Juneau Wetlands Functions and Values

Prepared by Adamus Resource Assessment, Inc.
Prepared for City and Borough of Juneau, Alaska
September 1987

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JUNEAU WETLANDS: FUNCTIONS AND VALUES

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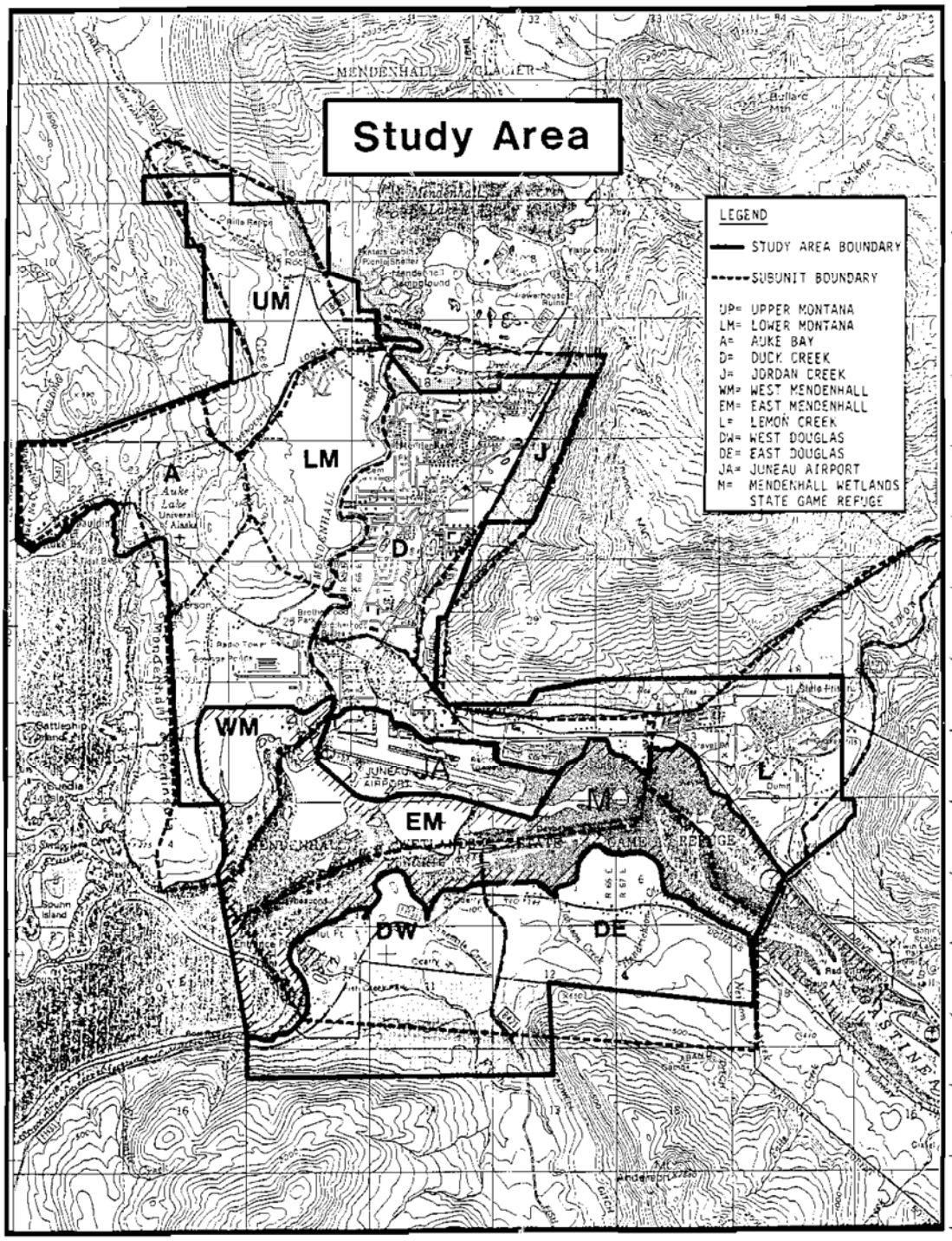

Study Area
LEGEND
STUDY AREA BOUNDARY
SUBUNIT BOUNDARY
UP= UPPER MONTANA
LM= LOWER MONTANA
A= AUKE BAY
D= DUCK CREEK
J= JORDAN CREEK
WM= WEST MENDENHALL
EM= EAST MENDENHALL
L= LEMON CREEK
DW= WEST DOUGLAS
DE= EAST DOUGLAS
JA= JUNEAU AIRPORT
M= MENDENHALL WETLANDS STATE GAME REFUGE
UM
LM
A
J
D
WM
JA
EM
M
L
DW
DE

1.0 INTRODUCTION

For more than a decade there have been laws which regulate development activities in Juneau wetlands. These laws reflect a national consensus that wetlands are sensitive, important areas. Until recently, these laws were enforced weakly or inconsistently. In the confusion, some normally law-abiding citizens discovered in retrospect that some of their activities – actions as simple as improving drainage on their land, filling a low spot, or putting in a driveway – violated wetland laws and perhaps degraded some aspects of the environment.

Wetlands occupy 54 percent of the study area's land surface, a relatively large amount even considering the fact that study boundaries were drawn to include most local wetlands. (This figure may be conservative, as it is based on the Corps of Engineers wetland maps and excludes wetlands smaller than 1 acre.) The study area of about 15 square miles comprises about half the land in City-Borough ownership. However, most of the CBJ owned land which is scheduled for provision of urban services, including public water, is within the study area. Freshwater wetlands alone occupy 31% of the study area.

If future growth is to remain an option, locations for industrial and residential growth must be found, without violating existing laws and with minimal compromise of the City's environmental integrity. The values of particular uplands, as well as wetlands, must be accounted for in the planning process, for their environmental functions in some cases may surpass those of particular wetlands. With due consideration given both to uplands and wetlands, and to local and national public interests, growth in Juneau can progress in the most environmentally responsible manner.

1.1 The Context: Wetland Loss in Juneau

Clearly, much of Juneau's growth has occurred on land that formerly was wetlands. Two graphics illustrate this fact. Both were prepared by U.S. Fish and Wildlife Service, Anchorage. Figure 1 depicts study wetlands area in 1948. Wetlands which since then have been filled are indicated. The second graphic is Table 1. Some salient points from this table are:

- Wetlands in 1948 comprised 59% of the study area.
- About 3032 of the original 9208 wetland acres (those present in 1948) have been filled (33%) for an annual loss rate of 0.9% per year.
- In all subunits of the study area (except Douglas Island and Lower Montana), there is more undeveloped upland remaining than undeveloped palustrine wetland. However, much of this upland has severe engineering limitations or consists of invaluable open space.
- Development since 1948 has been wetland-focused in the East and West Mendenhall subunits, but upland-focused elsewhere. These two subunits in 1948 had a greater percentage of their area in wetlands than did the other subunits.

The following should be kept in mind when interpreting these two graphics: (a) These estimates are based on interpretation of aerial photography, in which wetlands (particularly forested ones) are not always clearly identifiable, (b) the 1984 acreages for wetlands may differ from those derived from the 1984 Corps of Engineers maps, which had a greater degree of field verification but used a more conservative definition of "wetland," (c) The acreages reflect only direct destruction of wetlands due to roads, gravel pits, and residential/commercial development; they do not reflect the degradation (or perhaps in some cases, improvement) of some wetland functions which has occurred as an indirect result of development.

Although the Juneau study area's wetland loss rate (0.9% per year) is double the national loss rate, it represents the loss rate from a very localized area chosen specifically for its large wetland acreage and expected high loss rates. Southeast Alaska generally is expected to have lower wetland loss rates than the national average, despite widespread, usually indirect, impacts from resource extraction activities. Juneau is not unique in having a large portion of its land as wetland. However, around other cities with formerly great percentages of wetland (e.g., San Francisco, New Orleans) alternative building sites on non-

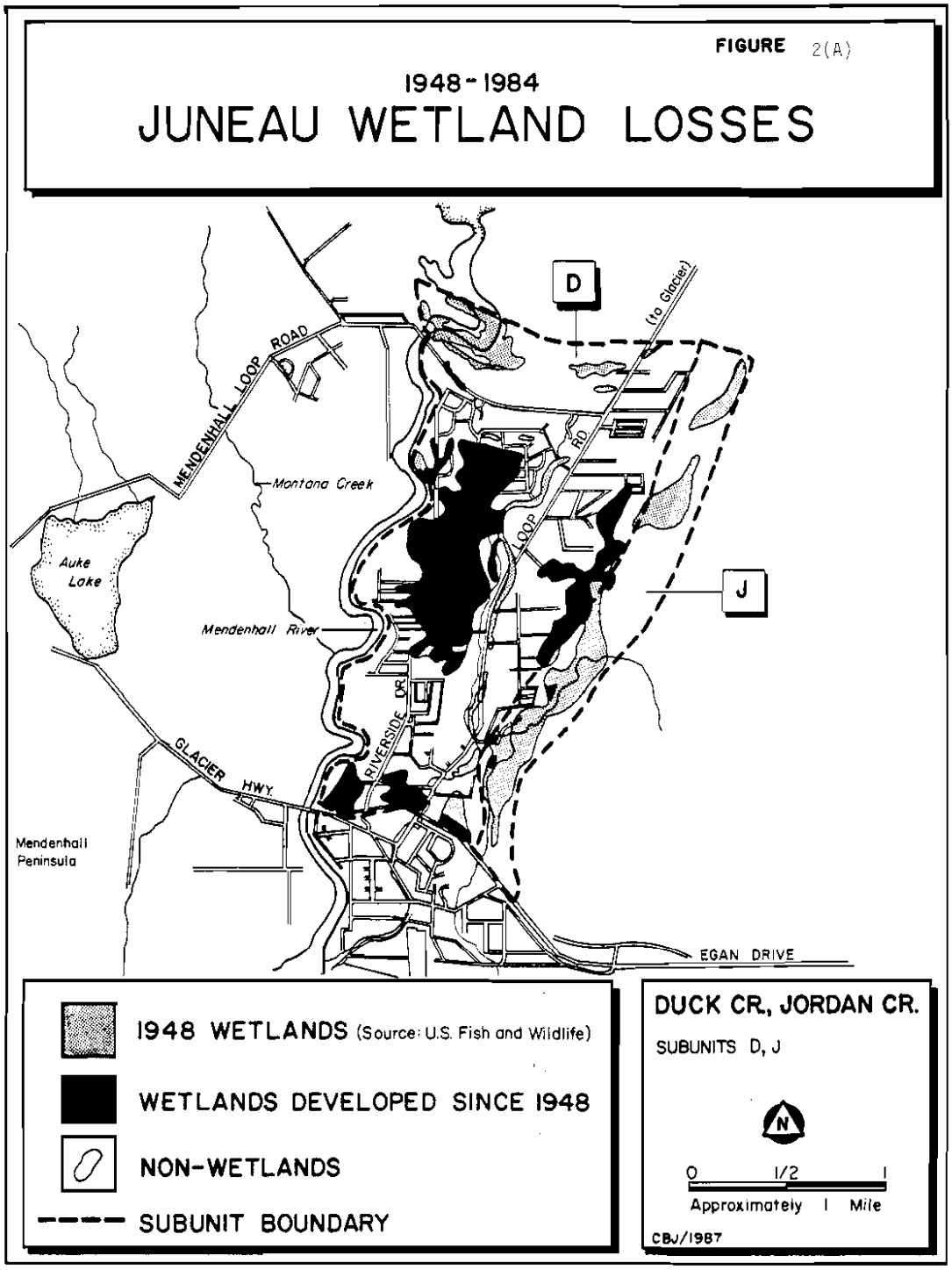


FIGURE 2(A)
1948-1984
JUNEAU WETLAND LOSSES
D
J
(to Glacier)
MENDENHALL LOOP ROAD
LOOP RD.
Montana Creek
Auke Lake
Mendenhall River
RIVERSIDE DR.
GLACIER HWY.
Mendenhall Peninsula
EGAN DRIVE
1948 WETLANDS (Source: U.S. Fish and Wildlife)
WETLANDS DEVELOPED SINCE 1948
NON-WETLANDS
SUBUNIT BOUNDARY
DUCK CR., JORDAN CR.
SUBUNITS D, J
N
0 1/2 1
Approximately 1 Mile
CBJ/1987

