.
1882	9 m (30 ft) entrance channel approved.
1883	Peak of cannery operations.

pre-1885	Only occasional dredging and a few training structures were employed to date.
mid-1880's	Minor dredging in Cordell Channel.
1885	South Jetty construction began.
1890	Cordell Channel no longer in use.
1890's	First pile dikes constructed in river channel.
1893	Snag Island dike (and Green Island and Marsh Island dikes?) built: Cordell Channel closed and flow diverted to North Channel.
1894	June freshet >33,980 m^3s^{-1} (1,2 kcfs); first extensive dredging (305,820 m^3, 400,000 yd^3) after freshet.
1895	6.8 km (4.25 mi) South Jetty completed with four groins; 9.5 m (31 ft) controlling depth in entrance channel; rock ledge near upper Astoria blasted.
1899	7.6 m (25 ft) river channel from mouth to Portland authorized.
1899-1902	Dredging across Upper Sands Shoal: navigation channel realigned.
1902	Three entrance channels, controlling depth 6.7 m (22 ft).
1903	Dredge Grant arrived.
1904	Dredge Chinook arrived.
1905	River and Harbor Act of 3 March 1905 approved 12.2 m (40 ft) Entrance Project, including extension of South Jetty.
1909	Grays River channel obstructions cleared.
1912	River and Harbor Act, 9.1 m (30 ft) channel authorized from Brookfield to Portland.
1913	North Jetty construction began; Cowlitz River channel dredged to 1.2 m (4 ft); Oregon slough dredged to 7.6 m (25 ft); Baker Bay (east) channel dredged to 3.4 m (11 ft).
1914	South Jetty extension completed; 7.3 m (24 ft) entrance channel obtained; extensive dredging and pile dike construction in Columbia River channel to Portland begins.
1917	North Jetty extension completed; 9.1 m (30 ft) channel authorized from mouth to Brookfield.
1918	Entrance channel controlling depth 12.2 m (40 ft).
1920	Skamokawa Creek channel cleared to 2 m (6.5 ft).

1924	Clatskanie River channel dredged to 1.8 m (6 ft).
1927	Entrance channel controlling depth 14.3 m (47 ft).
1928	Deep River channel cleared to 2.4 m (8 ft); 10.7 m (35 ft) river channel recommended.
1931	South Jetty rehabilitation begun; Lake River channel dredged to 1.8 m (6 ft).
1932	Chinook pile dike constructed; COE current survey at mouth.
1933	Rock Island Dam.
1934	Ilwaco (east) Channel completed (3.1 m, 10 ft).
1935	10.7 m (35 ft) Columbia River Channel completed; dikes along Columbia River completed, channel revision at Harrington Point completed; Multnomah channel completed (7.6 m, 25 f5); Cathlamet side channel (3.1 m, 10 ft) completed.
1935 -1939	USCGS bathymetric survey of estuary and river.
1936	Flood Control Act of 22 June 1936; extensive COE diking begun, largely completed by 1942; South Jetty rehabilitated (asphalt added); COE salinity measurements.
1938	Bonneville Dam; Youngs Bay channel cleared (3.1 m, 10 ft); North Jetty rehabilitation begun (concrete terminal and asphalt added).
1939	Jetty A completed; four Sand Island pile dikes completed; North Jetty rehabilitation completed; Skipanon channel dredged (9.1 m, 30 ft); Skipanon peninsula created with dredged material; Westport slough dredged (8.5 m, 28 ft); Elochoman slough dredged (3.1 m, 10 ft).
1939 -1955	Dredging at entrance confined to Clatsop Spit.
1940	Chinook Channel (3.1 m, 10 ft), mooring basin, and breakwaters completed.
1941	Grand Coulee Dam; concrete terminal added to South Jetty.
1942 -1945	Mott Basin dredged, Lois Island created/enlarged?
1944	Ilwaco (west) Channel mostly completed (3.1 m, 10 ft).
1945	Regular annual dredging (of outer bar?) initiated.
1947 -1958	USCGS bathymetric survey of estuary and river.

1948	June freshet >28,320 m^3s^{-1} (1 kcfs); Ilwaco (west) Channel (2.4 m, 8 ft) and three pile dikes (on larger Sand Island) completed.
1950	Flood Control Act of 17 May 1950; Astoria east boat basin completed.
1951	Channel alignment on Desdemona shoal.
1953	McNary Dam; fourth pile dike on larger Sand Island completed.
1954	River and Harbor Act of 3 September 1954: 14.6 m (48 ft) entrance channel project approved.
1955	Chief Joseph Dam.
1956	Begin dredging 14.6 m (48 ft) entrance channel.
1957	The Dalles Dam; Warrenton mooring basin (3.7 m, 12 ft) completed; Ilwaco (west) Channel (3.1 m, 10 ft) completed; 14.6 m (48 ft) entrance channel obtained.
1958	Westport slough cleared (8.5 m, 28 ft); Chinook harbor breakwaters extended; dredge material disposal Sites A and C abandoned, Site B used extensively.
1959	Priest Rapids Dam; COE current meter study.
1960	Cowlitz River channel dredged to 2.7 m (9 ft).
1961	Rocky Reach Dam; South Jetty and Jetty A rehabilitated.
1962	12.2 m (40 ft) Columbia River channel to RK-169 (RM-105) and 18.5 km (11.5 mi) up Willamette River authorized; completion of WES physical model of Columbia River.
1963	Wanapum Dam; prototype physical measurements initiated by WES.
1965	Radionuclide studies of estuary sediments
1966	Astoria-Megler Bridge completed, radionuclide studies of Columbia River sediments.
1967	Wells Dam.
1968	Mica Lake, Arrow Lake Dams.
1975	COE current meter studies.
1976	12.2 m (40 ft) river channel completed from mouth to Portland/Vancouver; Oregon slough deepened to 12.2 m (40 ft).
1977	15.9 m (52 ft) entrance project initiated; COE current meter studies.
1978	COE current meter studies.
1979	Initiation of CREDDP field work.

1980	Mt. St. Helens eruption and associated mudflows into the Columbia River at Kelso/Longview.
1980 -1983	5-11 million m^3 of material dredged from the Cowlitz/Columbia confluence.
1981	NOS current meter survey.
1982	Coal port channel (16.7-18.3 m, 55-60 ft) to Tongue Point (RM-18) proposed.

Sources: U.S. Army Engineers (1875, 1903), various Congressional documents (House of Representatives Document, 1899, 1900, 1917, 1919, 1921, 1946; House of Representatives Report, 1906; Senate Documents 1881, 1917), U.S. Army Corps of Engineers (1960), Lockett (1963, 1967), Oregon Historical Society (1980), Roy et al. (1982), George Blomberg (pers. communication), David Jay (pers. communication).