3

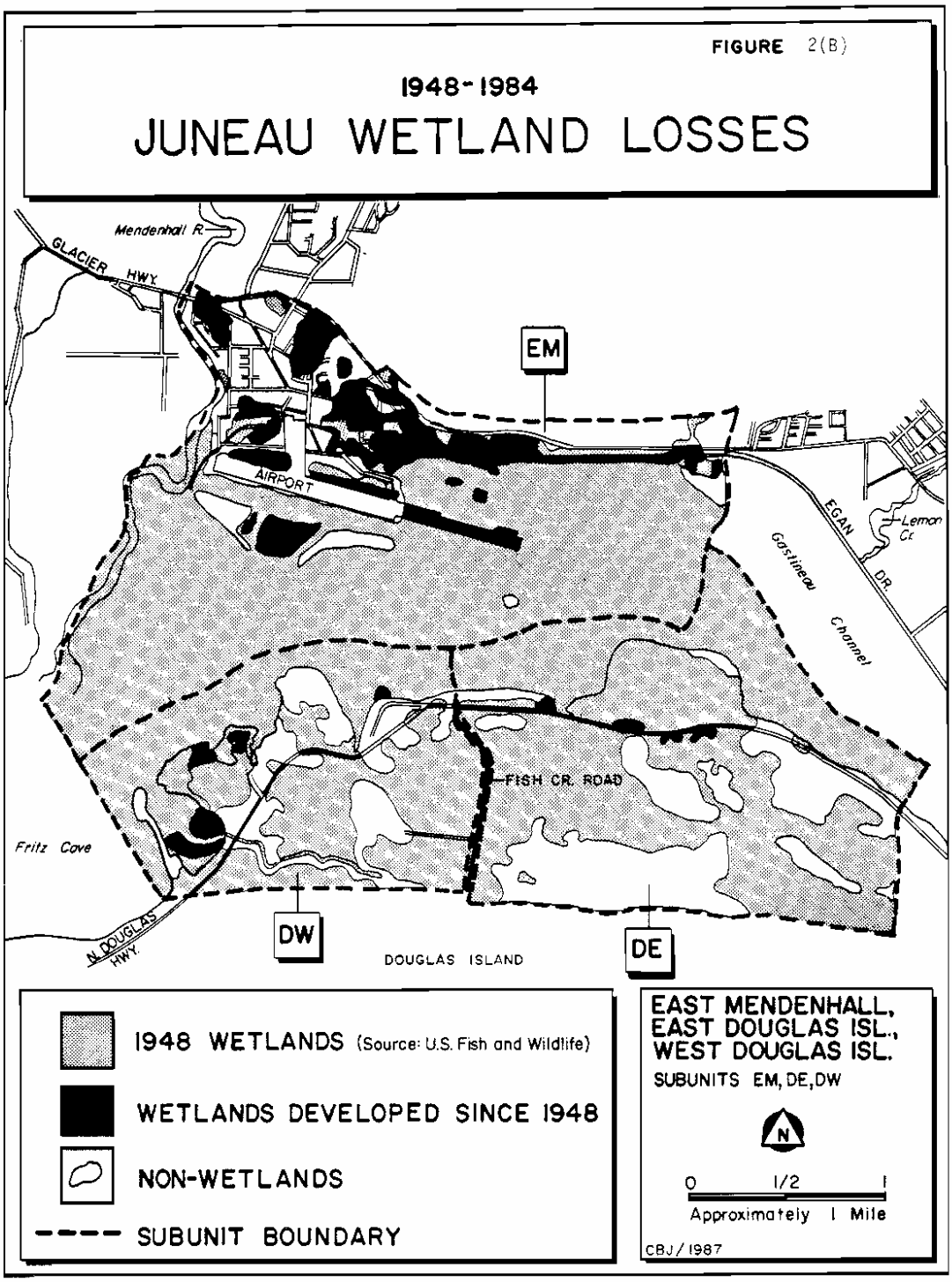


FIGURE 2(B)
1948-1984
JUNEAU WETLAND LOSSES
Mendenhall R.
GLACIER HWY.
EM
AIRPORT
EGAN DR.
Lemon Cr.
Gastineau Channel
FISH CR. ROAD
Fritz Cove
N. DOUGLAS HWY.
DW
DOUGLAS ISLAND
DE
1948 WETLANDS (Source: U.S. Fish and Wildlife)
WETLANDS DEVELOPED SINCE 1948
NON-WETLANDS
SUBUNIT BOUNDARY
EAST MENDENHALL,
EAST DOUGLAS ISL.,
WEST DOUGLAS ISL.
SUBUNITS EM, DE, DW
N
0 1/2 1
Approximately 1 Mile
CBJ/1987

4

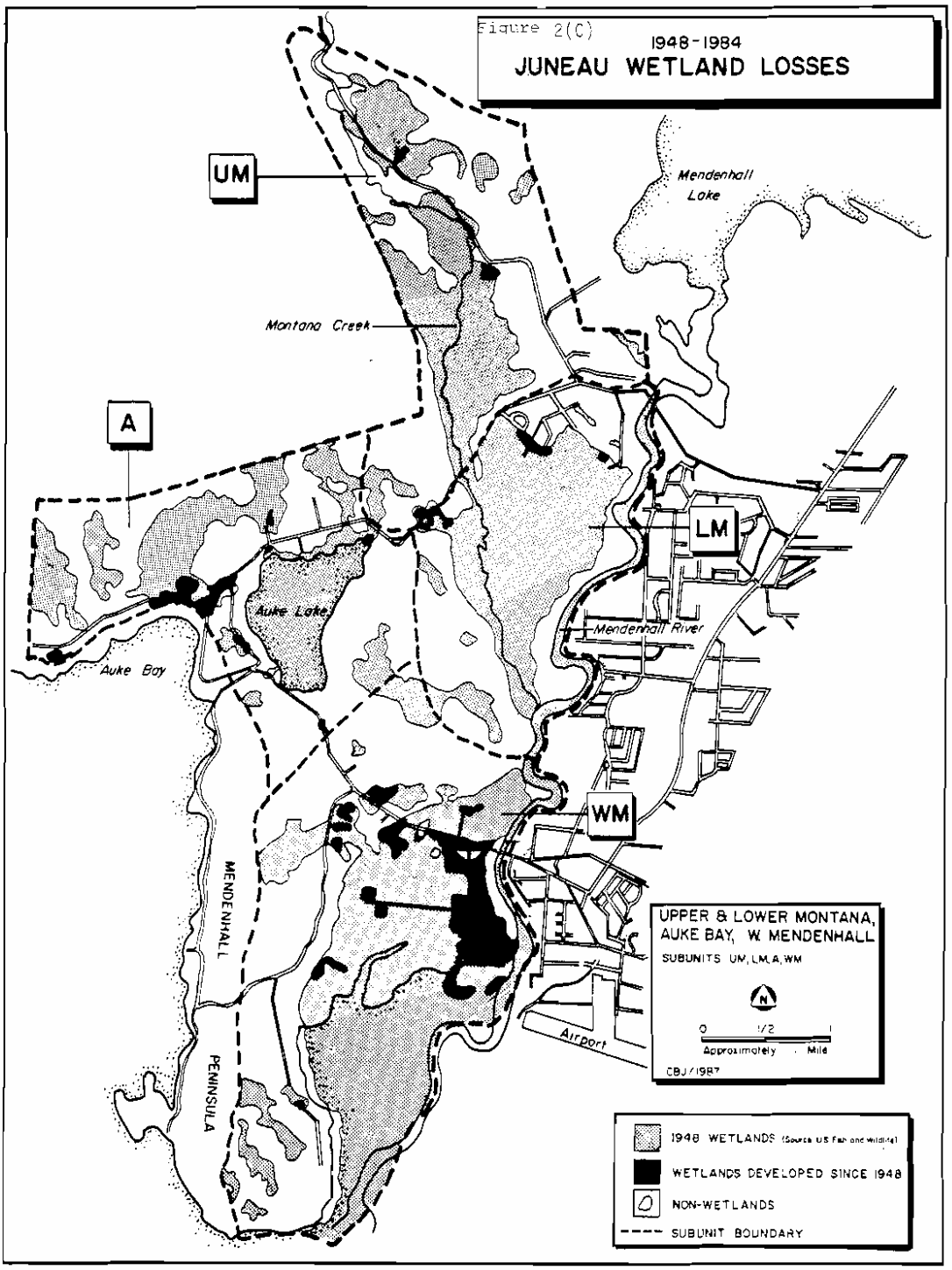


Figure 2(C)
1948-1984
JUNEAU WETLAND LOSSES
UM
Mendenhall Lake
Montana Creek
A
LM
Auke Lake
Mendenhall River
Auke Bay
WM
MENDENHALL
PENINSULA
Airport
UPPER & LOWER MONTANA, AUKE BAY, W. MENDENHALL
SUBUNITS UM, LM, A, WM
N
0 1/2 1
Approximately Mile
CBJ/1987
1948 WETLANDS (Source: U.S. Fish and Wildlife)
WETLANDS DEVELOPED SINCE 1948
NON-WETLANDS
SUBUNIT BOUNDARY

5

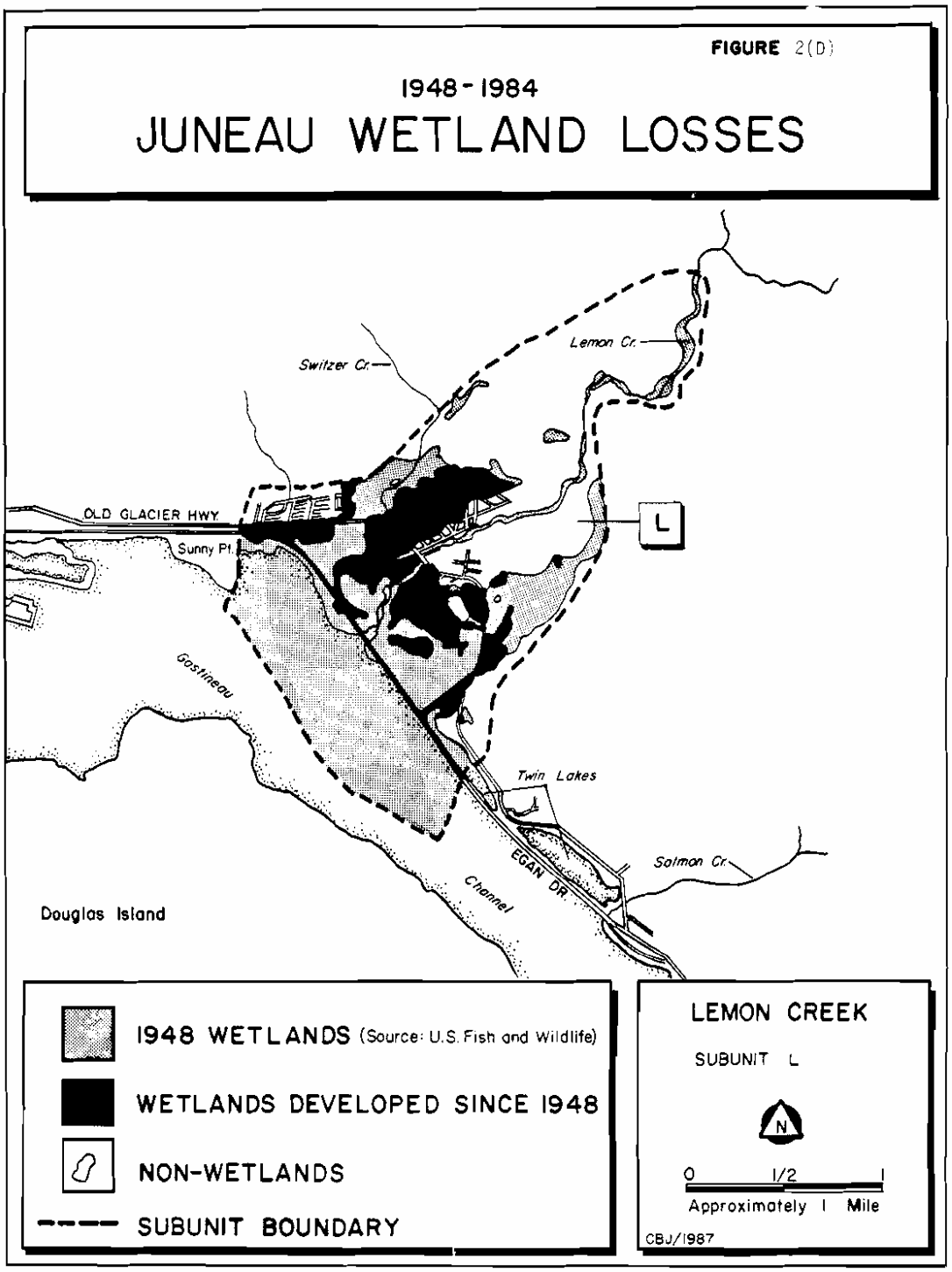


FIGURE 2(D)
1948-1984
JUNEAU WETLAND LOSSES
Switzer Cr.
Lemon Cr.
OLD GLACIER HWY
Sunny Pt.
L
Gastineau
Twin Lakes
Salmon Cr.
EGAN DR.
Channel
Douglas Island
1948 WETLANDS (Source: U.S. Fish and Wildlife)
WETLANDS DEVELOPED SINCE 1948
NON-WETLANDS
SUBUNIT BOUNDARY
LEMON CREEK
SUBUNIT L
N
0 1/2 1
Approximately 1 Mile
CBJ/1987

6

TABLE 1. Juneau Wetland Losses 1948-1984

Data courtesy U.S Fish and Wildlife Service, except the last column, which was developed by CBJ Department of Community Development. See Figure 2 for boundaries of statistical units and text for discussion.

		Wetlands Filled Since 1948		Development Since 1948 – Location of Development			Remaining Undeveloped Areas			
Subunit	**Subunit Size**	**Acres**	**Acres/Yr**	**% in Wetlands**	**% in Upland**	**Wetlands as % of Study Area (1948)**	**Total**	**Upland[1]**	**Palustrine[2]**	**Developable Upland[3]**
Duck (D)	1,690	320.6	8.9	28.0	71.7	27	508	379	95	51
Jordan (J)	484	4.3	0.1	9.5	90.5	32	484	332	152	0
Lower Montana (LM)	1,019	6.3	0.2	6.6	93.0	56	918	346	496	45
Upper Montana (UM)	1,207	6.5	1.8	7.8	92.0	37	1,101	656	444	110
Auke Bay (A)	1,208	30.2	0.8	43.8	56.0	42	1,115	642	307	202
West Mendenhall (WM)	1,901	119.6	3.3	73.0	26.8	58	1,710	728	524	137
East Mendenhall (EM)	2,712	309.2	8.6	66.6	33.3	81	1,997	126	84	126
Lemon (L)	2,049	309.9	8.6	35.1	64.9	58	1,146	258	226	134
East Douglas Island (DE)	2,002	21.2	0.6	42.1	57.9	75	1,952	477	1,038	24
West Douglas Island (DW)	1,334	25.1	0.7	60.9	39.1	78	1,292	280	564	232
TOTAL	15,606	1,162	92.3	38.3	61.7	59	15,277	4,224	7,933	1,061

[1] Much of this upland acreage may be unbuildable due to ownership, geotechnical limitations, and other factors.

[2] Palustrine wetlands basically are freshwater wetlands that are not lakes or rivers.

wetlands were sometimes more available. By contrast, in Juneau growth has not occurred on such sites for the following reasons:

- many non-wetlands are unbuildably steep
- mud slide (mass wastage) and avalanche hazards are present in many non-wetlands
- availability is reduced by Federal ownership
- higher construction costs in non-wetlands
- low density of road networks for focusing growth in narrow corridors (as happens in other cities)
- simple convenience

Growth potential is constrained by these factors so much that only 1061 acres (1.66 square Miles, or 7%) of the study area now remain available for construction. This figure was determined by the CBJ by using the following exclusion criteria:

- wetlands were considered not developable
- all areas with slope angle exceeding 20% were excluded
- all land presently developed was excluded
- lands presently having a restrictive classification, such as parks and open space, reservation for state jail expansion, and the airport approval zone were excluded.
- lands more than 1200 feet from existing roads were considered inaccessible and were excluded, except for some on Douglas Island where there is a possibility of future access
- all lands within 200 feet of streams were excluded, as designated by greenbelt provisions of The Comprehensive Plan.

The remaining figure of 1061 developable acres does not reflect the willingness or unwillingness of existing owners of such land to offer it to developers for purchase, the desires of neighbors to see it developed or remain intact, or the economic practicality of developing it as influenced by proximity to consumers and resources and the size of the available parcels.

One natural source of wetland alteration in Juneau has probably been glacial (isostatic) rebound; however, any wetland changes which may have occurred were not detectable during the 36-year span of the air photos, and were probably of an indirect nature (e.g., accelerated wetland plant succession). Glacial

rebound is the gradual upward vertical movement of land in the region as the Mendenhall Glacier recedes. Theoretically, over the long term this could increase the elevation and thus decrease the extent of tidal wetlands, and possibly isolate some freshwater wetlands from ground water sources.

Man-made development in the Mendenhall Valley area has progressed in roughly the following sequence (D. Peterson, NMFS, pers. comm.):

> Pre-World War II development consisted of several dairy farms near the mouth of Duck Creek and Jordan creek, some fur farms on Duck Creek which utilized the salmon runs for animal food, and a few commercial vegetable gardens. The A-J Mine had constructed the Mendenhall Loop road, which followed the same route as it does today. A few residents were scattered along its length.
>
> World War II brought an army camp into the Duck Creek drainage and also expanded construction at the Juneau Airport (originally built in the 1930s). The character of construction altered the mouths of Jordan and Duck Creeks.
>
> During the post-war years into the early 1960s, several events occurred;
>
> 1. Parts of middle Jordan Creek drainage were logged or high-graded for timber, with little control over logging slash disposal in or near the stream.
>
> 2. Portions of the Loop Road were widened, using alluvial material from dredged ponds near the road.
>
> 3. The Duck Creek drainage, particularly near its headwaters, began to be urbanized with the first tract home construction occurring in 1961.
>
> 4. A navigational channel was constructed by the Army Corps of Engineers in 1959 to join Gastineau Channel with Auke Bay. Before then, the flats could only be crossed at high tide by small craft. Dredged material was dumped in piles along the channel. Not long after the project was completed, shoaling in the channel began and has continued.
>
> During the past two decades, urban development in the Mendenhall valley has proceeded at an increased rate, particularly as the result of improved transportation and increased state employment. Present population of the valley is estimated to exceed 10,000 people; an increase of some 7,000 since 1967.

1.2 What Are Wetlands?

To most Juneau residents, the word "wetland" conjures up images of the open expanse of tidally-flooded grassland along Egan Drive and the Airport which are inhabited by Canada Geese and other wildlife (i.e., the Mendenhall flats). However, the scope of this study is much broader. The laws which regulate development in wetlands apply to many areas in addition to the Mendenhall Flats (the State Game Refuge lands), including many areas which to the lay person do not fit the conventional image of what a wetland should look like. Laws which address wetlands and special aquatic areas may cover rushing streams, some wet forested areas, and even some man-made ponds and infrequently-flooded gravel pits.

The definition of wetlands used in this study includes features from the regulatory one specified by the Federal Clean Water Act (40 CFR Section 230.3(t)). To be subject to Corps of Engineers regulation, the Corps requires an area to have ALL THREE of the following features:

a. Prevalence of plant species typically adapted for life in saturated soils;

b. Water (surface water or ground water), sufficient to inundate or merely saturate most of the soil for at least part of the growing season (the water need not cover the soil surface);

c. Soil conditions which indicate saturation; in the Juneau area, this includes but is not limited to the following hydric soil series: Kailki, Karheen, Kina, Kogish, Naybeso, and Wadleigh.

Other definitions of wetlands are sometimes used by various agencies. Some (e.g., Cowardin et al. 1979, as used by the U.S. Fish and Wildlife Service) are more comprehensive and are primarily intended for resource inventory, rather than regulation.

1.3 Why Study Juneau Wetlands?

Which of the remaining wetlands are most effective in naturally performing certain functions in the public interest? That is the primary question addressed by our data collection effort. The wetland functions, which are defined and explained in Section 2.2, are as follows:

- Ground Water Recharge and Discharge

- Surface Hydrologic Control

- Sediment/Toxicant Retention

- Nutrient Transformation and Export

- Riparian Support

- Salmonid Habitat

- Disturbance-sensitive Wildlife

- Regional Ecological Diversity

- Erosion Sensitivity

- Ecological Replacement Cost

- Recreational Use (actual, potential)

- Downslope Beneficiary Sites

These are functions which are widely attributable to wetlands, and form the foundation for laws which regulate wetland development. However, some functions will be incompatible with one another in the long term (see Section 12.2.14). Not all wetlands have all functions. Thus, the reason for investigating these functions is so that wetlands which are most likely or most effective in performing one or more of the functions will receive the greatest level of regulatory protection.

This report is not a land use plan or wetland management plan. Neither the public nor the regulatory agencies are obligated to use its recommendations in their decision-making. However, it represents the most comprehensive and technically valid synopsis available to date for functional values of Juneau wetlands. The purpose of this study and report is to provide a technical perspective for decisions which will later be made. This technical perspective is presented in the form of ratings (High, Moderate, Low, etc.) for each function of each of Juneau's major wetlands.

1.4 Study Background

Wetland assessment criteria had been developed previously for the Anchorage area by Fugro Northwest, Inc. (1980) and for Southeast Alaska by Swanson et al. (1977), Barber et al. (1982), Paustian et al. (unpublished). However, these criteria either were not technically appropriate for Juneau, or covered a limited number of wetland types and functions (e.g., streams and fisheries only), or were lacking in detail, field calibration, and documentation. Thus, no rapid assessment procedures were available for Juneau.

In 1983, the Federal Highway Administration (FHWA) published a systematic procedure (Adamus 1983) for assessing wetland functions which soon became the nationwide standard used by several wetland regulatory agencies. However, at FHWA's request, the procedure had been designed for use only in the

48 contiguous states. Recognizing this limitation, but desiring to use the procedure to help resolve wetland conflicts in the Juneau area, the City-Borough Department of Community Development approached the author of the FHWA method about the feasibility of his adapting and applying it to Juneau. The task seemed feasible, and support for the concept was gained from the Alaska directors of most major Federal and State resource agencies. A technical and committee was established, a Final Work Plan was approved by the Technical Committee in May 1986, and field work began in June.

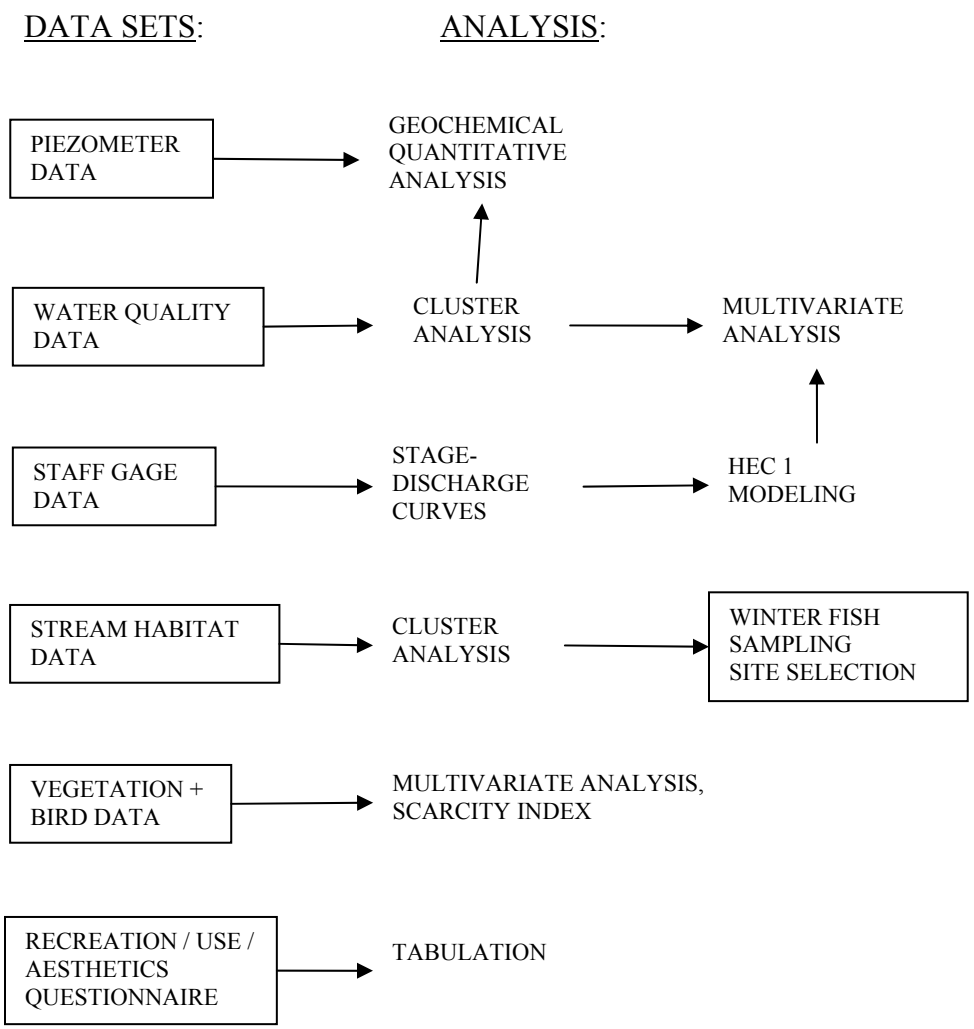
1.5 General Approach

Inasmuch as a) most of Juneau's intertidal wetlands are already granted a special level of protection through Federal and state law (e.g., the Coastal Zone Management Program and Mendenhall State Game Refuge), and b) the remainder are mostly being addressed by a parallel study (Airport wetlands), the Technical Committee agreed at the outset that efforts should be focused on the non-tidal wetlands. The functions of these muskegs, streams, and swamps were felt to be particularly ambiguous, and some scientists believe these wetlands may ultimately help sustain the high levels of function of the Mendenhall Estuary, as well as in some cases being important in their own right. The study boundaries, therefore, were established to include public and private lands in the Mendenhall Valley, Lemon Creek Valley, north Douglas Island, and parts of the Mendenhall Peninsula and Auke Bay (Figure 3). Areas farther to the west were considered unlikely to experience substantial growth in the foreseeable future, and areas closer to Juneau and Douglas has mostly been built up to their maximum potential. National Forest System lands were excluded. A small acreage of potentially buildable land (Sections 26, 27, 28 of T40 R65 and Section 4 of T41 R66) was excluded because no wetland maps had yet been prepared by the Corps of Engineers.

The object, then, was to study <u>some</u> of the study area wetlands sufficiently using intensive field research and data reduction methods, to allow us to extrapolate to other study area wetlands which had been studied in less detail. A decision had to be made whether to focus efforts on being sure the intensively-studied wetlands were truly representative, or to instead use manpower to directly collect a moderate amount of data on a more comprehensive (and perhaps less "representative") series of wetlands. In general, the latter option was preferred.

Detailed methods used in this study are discussed in Section 2.1. Basically, six types of field data useful for addressing the 13 functions were collected (Figure 2). Ground water functions were addressed by installing and monitoring 11 piezometer clusters; Surface Hydrology by installing and monitoring staff gages; Sediment/Toxicant Retention and Nutrient Transformation/Export by monitoring more than 50

Figure 3: RELATIONSHIP OF DATA SETS TO PRODUCTS



PRODUCTS:

1. RATINGS OF INDIVIDUAL WETLANDS.
   FORMAT:
   - MAPS (MATRIX IN LEGEND)
   - WETLAND FILE NARRATIVES
2. RAPID ASSESSMENT MODELS FOR SOUTHEAST ALASKA.
   FORMAT:
   - FIELD QUESTIONNAIRE
   - INTERPRETATION KEYS
3. SOUTHEAST ALASKA LITERATURE REVIEW.
   FORMAT:
   - PREDITORS
   - FUNCTIONS

locations monthly and analyzing for approximately 20 chemical or physical constituents; Salmonid Habitat by sampling overwintering fish and conducting a comprehensive habitat survey; Disturbance-sensitive Wildlife and Regional Ecological Diversity by directly monitoring animals, vegetation, and associated habitat features; Riparian Support, Erosion Sensitivity, and Ecological Replacement Cost by reviewing aerial photography, existing maps, and visiting some sites; and (perhaps most familiar to the public) Recreational Uses by conducting and analyzing a public mail survey as well as site observations (Table 2).

The accuracy of the study's ratings of particular functions depended not only on the manpower expended by topic, but on the general amenability or intractability of meaningfully measuring the function in the course of a field season. Table 3 provides a subjective, very gross evaluation of the relative confidence we feel in particular rated functions.

TABLE 2. Computer-accessible data bases constructed by the Juneau wetlands study.

Note: These data are not proprietary. Public agencies, researchers, and others are welcome to copy or use these data tapes for any purpose, by contacting the principal investigator or CBJ Department of Community Development. Raw field sheets are also available.

Database: AQUATIC HABITAT
Locations: 1,237 stream reaches in the Juneau area (primarily nontidal reaches of Jordan, Duck, Montana, Switzer, Vanderbilt, Fish, Ninemile, Johnson, Neilson, and "Casa Del Sol" Creeks).
Time of Data Collection: September 1986-January 1987.
Variables: total area; area of slow-shallow, slow-deep, fast- shallow, fast deep, rapid-shallow, rapid deep; length of banks with aquatic vegetation, overhanging vegetation, alders, undercut; maximum velocity, depth, soft-sediment depth; area and number of woody debris; substrate type; ratings for shade, iron stain, bank stability; presence of tributaries, upturned trees.
Derived Variables: Stream distance to similar condition, percent coverage of habitat types within each reach, cumulative habitat totals (moving downstream) for any reach.
Analyses Performed: Aggregative Clustering (total, by reach); reach maps, summary statistics.

Database: WATER QUALITY
Locations: Results of approximately 600 water quality analyses in Juneau study area streams, isolated wetlands, and estuary; mostly surface water, but over 100 ground water, 80 sediment, and a few precipitation samples. Basically from 80 surface water sampling locations (see section 2.1.3).
Time of Data Collection: mostly July 1986-February 1987, monthly samples.
Variables: NH3, N03 + N02, TKN, total phosphorus, total filterable P, filterable reactive P, turbidity, total solids, total dissolved solids, conductivity, alkalinity, pH, Ca, Mg, K, Na, Si, Fe, Al, Sr; Zn and Ni (sediment samples only); chlorophyll-a (a few), DOC (a few), Pb (a few), Cu (a few), D.O. (a few), precipitation on/near sample date, watershed characteristics. Selected August-September surface and ground water samples were also analyzed for Br, Cl, F, S04, N03, and P04.
Derived Variables: Ca-Mg ratio, loglO concentrations, concentrations x flow, concentrations divided by watershed area, total P: total N ratio, (N03+NH3), FRP/TFP, TFP/TP.
Analyses Performed: spatial plots along streams, correlation coefficients, ranking of stations by concentrations, summary statistics.

Database: BIRD-VEGETATION
Locations: 820 listening stations in approximately 50 wetlands and stream corridors throughout Juneau study area (see section 2.1.6).

Time of Data Collection: June-July 1986
Variables: bird species; community type (Viereck-Batten); major plant species; ecotones; distance to streams, upland; vertical strata of vegetation; minimum/maximum visibility; maximum dbh; % evergreen; % deciduous; number of fallen logs, snags, upturned roots, pools.
Analyses Performed: summary statistics, contingency tables, lists by species or by wetland, principal components analysis.

Database: WATERSHED CHARACTERISTICS
Locations: entire study area
Variables: Each wetland and/or water quality monitoring station is indexed as to total acreage; acres of each class, subclass, and hydroperiod (FWS classification); watershed (catchment) area; soil series; slope class; forest contiguity condition; precipitation zone; recharge/discharge condition; paired water quality stations (or wetlands); distance to nearest adjoining sampling station upstream, to nearest wetland, to open water, to nearest house/road; total length of internal channels.
Derived Variables: At any point in watershed, can determine wetland/watershed ratio, % of upstream area as wetland of a particular type or hydroperiod, etc,
Analyses Performed: Summary statistics (acres of each wetland type).

Database: PUBLIC SURVEY
Location, Time includes all of Juneau; conducted in Fall 1986.
Variables: Randomized survey of Juneau citizens (430 responses, for a response rate of 43 percent) regarding attitudes toward wetlands, wetland use and aesthetics.
Analyses: cross-tabulation by subarea, demographics, or response to a particular question is possible.

Note: Databases are mutually accessible, e.g., information on plant species (BIRD-VEGETATION database) can be paired with recharge/discharge information (WATERSHED database).

Table 3. Relative confidence in ratings assigned to Juneau wetlands.

Function	A. Confidence when Wetland Measured Directly	B. Spatial Confidence when extrapolated from Superficial characteristics	C. Temporal Confidence (Confidence when A. is Extrapolated to other seasons.)
Ground Water Recharge, Discharge	very high	moderate-high	moderate
Surface Hydrologic Control	moderate	low	moderate
Sediment/Toxicants, Nutrients	high	low	high
Riparian Support	moderate	moderate	moderate
Salmonid Habitat	high	moderate-high	N/A
Disturbances Wildlife	very high	moderate-high	N/A
Regional Ecological Diversity	moderate	low	N/A
Erosion Sensitivity	low-moderate	low	N/A
Ecological Replacement Cost	very high	very high	very high
Recreational Use	very high	low	moderate
Downslope Beneficiary Sites	high	high	high

Specific reasons for diminished confidence in some ratings are given in Section 2.2.

Usable wetland maps were a prerequisite for beginning the field work. The most convenient ones available were the draft version of the Corps of Engineers maps, at a scale of 1 inch = 200 feet. We did not make any wetland determinations as part of this project; the wetlands shown are exclusively those delineated by the Corps. After we had used the draft maps for field studies, the Corps in November released a final version (based on their subsequent field-checking) which had several changes. As a

result, some data (particularly for the Regional Ecological Diversity function) was collected needlessly, while other areas were missed. Most field work was completed by February, and data reduction and report preparation were completed by May.

Within any rated wetland, there may be areas that have higher or lower probability of supporting the given function. However, to separate out such areas would require a considerably greater technical effort; the vlsual complexity of such maps could also be overwhelming. Thus, in cases where a series of wetlands seem to run together (e.g., a wetland complex), standard guidelines were followed regarding where to delineate the end of one wet land and the beginning of another. These guidelines are described in Adamus et al. (1987). Often, hydrologic constrictions (e.g., roads) were used to separate parts of the same wetland for assessment purposes. Stream reach delineation procedures are described in Section 2.1.4.

1.6 Limitations and Assumptions

Although this study involved considerable manpower effort and probably represents the best available technical base for Juneau's wetlands, it has some limitations which should be understood:

1. This study's objective is to indicate which functions are most likely to be present in each wetland. Although a blanket presumption is made that each of the 12 functions used throughout has significance in some Juneau situations, this study is not intended to quantify the ecological, social, or economic significance of any function. For example:

    - The probability that a wetland discharges ground water was estimated, but it was not our charge to determine whether enough discharge occurs to benefit fish spawning and provide base flow.

    - The probability that a wetland retains toxicants and/or sediments was estimated, but it was not our charge to determine whether such retention in a specific case harms ecological functions within the wetland (while possibly benefiting downstream water quality).

    - The probability that a wetland retains nutrients or transforms them from inorganic to organic forms was estimated, but it was not our charge to prove which form is better for supporting food chains in the Mendenhall estuary or elsewhere.

    - The probability that one wetland, relative to others, modifies the timing and magnitude of runoff was estimated, but it was not our charge to investigate whether the modification is of such magnitude that it influences ecological processes or damages property from flooding.

2. What is presented here is the best available information given the significant constraints of time, funding, and scientific knowledge or ignorance of wetland functions. It is possible that new scientific discoveries about wetlands could increase or decrease the ratings of wetlands as presented herein, and it is likely that multiple-season or multiple year studies could modify a significant portion of the ratings.

3. This report is not intended to obviate the need for more detailed studies of specific wetlands where possible and appropriate. Rather, the report is intended to provide an area wide, contextual planning perspective, in contrast to exclusively using a reactionary approach of evaluating each wetland permit application independently of all others.

4. The ratings provided for each function are based on data collected during a single field season. Thus, they may not be universally typical of long-term conditions. For example, the winter of this study period was somewhat milder than usual, so fish and wildlife may have been less dependent on using a few traditional wetlands with intrinsically milder microclimates than they would have been during a severe winter. Ground water recharge and discharge conditions may change seasonally also.

5. While every effort was made to calibrate the qualitative models (Section 2.2, Criteria) with the collected field data and literature review, occasions arose where criteria had to be based in part on extrapolation of general (and in some cases, weakly-supported) scientific principles from other parts of Southeast Alaska to the Juneau area, and some technical subjectivity was required.

6. The 12 functions we evaluated are ones most generally believed to be typical of wetlands, but they are by no means the only functions. Wetlands may possess other functions, both negative and positive. Some, such as the cumulative role of wetlands for global carbon cycling, may influence continental weather patterns but are important only in the aggregate, i.e., site-specific distinctions are virtually meaningless since any given site's contribution is minuscule compared to the whole.

7. The ratings presented herein have no explicit acreage context. Thus, the destruction of many low-rated wetlands may sometimes have an equal or even greater effect than the destruction of a single high-rated wetland. Without exhaustive, quantitative modeling studies, such tradeoffs between acreage and size cannot be predicted.

8. This is not an impact assessment study. Such studies must be conducted individually for proposed developments, since even a low-rated wetland may be destroyed by extremely impacting activities (e.g., landfills) and seemingly innocuous activities (e.g., hiking trails) may adversely affect some high-rated wetlands. Similarly, some wetland functions (e.g., Ground Water Discharge) are quite robust, while others (e.g. Wildlife) are extremely sensitive.

9. The intertidal wetlands (Mendenhall State Game Refuge area) were usually not rated except where adequate data on one of their functions already existed (this was true mainly for the wildlife functions).

1.7 Responsibilities

Paul Adamus was responsible for the overall study design, field data collection procedures, data reduction design, assistance with field work, report preparation, and related activities. Bird, plant, and wildlife habitat field data were collected by Koren Zimmerman Bosworth and Richard Carstensen. Virtually all of the estuarine bird data were collected as part of a separate effort by U.S. Fish and Wildlife Service-Juneau biologists, and kindly shared. Fish habitat mapping and population surveys were conducted under frequently adverse winter conditions by Koren Bosworth, Dean Beers, and Kristen Hunk. Water sampling and sample filtration was done by Koren Bosworth and Dean Beers with assistance from Nate Johnson. Stream geographic descriptions, spawning data, and some rearing data came from write-ups provided by Gary Sanders of ADFG.

Dr. Donald Siegel was responsible for ground water field studies and data analysis, and was assisted by Dr. Paul Glaser, Ann Veeger, and Phil Bennett. He also supervised all surface water and sediment analyses for metals. Analyses for nutrient concentrations were done by the FRED Lab at Eagle River on a sample exchange agreement. Surface hydrologic modeling was conducted by Mark Ingrham and others of the Alaska Department of Natural Resources - DGGS (Anchorage), with conceptual input from Woody Trlhey and field data collection by ARA, Inc. staff. Dr. Geoffrey Gordon of Spectrum Research, Inc. (Orono, Maine) was responsible for the frustrating logistics of the extensive computer analysis. The public opinion survey was designed, distributed, and compiled by Drs. Richard Smardon and James Palmer, with their assistants. They also were responsible for all aspects of the Recreational Use function. All subcontractors were suggested and/or approved by the CBJ.

1.8 Organization of Report

The crux of the report is the wetland function ratings, presented in the Map Appendix. These ratings are documented in two ways:

a. Section 2.1 (Methods) describes how the data were collected and analyzed to provide the criteria and/or the background-information sufficient to rate the wetland.

b. Section 2.2 (Criteria) describes the criteria used and their basis, both from our field results and from supportive technical literature from Southeast Alaska.

The report also includes a rapid assessment procedure for Southeast Alaska wetlands based partly on analysis of our data set. This assessment procedure has not, to date, been tested outside of Juneau.

2.0 CALIBRATION STUDY

2.1 Methods

2.1.1 Ground Water Hydrology

(1) Data Collection and Limitations. Measuring movement of water beneath the ground is a very complex process. Therefore, we used several complimentary, accepted methods for doing so. These are as follows:

1. Soil Cores: Knowledge of soil textures gained from cores is essential for determining how easily water moves about underground at various depths.

2. Pressure Head Characteristics: Small observation wells (piezometers) and pressure-sensitive electronic probes indicate the upward or downward movement of groundwater.

3. Hydraulic Conductivity: This basically involves pumping out a shallow well and timing the recovery of water levels. It approximates the possible flow rates of groundwater under more natural conditions.

4. Stream Flow: "Gaining" and "losing" reaches can be identified by careful measurements, but these proved difficult to measure reliably in the Juneau area.

5. Groundwater Quality: Analysis of groundwater samples from various depths for certain metals can suggest recharge or discharge, because of differences in the rates at which surface plants take up these metals.

The above methods are now described in detail:

Soil Cores: Cores of organic soil and underlying mineral soil were collected with a modified Livingston corer in Montana fen and blanket bogs (Wright et al., 1984) for soils characterization. Elsewhere, depth to mineral soil was determined by probing with a Davis rod.

Head Measurements: Piezometers and a pore-water pressure probe were used to measure hydraulic head with depth. Thirty-eight measurements of pore-water pressure were made in May and June, 1986 as an initial reconnaissance of the recharge-discharge function.

The pore-water pressure probe consists of a Druck pressure transducer mounted at the end of a 1 1/2 inch diameter, stainless steel casing fitted with a pointed end. Drilled holes at the end of the probe allow pore water to contact the transducer.

Electronic output of the probe is converted to digital output and read on a monitor as equivalent feet of static water. The probe effectively measures pore pressures to ±0.02 feet in medium to fine grained mineral soils and in undecomposed peat, and less effectively in humified peat and clayey sediment (Bennett et al., 1987).

Piezometer nests, consisting of 3 to 4 piezometers, placed about 2 feet apart, were installed in blanket bogs north of Montana Creek and on Douglas Island, in the patterned fen between Montana Creek and Mendenhall River, next to Mendenhall River in a freshwater marsh, in the tidal marsh near Mendenhall River, and on upland forested wetlands near Jordan and Switzer Creeks These locations are shown in the Map Appendix. Piezometer nests were located either at the margins or centers of the wetlands where hydraulic gradients would be greatest and the recharge or discharge function most pronounced.

Piezometers consisted of 1/2 inch (I.D.), schedule-80 PVC casings, inserted into the soil using a pointed, solid aluminum rod. Details on the piezometer installation method are given in Chason and Slegel (1986). Similar piezometers were effectively used by Rutter (1955) and Boelter (1972) to determine hydraulic gradients near ditches. The land surface elevation can be assumed nearly the same (+0.1 foot) for the piezometers, only a few inches apart, in each nest. Piezometers in each nest were completed at various depths depending on the soil stratigraphy at each site, and were surveyed into a benchmark for elevation determination.

Water-level measurements were made monthly from spring thaw to fall freeze – June to October, 1986. Ground water was pumped from the piezometers for chemical analysis after each water level measurement. The narrow diameter of the piezometers assured complete recovery after one month (Chason and Siegel, 1986; Hsvorslev, 1951).

Hydraulic Conductivity: Field hydraulic conductivity of organic soils and the underlying mineral soils was determined at 22 piezometers by the hydrostatic time-lag method, the preferred field technique used in soils with low permeability (Hvorslev, 1951; Cedergren, 1967). The time-lag method relates the rate of water level recovery in an evacuated piezometer to the hydraulic conductivity.

Groundwater Quality: Samples of ground water were collected monthly with a peristaltic pump from the piezometers in the instrumented wetlands. Most samples were collected from the initial evacuation of the piezometers because recovery time was long. Consequently, samples integrated a small portion of the groundwater system around the piezometers. Because water in the piezometers was in contact with the atmosphere, iron concentrations are only qualitative because of possible precipitation of iron oxides and hydroxides upon oxygenation. Nevertheless, concentrations gradients determined with depth of total concentrations of metals (herein called "total metals") probably will not be obscured by chemical changes in the piezometers. Any possible change in ground water caused by precipitation of solids in the casings would be considerably less than the difference between the total metal concentrations of end member solutions—precipitation and deep ground water. Total metal concentrations in ground water in the study area typically are over 100 mg/L, compared to less than 5 mg/L in precipitation (Barnwell and Boning, 1968; Stednick, 1981). Dissolved metals contributed by organic decomposition of the peat are small compared to that in ground water from mineral soils (Siegel and Glaser, 1937).

In addition to the groundwater samples, surface water was collected from pools at each site when the water table was at the land surface. All water samples were filtered in the field through 0.2 micron Nuclepore filters and acidified. Additional non-acidified sample was collected to determine pH, specific conductance, anions, and dissolved organic carbon for selected piezometers. Water from twelve domestic wells was also sampled in June.

Concentrations of calcium, magnesium, sodium, potassium, iron, silicon, strontium, and aluminum were analyzed in triplicate by direct current, plasma emission spectroscopy. Precision and accuracy of the metals analyses were generally within 2% and 5%, respectively. Ammonia and anion concentrations were determined by ion-chromatography with similar accuracy and precision as that for the metals analysis.

All other analyses were done by standard methods (American Public. Health Association, 1984). Statistical analysis of the data was made using the Statistical Analysis System (SAS) (1986).

Limitations: It is important to recognize that the work is at a reconnaissance level. Careful attention should be paid to all assumptions that went into the study before 1) predictions are made on future hydrologic impacts on the studied wetlands or 2) the results of this study are "generically" applied to other wetlands.

It was assumed, based on the experience and best judgment of the author, that the instrumented wetlands are typical or "representative" of their classified type. However, because groundwater-surface water interaction in wetlands can be very complicated, additional piezometers placed elsewhere in the wetlands or at other seasons or years may have produced different results. All calculations of the amounts of groundwater recharge and discharge to evaluate recharge-discharge functions were made to give the maximum possible volumes. These calculated volumes, based on the field data, may be significantly in error (probably low) because the period of record was drier than this season during most years.

For the above reasons, the determinations of the "probable" recharge-discharge function of non-instrumented wetlands made by the author in this report are but qualitative judgments. Although the results of this study provide the conceptual frame work to evaluate the recharge-discharge function of wetlands near Juneau, detailed site-specific studies may still be needed to determine potential hydrologic impacts on wetlands not instrumented in the study, particularly at other seasons of the year.

(2) Data Reduction

Data from the above was used in a computer simulation exercise. The output was one of several analyses considered in assessing the recharge-discharge functions of the piezometer sites.

Numerical Simulations of Groundwater Flow. The numerical simulation experiments of groundwater flow were done to theoretically evaluate the recharge-discharge relationship between kettle lake wetlands located on the recessional moraines in Mendenhall Valley and the large patterned fen. The model transect was chosen along the approximate surface-water divide in the patterned fen. Groundwater movement across this divide can be considered negligible as a first approximation. The lower "no-flow" boundary of the models was set at about 300 feet deep, where marine clays in the stratigraphic section have very low hydraulic conductivity.

The area of the cross section was divided into rectangles, the centers of which are called "nodes," spaced vertically at 10- foot intervals and horizontally at 400-foot intervals. The resulting grid was 31 nodes long and 27 nodes wide.

A strongly implicit, finite-difference procedure (SIP) was used to simulate steady-state groundwater flow (Trescott et al., 1976). Water table elevations were held constant throughout the simulation, implying that over a long time, total recharge equals discharge in the groundwater system. Models were run using different scenarios for anisotropy and heterogeneity of the surficial materials. The boundary conditions selected for the models are similar to that used by Siegel (1983) to evaluate groundwater flow systems in fens and raised bogs in northern Minnesota.

2.1.2 Surface Water Hydrology

(1) Data Collection and Limitations

The field work was designed as a low-effort attempt to gain a minimal understanding of how various wetlands associated with Duck, Jordan, and Montana Creeks influence precipitation-runoff events. This allows index ratings to be assigned to these wetlands for Surface Hydrologic Control.

Staff gages were placed at 6 locations on Jordan, 6 on Duck, 1 on Montana, and 2 (data not subsequently analyzed) on Ninemile Stream on Douglas Island. Locations are shown on the photomaps in the map appendix. The gages were simply metal rebar pipes driven solidly into the streambed in areas with relatively little upstream vegetation or obstructions. Permanent gage marks were painted on each pipe, and surveyed to benchmark locations. All gages were visited 12 times between September 3 and November 25, 1986. Ice-ups at some locations prohibited systematic collection of winter data. During 6 of these visits, stream discharge was simultaneously measured by the 20-point transect method using a Marsh-McBirney current meter. The staff gage and transect measurements are believed to be quite accurate, if not necessarily representative. On any given date, all gages were visited within a few hours, and never during a period of significant continuing rainfall.

In general, the period was drier than the average autumn, and November was colder. Inasmuch as precipitation is known to show great spatial variation within the study area, we installed rain gages at several locations, but with generally poor results due to vandalism and breakage. The NOAA weather station at the Juneau Airport recorded maximum 24-hour rainfall events during the period on November 1 (1.91 inches), October 15 (1.31 inches), and October 5 (1.04 inches).

(2) Data Reduction and Cautions

The Corps of Engineers runoff model, HEC-1, was adapted and used by the Alaska Department of Natural Resources-DGGS to simulate input and output hydrographs for 25 individual storage areas (i.e., wetlands or stream reaches) on the 3 study streams. The model outputs reflect somewhat the spatial variability of precipitation in the study area, and incorporate the results of the stage-discharge curves developed from the staff gage data, as well as on-site estimates of channel roughness coefficients and identification of gaining and losing reaches. Somewhat similar efforts had been conducted previously by the Corps of Engineers (1971a, b) and particularly EMPS, Inc. (1979), but primarily examined flood stages and flows under maximum storm conditions, as is appropriate for the engineering design goals of those studies. However, for inputs to our computer model, we chose to use the average monthly maximum storm (e.g., the largest 24-hour Airport precipitation event averaged over each of the [Octobers] between 1970 and 1986). The "average monthly maximum storm" was used because we suspected this might provide a better indication of the ecological significance of runoff from wetlands.

Precipitation data for the average maximum monthly storm was compiled for each month using 16 years of data, and a thirteenth event — the maximum storm of record, was also loaded into the computer. Thus, 325 hydrographs were generated for 13 storm events in 25 storage areas (as well as for their upland runoff areas). In addition to the hydrographs, the HEC-1 program routed storm flows downstream to the estuary and calculated (for each event-area combination) the time to peak; storage; peak flow (in cfs); average flows at 6, 24, and 72 hours; and maximum stage height. These measurements were used as a basis for rating their associated wetlands. Many stacks of HEC computer printout are available for review from the principal investigator, and tapes are housed with the Alaska DNR-DGGS in Eagle River.

Although use of this quantitative approach probably gives better results than "best judgment" estimates based on a rapid site inspection, it involved no follow-up field calibration and thus has several limitations, none considered so great as to invalidate the order-of-magnitude distinctions needed for this study:

1. Wetlands with no discernable inlet and outlet could not be modeled. Computer models for such storage areas are available, but require considerably greater effort for collection of input data. Moreover, some slope wetlands on Douglas Island literally straddle two adjoining watersheds, and spatial flow patterns are very ambiguous, depending on the amount of rainfall.

2. The HEC-1 program requires certain assumptions to be made about the circuitousness of flow paths, the hourly distribution of rainfall, and other factors. These assumptions cannot always be substantiated by direct field observations before running the models.

3. The effectiveness of a storage area for attenuating the peak flow hydrograph downstream at the estuary ultimately depends not only on its ability to dampen incoming runoff peaks, but also on its position in the watershed. Although such an analysis was originally planned, it was never completed.

4. In the lower portions of all 3 streams, a backwater effect often occurs due to high tides. Although this effect may accentuate flooding, it could not be factored into the HEC-1 model.

5. Inasmuch as the program used stage-discharge curves from only one short period (September-November 1986), its ability to predict wetland response becomes more ambiguous when other months (particularly icy winter months) and extreme storm events are considered. Long- term, detailed, year-round measurements from a USGS gage on Montana Creek were found to be useful for predictions there, but could not be extrapolated to Duck, Jordan or other Creeks, because only Montana Creek is influenced by glacier-melt.

6. Precipitation estimates for non-monitored months (January-August) were based on Juneau Airport data. Inasmuch as the Airport has much smaller amounts of precipitation (due to the rain shadow effect of Douglas Island), our subsequent calibration using this data may contain some errors.

7. Using the HEC-1 runoff routing subroutine, channel geometry and roughness (retardance) coefficients exert a substantial influence on the computed values for peak flow and travel tine. In this simulation effort, we estimated roughness coefficients vlsually during field work. The eight segments of Montana Creek in the study area were assigned coefficients ranging from 0.041 to 0.075; the five segments of Duck Creek were assigned coefficients ranging from 0.043 to 0.070; and four segments of Jordan Creek were assigned coefficients from 0.030 to 0.070. Assignment of roughness coefficients is generally acknowledged by hydrologists to be a very subjective process.

It is hoped that future flood plain studies in the Juneau area can provide hydrologic information in a computer format usable for addressing wetland hydrology questions such as those we attempted to address with this study.

2.1.3 Water Quality

This data collection effort was conducted in partial support of the functions "Nutrient Transformation/Export/1 "Sediment/ Toxicant Retention," and "Riparian Support."

(1) Data Collection and Limitations

The primary objectives were to (a) examine the manner in which specific Juneau wetlands may serve as geochemical sources and sinks, (b) determine spatial and temporal variation in nutrient fluxes to the estuary, and (c) identify possible instances of chemically significant inputs of ground water into surface water. For these objectives, the sampling program was mostly successful.

Surface water samples were collected from approximately 60 locations monthly from July through November, and then again in February. A "core" group of stations (more than 20) were sampled each time, with the remaining sampling locations being rotated or sampled irregularly. Whenever possible, samples were collected simultaneously upstream and downstream of a wetland, and above and below the Junction of tributary streams with larger streams. However, many Juneau wetlands occur on slopes or in other situations with no distinct inlets and outlets, making sample interpretation tenuous.

Samples were always collected within a 5-day period, and usually within 3 days, so as to minimize varying effects of weather on runoff quality. Precipitation was below normal in July, September, and November and above normal in August. Monthly precipitation totals at the Airport were: October - 11.96, August - 6.89, November - 5.20, February - 3.13, September – 2.41, and July - 2.34.

In general, samples within the same watercourse were sampled the same day. The 1-gallon sample containers were either new or triple acid-washed. Discharge measurements were made within a Marsh-McBirney current meter, but to conserve time they were crude (3 points across a stream) and could seldom be made at a majority of sampling stations because at many stations current velocities were too low or rivers too deep and wide. Samples were kept cool and taken to the laboratory in Juneau within a few hours. Procedures for sample filtration as detailed by Floenings et al. (1987) were followed. Disguised blanks and replicates were occasionally analyzed for quality assurance. Samples were shipped express to the ADFG-FRED Lab in Eagle River for analysis of the following constituents:

— phosphorus (total P, total filterable Pf filterable reactive P)

— nitrogen (total Kjeldahl N, NH3, N03 + N02)

— turbidity (NTU)

— alkalinity

— specific conductance

— pH

Detection limits of the laboratory analysis were as follows: TKN = 3 ug/L., NH3 = 1 ug/L, N03 + N02 = 1 ug/L, total phosphorus (TP) = 1 ug/L, FRP = 0.5 ug/L. In general, determinations have an error of less than 10%, with the largest errors being potentially associated with determinations of NH3 and TP.

The acidified filtrate from the same samples was also analyzed according to standard protocols for the following metals by the USGS-certified laboratory of the Department of Geology, Syracuse University:

— lead, copper, iron, calcium, magnesium, strontium, silica, aluminum, sodium, potassium

In addition, a few of the samples were analyzed for chlorophyll-a by the FRED Lab, and a few for dissolved organic carbon by the Syracuse lab. Water quality data simultaneously collected in the study area at Auke Lake by the FRED Division was included in the computer database.

The choice of constituents was based on a balance between ease of measurement and relevance to the study. For example, more frequent sampling of turbidity, particulate organic carbon, or chlorophyll; or even occasional sampling of aromatic hydrocarbons or mercury, arsenic, and similar highly toxic substances might have provided information somewhat more useful to the study. However, manpower and laboratory costs would have been excessive. Moreover, the objectives of the study extend beyond simply trying to determine which waters may violate some standard.

In addition to surface water chemistry, we collected two other types of water quality data — sediment chemistry and water temperature. In August and again in March, samples were collected in the upper few centimeters of depositional microenvironments at several of the surface water stations. Moist sediments were placed directly in Zip-loc bags and sent to the Syracuse lab for analysis of lead, zinc, and nickel.

The reason for collecting water temperature data was to grossly identify the extent of daily and diurnal fluctuation which occurs in different Juneau streams in comparison with simultaneous air temperature fluctuations, and to identify maximum summer water temperature at various points. Approximately 15 max-min thermometers were strapped to the undersides of submerged boulders in July, and readings were taken at irregular intervals (usually a few weeks apart), resetting the thermo meters each time, from July through November. Data from this low-effort survey are presented in Table 9.

The primary limitation of the water quality survey was the difficulty in getting good temporal coverage. Nutrients and other chemical constituents often reach their greatest levels of export during infrequent but ecologically and geochemically significant storms. Our attempts to include such an episodic pulse in our study were unsuccessful. However, we did sample surface waters during another critical nutrient pulse event in Southeast Alaska — salmon spawning. And although the major estuarine phytoplankton bloom occurs during the spring (when we did not sample), other researchers (e.g., Kirk 1973) have postulated that this bloom is not related directly to nutrient runoff at this time, but rather a response to increased light and physical mixing.

(2) Data Reduction

Data Reduction

Several computer-generated printouts were constructed to organize the data:

a. Certain ratios with potential ecological and hydrologic significance were calculated. The available N:P ratio was calculated as inorganic nitrogen (NH_3+NO_3+NO_2) divided by inorganic phosphorus (FRP). Also, the total H: total P ratio was calculated. This ratio has been widely used as an indicator of N versus P - limitation of aquatic communities, with ratios less than about 16 (after multiplication by 2.22 to convert to atomic weight) being suggestive of nitrogen limitation, and ratios greater than 35 suggestive of phosphorus limitation. Ratios exceeding 29 may limit growth of blue-green algae in lakes. The organic to inorganic nitrogen ratio was calculated as (TKN-NH_3)/(TKN+$N0_3$) and is used to monitor conversion of inorganic N to organic N. The percent reactive phosphorus was calculated as FRP/TFP and is used (albeit crudely) to monitor conversion of inorganic P to organic P. The calcium-magnesium ratio has been used in other regions as one indication of ground water discharge, with higher ratios (in the absence of marine influence) suggesting discharge. Concentrations of all substances were flow-adjusted by dividing or multiplying by stream discharge (when available) and by dividing by the log of the drainage area of the station.

b. Water quality stations located in sequence on the same stream were graphed with the graphs showing the change in concentration of various substances from station-to-station at various seasons, from headwaters to estuary. Concentrations at the mouths of all tributaries were also compared. It is assumed that collected samples are representative of the reach generally, and not merely the result of a localized stream micro-environment. Diurnal effects also were not monitored, but could affect the nutrient concentration results.

c. Data for each chemical constituent (and ratio) were sorted and listed in ascending numerical order, so the percentage and identity of stations falling above or below a particular threshold could be easily reviewed.

d. A correlation matrix of relationships was constructed after log-transforming the concentration data. Separate matrices were prepared for freshwater vs. "saltwater-influenced" stations, the latter being defined as those with conductivity exceeding 215 uM/L (this seemed a logical breaking point based on our knowledge of the study area).

Original laboratory sheets containing results of all water quality analyses have been placed in repository with the Alaska Department of Environmental Conservation (Jordan Creek office).

2.1.4 Fish Survey

(1) Data Collection and Limitations

Censusing the fish in all reaches of Juneau streams would be a virtually impossible undertaking, without considerable expense and manpower. Even "relative abundance" is difficult to estimate due to great year-to-year and seasonal variation in fish use of particular areas. Also, a possibly significant portion of some juvenile fish populations consists of "nomads" whose presence may be opportunistic, rather than reflecting the true production capacity of the stream habitat. Short of measuring fish time-of-residence in each wetland, the best estimator of wetland importance is probably habitat quality. Thus, an inventory of Juneau freshwater fish habitats was under- taken as part of this project.

The inventory was relatively comprehensive in scope, and used the diagrammatic method of habitat inventory (Barber et al. 1982). It involved mapping most of the study area streams at a scale of 1 inch = 4 feet, between September 1986 and January 1987. Over 10 miles of stream were mapped, generally in 50-foot reaches, but due to time and manpower constraints, estuarine portions of most streams were not mapped, nor were Bay and Waydelich Creeks, Hendrickson Creek, and the upper portions of Douglas Island streams within the study area. Stream conditions immediately upstream of all water quality monitoring stations were also mapped.

Covering a large number of locations was deemed more essential to project objectives than measuring habitat features in detail. Thus, the map for any given reach was not necessarily accurate in showing the exact position of logs, curves in the direction of stream flow, location of aquatic vegetation, etc. However,

the proportional size of such habitat features relative to the total area or length of the stream reach is generally accurate.

Limitations associated with the fish habitat survey area are as follows:

(a) Mapped conditions represent those existing only in Winter 1986-87. Even on a day-to-day basis, the location of positive habitat features may change as high flows cause pools to become fast water and streamside logs and vegetation become submerged; or low flows cause former riffles (fast water areas) to become dry gravel bars which may impede fish movement. Nonetheless, the proportionate distribution of habitat types as depicted by these maps is approximately accurate for relative comparisons.

(b) Observer variability influenced the level of detail and consistency of mapping certain features. Inventory procedures and models of Barber et al. (1982), Platts et al. (1983), Johnson and Helfetz (1985), Raleigh (1985), and Hale et al. (1985) served as source material, but were tailored to the Juneau situation. Limitations in mapping specific features are discussed in section 2.2.6.

(2) Data Reduction

Maps were drawn on gridded paper, and surface areas of the habitat features were thus easily determined in the office for each reach. These numerical data for all 30 variables and 1237 reaches were entered into a computer database. The SAS computer software series was used to cross-tabulate data, compute frequencies, and calculate descriptive statistics.

A statistical clustering algorithm was applied to the entire data set and to data from individual streams, for two purposes: (a) to identify population estimate sites which would facilitate a maximum ability to extrapolate results to other sites, (b) to identity consecutive reaches that are similar, so they might be objectively combined for purposes of simplifying the assignments of ratings.

The clustering effort was only partly successful, so pooling of consecutive reaches was additionally accomplished by assigning habitat quality ratings to all individual consecutive reaches which were then combined based on similarity of this rating, rather than on clustering of its habitat components.

The computer tape for this database is available from the author, and original maps have been placed in repository with the Habitat Division of the Alaska Department of Fish and Game, Juneau.

2.1.5 Fish Populations

(1) Data Collection and Limitations

Winter fish populations at 21 locations were determined using mark-recapture methods and a Smith-Root gas-powered backpack electroshocker. The locations were selected (a) such that each of the stream reach "types" identified by the statistical clustering procedure would be represented (see above), (b) based on reconnaissance electroshocking runs which indicated presence of fish in sufficient numbers to comprise a statistically adequate sample size.

Different-sized reaches were used in different streams so as to attain adequate fish population sample sizes with the least effort. Most reaches were 200 feet in length; some were 100 feet or 50 feet; one was 400 feet. Surveys were done February 10-26, 1987.

Blocking screens of 0.5-inch mesh hardware cloth were first set up at both ends. In most reaches, we did two passes over the reach with the electroshocker, working upstream and especially focusing on likely habitats (e.g., undercut banks, woody debris). One or two people stood behind the person with the electrode to capture any fish not seen by the electrode person. Fish were placed in a holding bucket, clipped on their caudal fin, and released evenly throughout the reach or slightly skewed toward the upstream end. A minimum of 2 hours was allowed for fish to become redistributed. Then, two recapture runs were made in similar fashion. Occasionally, one or two fish per reach (out of many dozen) remained stunned, and were not released in the blocked reach.

Limitations associated with the procedure are as follows: (a) many fish (especially small ones) are difficult to see even when shocked, especially under deeply incised banks or in deep or turbid water, (b) Dolly Varden are less susceptible to shocking and/or are more difficult to see than Coho, (c) parts of some reaches (on Jordan, Montana especially) were not accessible due to deep water, (d) blocking nets on ends of the reaches were not impervious to passage of the smallest individuals.

In addition to the population surveys, more rapid means were used to simply determine presence or absence of juvenile fish in a wider range of streams. During the same February period, a 10-minute shocking run was conducted on at least 30 additional reaches. Also, in August-September minnow traps baited with salmon eggs were left for 24 hours at several locations to determine fish presence/absence. Minnow trapping seemed less successful in winter.

(2) Data Reduction and Interpretive Cautions

Fish populations in shocked reaches were estimated using the Peterson formula:

$$N \frac{(M)(C)}{R}$$

where M = marked fish
C = recaps plus no-marks
R = recaps
N = population estimate

This equation should be considered only a crude estimator of fish populations, but is probably sufficient for generally indicating the relative population densities in different reaches.

When interpreting the data in Table 13, note the standard deviations and be aware that some of the sample sizes were statistically insufficient (as noted in a footnote). Also note the conversions to fish per foot of stream reach (i.e., "N" divided by reach length) and fish per square foot. The latter was based on width data collected in December or January, not at the time of February surveys. In most cases the physical difference is negligible.

Standard deviations of the samples were calculated using the same factors as above in the formula:

$$S = \sqrt{\frac{(M^2C)x(c-r)}{r^3}}$$

where S is the standard deviation.

2.1.6 Wildlife and Vegetation

This data collection effort was conducted in partial support of the analysis for the functions "Regional Ecological Diversity," "Disturbance-Sensitive Wildlife," and "Erosion Sensitivity."

A. Estuarine Birds

(1) Data Collection and Limitations

Three data sets were compiled. One, based on a 1981 survey by ADFG, was included for historical purposes, given the fact that weather during 1986 surveys may not have been "typical."

Another, conducted by ARA, Inc. biologists, focused on fresh water areas near the estuary. A third, now ongoing by USFWS biologists, contains the most observation points and the most frequent coverage.

Results from the three studies are only crudely comparable, due partly to different subunit boundaries and dates. Even within a single data set, conclusions should not be drawn without noting the variability caused by different observers; human disturbance intensity; weather and tide conditions; size of the subunit; and visibility of birds as governed by the size of birds which characterize the site relative to the size of obscuring vegetation and topography. Also, on some survey dates, numbers may be artificially low due to intentional harassment of birds by Airport personnel.

Methods used in each of the studies are summarized as follows:

ARA 1986 Ground Survey

A total of 9 counts were made by ARA, Inc. personnel between April 29 and August 21, 1986. During each survey period (which lasted 1-2 days), observations were made while walking between multiple points in approximately 30 wetlands, all but 4 of which were freshwater wetlands. Only the more obvious, wetland- dependent birds were surveyed systematically (e.g., shorebirds, waterfowl, swallows); less obvious species were noted nonsystematically.

APFG 1981 Ground Survey

A total of 21 counts were made by Alaska Department of Fish and Game (ADFG) biologists between February 11 and October 28, 1981. Data collection focused on waterfowl; some nongame birds were noted incidentally. Observations were plotted to within about 100 ft. on overlay mylars contained in ADFG Game Division files.

USFWS 1986 Ground Survey

This is by far the most comprehensive survey, and is ongoing (it began in February 1986). Some 32 areas are checked regularly; some twice a week (ES 1 through ES 16) and some once every 2 weeks. The exact dates and times of visit are selected randomly. No attempt is being made to systematically inventory the smaller, less obvious songbird species.

(2) Data Reduction

Data from the surveys was tabulated manually, and reported in Tables 15 - 18. No attempt was made to associate certain species with certain habitat types within the estuary.

B. Non-estuarine Birds

(1) Data Collection and Limitations

From June A to July 10, 1986 two observers trained in plant identification and vocal recognition of birds visited most study area wetlands. A single visit was made to each wetland. Visits were timed to coincide with maximum vocal activity for most bird species, between 3 and 9 am. In each case, birds were noted primarily at "listening stations," but also between stations, although always within the wetland boundary. Listening stations were approximately 200 feet apart on transects located 400 feet apart, except in smaller wetlands where stations were few but densely spaced. No visits were made during extremely inclement weather, and the weather during the survey period was relatively dry.

At each listening station, habitat conditions were noted on a standard form and dominant plant communities and species were recorded. A total of 820 listening stations were visited. Habitat data were collected from some additional stations which were not visited at a time when bird fauna could be appropriately determined.

A major limitation of the survey is that bird singing activity, even at the peak of the breeding season, tends to be very sporadic in Southeast Alaska, making birds difficult to detect, especially on the basis of a single visit (Kessler and Milne 1982). Examples of species which were probably present but are characteristically difficult to detect are Pygmy Owl, Brown Creeper, Northern Goshawk, and nesting waterfowl. Time constraints prohibited visitation of all study wetlands during the appropriate season. It was also impossible to determine the site fidelity of most observed species, i.e., were they briefly wandering into the wetland from adjoining non-wetlands, or were they genuine residents at this season?

(2) Data Reduction

Species and wetlands were cross-tabulated, allowing generation either of a list of all wetlands where a given species occurred, or a list of all species in a given wetland. A contingency table was prepared for each species - habitat feature combination, but statistical analysis showed few significant relationships due to the skewness and sparseness of the data set (see Table 20). A "scarcity index" was also calculated for each inventoried wetland to address situations where a wetland might have several uncommon species, none exceptionally rare, but together indicating locally specialized habitat conditions. The index was calculated as follows:

1. The frequency of occurrence of each species at all 820 listening stations was tallied and used as a weighting factor (e.g., a warbler recorded at 164 stations received a weighting factor of 164/820 - 0.2).

2. A composite list of all species occurring in each wetland (all listening stations pooled) was drafted.

3. The mean weight of all species on this list is the "scarcity index".

Values of less than 0.2 for this index represented the most overall unique wetland bird assemblages, while those over 0.4 indicated presence mostly of generally widespread species.

2.1.7 Recreational Use

(1) Data Collection and Limitations

Data on Renewable Human Use (recreation, aesthetics, etc. – see Section 2.2.11) in the Juneau area were compiled by three methods:

1. review of previous recreation literature and surveys for Southeast Alaska
2. open-agenda, well-publicized public meetings (May 1986)
3. mail-out survey

These were then used as a partial basis for developing assessment criteria.

The literature review yielded little information relevant to Juneau, as few appropriate surveys have been conducted. Some site-specific information on human use of estuarine wetlands was gleaned from a 1986 U.S. Fish & Wildlife Service wildlife survey.

The two public meetings were well-attended. At these meetings we solicited information and opinions about wetlands, using a standard form. Although the meetings provided useful background material for subsequently constructing the mail-out questionnaire, the information provided was non-random.

The mail-out survey was the most publicly-visible aspect of the effort. A random sample of Juneau residents were asked to respond to the survey to better understand public perceptions of (1) wetland scenic quality, (2) the importance of wetland functions and attributes, (3) special issues and concerns, and (4) recreation use.

During October 1986, questionnaires were mailed to 1560 residences that were randomly identified from the Juneau City Directory (Polk, 1985). A second mailing was made in December to all those who had

not responded by that time. Of these, 197 were returned because there was no mall receptacle at the address. These were replaced by 199 randomly-sampled residential postal boxes. An additional 564 questionnaires were returned by the Postal Service for other reasons. A total of 430 responses were received of a possible 998, for a total response rate of 43 percent.

Although the response rate was excellent and those who were asked to respond were probably close to a true cross-section of Juneau's voting population, those who actually returned the questionnaire were not necessarily representative (Table 4), despite our best efforts. As with any survey addressing a highly controversial and technically complex subject, some users perceived biases in the wording of questions, but generally could not agree as to the direction of the bias. Inaccurate boundaries on one map which accompanied the survey made the Auke Bay/Lake data difficult to interpret. And as with other components of this study, seasonally may influence the results — in this case, the summer population was largely excluded. A direct field monitoring of wetland use by people might have been technically preferable, but would have been too labor-intensive.

Also, at the CBJ's request, copies of the survey were mailed to a non-random sample of the public, specifically, most citizens who attended the initial information meetings and others who had requested information directly. Results of this survey are being tabulated separately.

(2) Data Reduction and Interpretation

Survey results were tabulated on a SAS software package. Considerable understanding of resource attitudes might be gained by cross-tabulating the data in various ways, but we limited ourselves to the primary study objective of documenting existing use and attitudes. Thus, little interpretation is offered. A complete statistical summary, as well as the response forms themselves, are available for public review at CBJ offices.

Separate ratings for the Renewable Human Use function were assigned to potential use and actual use. The potential use rating of each wetland was based on criteria given in Section 2.2.11. With a few exceptions (estuarine wetlands covered by USFWS survey, and streams) the actual use rating was not baaed on data specific to each wetland. To do so would have required us to monitor human activity constantly in over 120 wetlands, or to ask survey respondents to fill out a matrix of 120 wetlands x 18 activities.

The ratings of actual human use for the wetlands are based on survey responses which evaluate human-use within six large wetland-complexes containing many individual sites. Actual human-use ratings, therefore, are given for the general sub- areas of Douglas Island, Lemon Creek, West Mendenhall, East

TABLE 4
Characteristics of the Juneau Wetlands Survey

Characteristic	Percent
Sex Male	72
Female	28
Own property in Juneau	
Yes	81
No	19
Area of residence	
Douglas Island system	6
Mendenhall West system	6
Auke B ay-Auke Lake system	13
Lemon Creek system	8
Montana system	3
East Valley-Airport system	24
Other areas	39
Ethnic background	
White	93
American Indian/Inuit/Aleut	4
Other	3
Income	
Under $20,000	8
$20,000 to $39,999	30
$40,000 to $59,999	30
$60,000 or more	31
Occupation	
Professional/Managerial	46
Service/Technical/Admin. Support	30
Crafts/Operators/Laborers	11
Not in labor pool	13
Education	
High school (1-12 years)	12
Some post-high school training	32
College degree (4 year)	28
Graduate or professional degree	29
Development or environment meetings attended in the past two years.	
None	28
Once or twice	38
Three or more	34

Valley/Airport. Auke Lake/Bay, and Montana Creek. Since actual use ratings were not available for each wetland site, in order to ensure the validity of the predictions, the potential and actual human-use ratings are not combined into one overall human-use rating for each wetland.

One aspect of the public survey concerned preferences of Juneau residents to different landscape types, and was based on responses to different wetland landscape photos included in the questionnaire. Data analysis focused on determining:

a. which wetland characteristics might be associated with higher vlsual preference ratings, and

b. effect of development on vlsual preference ratings.

Information from these responses was used to assign a Vlsual Quality rating to each wetland. This was considered equivalent to each wetland's ratings for the other recreational activities which together ultimately comprised the rating for Renewable Human Use. All recreational activities (Including Vlsual Quality) were considered to have equal weight (Importance) for the purpose of combining them into a single rating for actual and potential use. That is, the assigned rating for actual or potential use reflected whichever rating was preponderant for the listed activities — High, Moderate, or Low.

2.2 Criteria for ratings; Results for measured predictors

2.2.1 Ground Water Recharge and Discharge

Definition and Function Rationale. Ground water recharge is the net downward vertical movement of the wetland's surface water into underlying local or regional aquifers. Ground water discharge is the net upward vertical movement of ground water from the aquifer to the surface. Lateral flow conditions may also exist, where net water movement below the plant root zone is horizontal (Figure 4). These three conditions can change seasonally and vary over short distances.

Recharge is considered because of its importance to aquifers used for drinking water. Also, recharge wetlands are usually more tightly linked (hydrologically) to other wetlands, such that disturbances in recharge wetlands may have far-ranging consequences. Ground water discharge is considered because of its importance to fisheries (Bilby 1984, Scarnecchia 1981). Discharge helps sustain low flows in streams, but quantitatively is usually more immune than recharge to environmental disturbances occurring on the land surface (but not necessarily in the wetland itself). Disturbances may change its water quality, however (see Section 2.2.3), and developments located on top of former discharge sites will be plagued with chronic drainage problems and possible mass wastage problems.

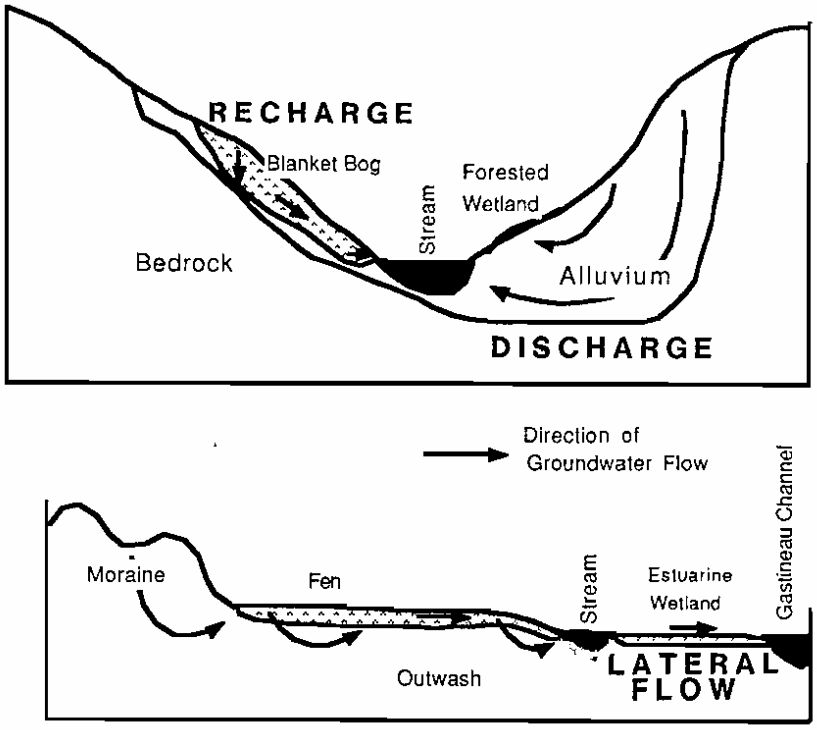


Figure 4. Recharge and discharge of ground water in types of Juneau wetlands.

Recharge and discharge are not strictly limited to wetlands, and there is no particular feature of wetlands which significantly enhances these functions. More typically, wetlands are simply manifestations of recharge or discharge which will occur under natural conditions regardless of whether wetlands or non-wetlands overlay the aquifer. The water source, then, is not the wetland, but rather the sediments which underlie it.

Criteria and Their Basis

Juneau's wetlands were assigned ratings of High, Moderate, or Low for Recharge, for Discharge, and for Lateral Flow. For non- instrumented wetlands, this was based on the following considerations:

1. Wetlands located at or near topographic divides for surface-water systems were given a high to moderate value for recharge. Examples are MW12-MW15. Modeling efforts and field studies show that groundwater systems are generally recharged at topographic highs on the water table, which in humid regions coincides with surface water divides.

2. Wetlands completely located within 200 feet of streams were given a high to moderate discharge rating. This criterion is based on the assumption that streams in the study area generally are gaining streams. Instrumented site MR1, next to the Mendenhall River, is mostly a discharge area and may be considered a "typical wetland" within this ranking criterion.

3. Wetlands partly located within 200 feet of streams were given a high to moderate lateral flow rating. Wetland MW1 and Mil are examples. This criterion is based on the assumption, supported by field studies and numerical modeling experiments in the literature, that most groundwater discharge to streams occurs at or near stream margins.

4. Wetlands in estuarine areas were specifically given a high to medium value for lateral flow because base flow, by definition, is the ocean. Upward gradients would be exceptionally small.

5. Muskeg wetlands were given a high to moderate recharge function based on the data from DI1, DI2, MCI and MC2 piezometer sites.

6. Low values for all ground water functions were given for wetlands enclosed on all sides by development (an example is M52), due to the probability that some are now isolated from ground water flow systems.

7. Wetlands underlain by alluvium located on mountain slopes were given a moderate to high discharge value based on data from piezometer nest JC1, located on the slope of an alluvial fan east of Jordan Creek.

8. Wetlands located approximately halfway on slopes between topographic divides and streams were given moderate to high lateral flow values. Typically, there is a zone of lateral flow between groundwater recharge and groundwater discharge areas in flow systems of any scale.

9. The function for the fen system in the lower Montana Creek area was assigned based on the results of the numerical modeling experiments and data from the headwater piezometer nests. For example, ML1 was assigned a high value for recharge.

Other factors which might be considered elsewhere in Southeast Alaska are as follows:

Recharge of ground water aquifers by Southeast Alaskan wetlands (except for "losing streams") has not been documented in the published literature to date. Near Fairbanks, most recharge occurs in nonpermafrost areas — areas usually less likely in that locality to have wetlands (Kane and Stein 1983). Most recharge occurred during the snowmelt period when losses via evapotranspiration were low. On wind-swept landscapes, woody vegetation may play a significant role in trapping snow and increasing the opportunity for recharge. However, in the Matanuska Valley, Trainer (1960) found the greatest recharge occurred after the summer rainfall because at other seasons much of the snowmelt was prevented from Infiltrating by frozen ground. The high infiltration rate of organic soils (as opposed to more-frequently frozen mineral soils) was also noted by Slaugther and Kane (1979). In Minnesota peatlands, Verry and Boelter (1979) generally found negligible recharge of ground water; some slight apparent recharge was noted where permeable mineral sediments were present beneath a thin peat layer.

Discharge of ground water as springs and "gaining" streams has been documented in a few places in Southeast Alaska (Harrison and Clayton 1970; Bishop 1980, 1981; Bugliosi 1985) and is probably commonplace. Muskeg peatlands in northern Alberta were usually characterized by discharge or lateral flow (Ozoray 1974), as were Minnesota peatlands (Verry and Boelter 1979, Siegel and Glaser 1987, Gorham and Hofstetter 1971).

For instrumented wetlands (where piezometer or pore-pressure data were available), our data analysis led to the following conclusions (additional data and discussion may be found in a supporting technical report available at CBJ offices):

Water-level measurements in piezometer nests, determinations of hydraulic conductivity of soils, and theoretical computer models of groundwater flow in representative wetlands show that the recharge-discharge function depends more on (1) the hydrogeologic setting than the wetland type, and (2) the volumes of groundwater in storage and surface runoff in streams.

Blanket bogs near Montana Creek and on Douglas Island are probably recharge areas when they are located significantly upgradient from streams. The bogs are probably discharge areas where they occur adjacent to streams, the discharge boundaries of wetland groundwater systems. Groundwater discharge is especially focused in linear discontinuities in the bog peat ("pipes"), which are probably recharged by groundwater flow systems in alluvial fans upon which the bogs have formed. Similarly, forested wetlands located on alluvial fans near Jordan Creek and Switzer Creek are dominantly discharge zones.

Recharge in the large lower Montana wetland (ML1), a patterned fen, has not been identified in fens elsewhere. Patterned fens are universally considered discharge zones (e.g. Ingram, 1983; Boelter and Verry, 1977; Ivanov, 1981), and the recharge function in the studied fen is unique. Computer modeling experiments suggest that the recharge mostly occurs in the fen headwaters and only penetrates to a depth of about 30 feet in the thick outwash deposits underlying the peat. This theoretical result needs to be tested by additional studies.

Although hydraulic head data is scant, estuarine wetlands appear either to be areas of lateral groundwater flow or of groundwater discharge, because the ocean is the ultimate base level, and dense, saline water occurs at depth.

The recharge-discharge functions of the blanket bogs, forested wetlands, and estuarine wetlands are identical to those deter- mined in similar wetlands in the lower forty-eight states (e.g. Novltski, 1979; Siegel and Glaser, 1987; Boelter and Verry, 1977; Valierla et al., 1978).

However, the recharge function is most meaningful where aquifers are present beneath the organic soils, and that setting applies only to the patterned fen (ML1) in the study area. The amount of recharge to the outwash aquifer underlying the Montana fen was liberally calculated as about 1,700,000 cubic feet for the period of record. This amount is relatively small, about equal to the amount of water pumped in one week from a single high capacity production well (1000 gallons/mln).

All other wetlands studied are underlain by low permeability till or marine deposits which are the lower boundary of the wetland hydrogeologic systems. The hydraulic gradients that define recharge and discharge are small in the wetlands. The amount of discharge of ground water to Montana Creek from the fen (ML1) and to Jordan Creek from forested wetlands (J4) is too small to be detected by standard stream flow measurements, although at some seasons it theoretically could have ecological significance.

Average concentrations of major metals defined the major wetland types. Bogs and fens were in recharge areas and had the most dilute ground water. Forested wetlands were in discharge areas and had concentrations similar to that found in domestic wells completed in mineral soils.

Bivariate correlations and scatterplots suggest that variations in concentrations of metals in domestic wells, bogs, and forested wetlands are related to the dissolution of minerals in mineral soils under the peat and concentrations of solutes in precipitation. High iron concentrations are being maintained in all ground water by reducing conditions and iron-organic acid complexes. Concentrations of aluminum are directly related to concentrations of dissolved organic carbon. The most concentrated ground water is found in estuarine wetlands where seawater mixes with precipitation and ground water.

Concentration profiles of total metals in blanket bogs were compared to theoretical concentrations based on the diffusion of solutes from mineral soil into the overlying peat. All observed concentration profiles are less than predicted by diffusion, showing that the blanket bogs are recharge zones. Assuming that the bogs are at least 1,000 years old, the discharge function determined from water levels at two sites probably is transient, and related to either recent climatic changes or the formation of subsurface pipes. Specific conductance profiles, similar in shape to the profiles of total metals, can also be compared to theoretical diffusion models because specific conductance correlates well with dissolved inorganic solids. This use of specific conductance profiles potentially may be a relatively easy method to qualitatively identify the recharge-discharge function for wetlands, in general, that are underlain by thick peat.

2.2.2 Surface Hydrologic Control

Definition and Function Rationale: Surface Hydrologic Control refers to the ability of wetlands to (a) reduce the magnitude of peak flows and associated flood stages, (b) delay the release of water to downslope/downstream areas immediately after storms, (c) sustain stream flows during dry seasons by yielding a steady outflow, and (d) reduce bank erosion and channelbed scour (see Section 2.2.9).

Reducing flood peaks and stage heights is primarily a direct economic concern, as high peaks often damage property within the floodplain. Under some circumstances, wetlands may reduce such damage. These circumstances are described below under "Basis for Criteria."

Considering the small size of their watersheds, it intuitively seems unlikely that wetland storage areas would have much effect on flooding caused by the major rivers (Mendenhall River and Lemon Creek) during extreme events. However, wetland storage areas might cause some lowering of downstream flood peaks on Duck and Jordan Creeks during less extreme events. Moreover, if such storage area were even partly converted to impermeable surfaces, runoff would be more rapid and flooding could be aggravated downstream.

Another aspect of Surface Hydrologic Control concerns the persistent drainage problems which occur throughout many areas of the Mendenhall Valley (EMPS 1979). In some cases individual yards may have become wetter over the years as upslope wetlands, which otherwise might have retained much of the runoff safely away from downstream properties, have been filled. Unless drainage plans are property implemented, such filling simply displaces water. Even when drainage plans are properly implemented, the ecological damage can be doubled — not only are productive wetlands lost, but runoff is moved downstream more rapidly. This has several potentially serious implications, both on-site and in the estuary.

The seasonal timing and post-storm duration of flows potentially affects several local events. The production of fish-food and wildlife-food organisms and plants within and near the mouths of Duck, Jordan, and other local creeks may be altered if flows arrive at a time when seasonal temperatures are not optimal for growth of these organisms or plants. However, in a comparison of an urbanized and a "natural" stream, Scott et al. (1986) found that the increased "flashiness" of flows in the former had no detectable effect on salmonid displacement or total biomass.

Changes in the seasonal timing or the amounts of freshwater outflow to the estuary may result in salinity increases or decreases at inappropriate times of the year. As a result, a wedge of higher salinity water

may intrude for longer durations (per tidal cycle) into fresh water habitats which have structurally better habitat, or fresher water may intrude farther and longer into parts of the estuary with physically superior habitat. In any case, biological production will be altered. The species composition of plant communities in the Mendenhall estuary depends largely on the duration of tidal saltwater inundation (Watson 1979), with the primary waterfowl food— Carex lyngbyei— probably growing best at salinities less than 10 parts per thousand (Beak Ltd. 1982). Salinity penetration during April may be most stressful to this species.

The same considerations apply to nutrients. Changes in the rate and seasonal timing of runoff may cause temporal and spatial displacement of sediment and nutrient loading in the estuary, such that flow and salinity shifts could cause sediment and nutrient deposition in areas of the estuary which may or may not have suitable physical habitat. Shorter post-storm flow durations (i.e., increased "flashiness") caused by loss of headwater wetlands may further stress biological communities in the streams and estuary, and allow less time for processing of wastes.

These hypothetical changes are unlikely to cause widespread alteration of the entire estuarine system because most impacts of wetland loss will be felt where most wetlands presently occur — Douglas Island, Auke Bay, and Jordan Creek. Effects will probably be localized near the mouths of streams draining these areas. This is because the glacially-fed Mendenhall River, which at all seasons dominates the freshwater flow input to the estuary, will experience no major wetland loss and thus will continue to be a moderating influence.

Basis for Criteria:

Criteria

HIGH

(1) Wetland has no permanent or tidal outlet (however, its edge may consist partly of a ditch which leads into permanent waters) and has a slope angle of less than 3%, or

(2) The HEC-1 hydrologic model (of Jordan and Duck Creeks) indicates the wetland is one of the three most effective areas on the stream for desynchronizing monthly peak flows, or

(3) Wetland is nontidal, and ground water discharge = low, and

3a. peat soils or shrubby vegetation prevail, and slope angle is less than 3%, or

3b. slope angle is 3-7% and other soils or cover types may be present, but wetland is large relative to its watershed (normally at least 5% by area, or smaller and wetlands are generally absent upslope).

An outlet may or may not be present.

MODERATE - HIGH

(1) The HEC-1 modeling indicates some runoff lag occurs between wetland inlet and outlet, or

(2) Wetland is nontidal, and ground water discharge = low, and slope angle is less than 7%,

(3) Outlet is constricted or absent, and wetland does not meet criteria above for High.

MODERATE - LOW

(1) Wetland is usually or mostly nontidal, but is within 25 vertical feet of sea level and slope angle is less than 3%, or

(2) Groundwater discharge is rated Moderate or High, and slope angle is less than 7%.

LOW

Tidal wetlands and wetlands with greater than 7% slope.

The wetlands most likely to reduce peak flow are those which have large surface areas, dense herbaceous vegetation, mild slope angles, and the deepest and largest layer of unsaturated (dry) soil for the longest portion or most critical time of the year, so that they are likely to be "prepared" to absorb sudden precipitation extremes. As noted by Sidle and Campbell (1985) "numerous muskegs, interspersed at lower elevations, may moderate peak runoff during major storm flow events." However, Schwan (1985) and Chamberlain (1982) note that peak flows in wetland watersheds may be higher because saltwater comes out of wet soils faster (this may not be true if they are decomposed peat soils). Wetland openings in the forest which are 2 to 6 times as wide as tree height may accumulate the most snow, and depending on their elevation in the watershed, may theoretically synchronize and thus aggravate spring flood peaks (Chamberlain 1982).

Some researchers report that the Kogish peak and Maybeso muck soils which typify many Juneau muskeg areas remain saturated throughout much of the summer (Patric and Stephens 1968) and thus would seem less likely than mineral soils to reduce peak flows. However, our data indicate that, at least in mid-summer, water levels in mineral soils responded more quickly to rainfall (i.e., little storage or lag effect was evident) while those in organic peat soils lagged behind. Perhaps the reportedly better ability of the mineral soils for soaking up precipitation was offset in this local instance because they may have had sparser vegetative cover or because geological conditions which favored their allowing ground water to be discharged, thus maintaining a more constant saturation which limited their ability to absorb rainfall (Carter 1986). Similarly, the relatively unsaturated summer conditions in the organic peat soils might have been caused by geologic conditions favoring ground water recharge, by the prevalence of natural subsurface tunnels ("pipes"), by increased evapotranspiration or interception from an extensive shrub community, or by greater evaporative water loss due to greater exposure to drying winds. Peatlands often do have higher evaporation than mineral soil watersheds (Eggelsmann 1975), and evapotranspiration may be a primary factor in wetland water budgets. Mineral soils in general are less likely than organic soils to be the site of a wetland unless dammed or fed by ground water discharge, which limits their ability to absorb precipitation. Wetlands may occur more characteristically on organic soils because of the slower percolation rate on such soils, rather than because of high water tables or ground water discharge.

Regardless of whether unaltered organic or mineral wetland soils serve as a better "sponge" for runoff, both are better "sponges" than altered wetland soils. This is particularly true where the top layer of peat has been scraped off, leaving a formerly deep peat which is characteristically a worse sponge than many mineral soils (Schwartz and Milne-Home 1982). Such situations often occur where urban development (with attendant gravel pads and/or impervious surfacing) is widespread on former wetland soils, and the result is higher peak flows downstream (Clausen 1980).

Watershed position is another factor which influences a wet- land's ability to attenuate peak flows. Downstream hydrographs may be modified the most (i.e., peaks are lowest) where unsaturated wetlands are large in proportion to their contributing drainage area (i.e., usually higher elevation wetlands) (Dunn and Leopold 1979, Van Haweren 1986). However, loss of wetland storage areas low in a watershed as a result of filling can have more far-ranging effects, because there is proportionally less remaining storage to compensate for even a small loss (Ogawa and Male 1983). The effect of a given development is greater when it occurs within the floodplain of a flatter river than of a steeper one (DeVries 1980). Flatter wetlands naturally tend to retain water more effectively.

The ability of a wetland to reduce peaks and sustain low flows is also sometimes related to its degree of internal drainage. Wetlands with numerous interconnecting ditches — while they provide extensive fish habitat — may also accelerate runoff and be less efficient for maintaining low flows downstream. Wetlands with many underground "pipes" or channels may be similarly ineffective. Wetlands with constricted outlets — due to beaver dams, clogged or undersized culverts, or natural topographic features — will usually provide longer detention times and thus may augment low flow regardless of whether they have mineral or organic soils. And finally, wetlands located at higher elevations in the watershed may be less effective for modifying the runoff response because in the Juneau area they are kept constantly saturated by frequent precipitation. In their state of constant saturation, they are less effective for absorbing runoff. They also remain frozen for a longer portion of the year.

Although peatlands may reduce peak flows and do delay runoff somewhat, there is no clear evidence that they slowly release water over time (Clausen 1980). As noted by Patric and Stephens (1968):

> "Muskegs are often regarded as sources of base flow. However, from [our] observations it seems more likely they behave more as ponds with rain flowing almost immediately from the nearly saturated organic surfaces...losses are immediately replaced by drainage from surrounding higher land...this land is the real source of base flow with muskegs being a sort of saturated wick conducting water...to streams".

A statistical analysis of Southeast Alaska streams (Schramek et al. 1984) found that watersheds containing a greater percentage of main-channel lakes had higher mean flows and low flows in winter, and especially, lesser 2-year and 100-year peak flows and lesser annual flows in May. When non-lake wetlands were combined with lakes for the analysis, results were still statistically significant, but not as clearly as when only lakes were considered. This might suggest that the greater volumes, lower gradients, and more constricted outlets of lakes provide better or more consistent flow control than the often diffuse outlets and sloping gradients of many non-lake wetlands (e.g., muskeg).

We examined the data collected by this study to consider whether muskegs (organic peat wetlands) contribute significantly to summer base flow in our streams. In our study area, Nine mile and Johnson Creeks (and to a lesser extent, Fish Creek) have predominantly peatland watersheds. If base flows in these streams are being sustained by water from the peat layer (as opposed to discharge from ground water), we

would expect to possibly see a lower Ca-Mg ratio, less iron, more aluminum, greater organic/inorganic nitrogen ratio, and/or smaller FRP/TFP ratio in July (presumably the drier month) than October. For Ninemile, this was true for iron, Ca-Mg, and FRP/TFP ratios. For Johnson, the case is weaker, as only the Ca-Mg ratio meets these criteria (see tables in Section 2.2.4). There may be differences between streams and months in precipitation quantity and quality, stream discharge amount, type of vegetation, evapotranspiration, and amount of spawning fish. It is also possible that base flow is fed directly and primarily by lateral flow (horizontal subsurface flow below the root zone of nonwetlands or wetlands) rather than flow directly from the peat itself ("acrotelm") or from discharge of deep ground water systems. Although peat may hold large quantities of water, the water is held very tightly by the peat and outflow at any moment in many peatlands is probably only a trickle. Thus, no conclusive evidence was found of muskeg contribution to base flow, but as noted earlier, Juneau muskegs may help attenuate peak flows (at some seasons) more effectively than non-peat wetlands.

2.2.3 Sediment/Toxicant Retention

Definition and Function Rationale; Sediment and Toxicant Retention is the removal of inorganic sediments (particularly finer materials) from aqueous suspension and/or the removal of potentially toxic metals or hydrocarbons from solution. No assessment is made as to the longevity or value of this function in any particular wetland. Sediment may be retained in a wet- land for years, only to be scoured out by a severe storm. Toxicants also may be retained in an undecomposed state for long periods, only to be released by a sudden change in the acidity or aeration of the water. And the retention by a wetland of sediments and/or toxicants may provide both considerable benefits for downstream water quality and considerable adverse consequences for on-site habitat.

Sediment retention by Juneau wetlands has several possible con sequences for downstream areas. Downstream water clarity may be improved, which will result in increased productivity of aquatic organisms, ultimately including salmon. Turbidity has been shown to be one of the strongest factors responsible for reduced density and biomass of macroinvertebrate fish foods in some Alaskan streams (Wagener 1984). A turbidity increase of 25 NTU can decrease primary production by 13 to 50% in shallow streams, and as such, is probably more important than nutrients in limiting production in many streams (Lloyd et al., unpublished). Excessive shade may have the same effect as turbidity, ultimately decreasing salmonid production (Murphy et al. 1981). Juvenile coho salmon avoid fresh waters with turbidities exceeding 70 NTU (Bisson and Bilby 1982), and larval herring may exhibit stress in estuaries at suspended sediment concentrations of 20 mg/L. Submerged aquatic plants and algae generally require turbidities of less than 30 NTU. Thus, retention of sediment in headwater areas can improve downstream water quality.

Of course, many headwater wetlands are intrinsically important for flood storage and fish habitat, and sediment can have very destructive effects on-site in these areas. Seepage of ground water into a stream can be cut off by excessive sediment retention, and aquatic production can consequently suffer (See section 2.2.13). Deep deposits of fine sediments tend to develop anaerobic (lacking oxygen) conditions, which may provide a warmer winter microclimate, e.g., we measured February temperatures 3 degrees (F) warmer 4 inches beneath the sediment-water interface on Jordan Creek near the Egan Expressway. Such conditions may also result in smaller fish food populations and release of some toxic substances.

Sediment retention has economic consequences as well. Taxpayers support financially the dredging of channels in Southeast Alaska by the Corps of Engineers and the periodic removal of accumulated sediment from drainage ditches by CBJ work crews. If such sediment could be retained in upstream wetlands or, better yet, not allowed to erode in the first place (see section 2.2.9, Erosion Sensitivity), then tax money could be spent for other causes. If sediment is allowed to accumulate in ditches and other areas, water (particularly during flood season) may be displaced onto adjoining property or cause increased flooding downstream. Displacement into adjoining vegetated areas may provide enhanced fish rearing opportunities, as may the enhanced conditions for rooting of aquatic plants in newly deposited fine sediments. The long-term net result of these changes is uncertain.

Toxicants, as well as sediments, can impose a financial burden on landowners in the form of additional costs for drinking water or wastewater treatment facilities, or as direct health hazards. Concentrations of lead in excess of 50 ug/L are believed to be hazardous for human health, and lesser concentrations can be harmful to fish and wildlife. Retention of lead by some head- water palustrine (freshwater) wetlands may be preferable in Juneau to its accumulation in estuarine wetlands, as the potential for being recycled seems greater in estuaries due to their more complex food chains, with greater prevalence of sensitive species (e.g., Bald Eagle). Studies elsewhere indicate approximately 90% of estuarine lead is retained in sediments, and the remainder is available to animals (e.g., geese) which graze on wetland plants.

Criteria

Wetlands were rated for Sediment/Toxicant Retention by the following criteria:

HIGH

(1) Measurements from at least one season indicate a reduction in turbidity as it flows through the wetland, or (if water quality not monitored)

(2) Wetland has no permanent outlet, has a slope angle of 0-3%, and is in a landscape depression (at least 25% of the immediately abutting land slopes into the wetland without being intercepted by a ditch or berm), or

(3) Peat soils prevail, much of wetland is in a landscape depression, and slope angle is 0-3%, or

(4) Specific conductance of water samples is 500-1000 uM/L and stream or wetland gradient is less than 3%.

MODERATE - HIGH

(1) Slope is less than 7% and wetland is in the lower 2/3 of a watershed which has had turbidity levels frequently inhibitory of aquatic production (Duck, Casa del Sol, Lemon, Mendenhall), or

(2) Wetland is tidal or primarily lacustrine, or regularly supports beaver.

MODERATE - LOW

Wetland is primarily vegetated and slope angle is generally less than 7%.

LOW

Slope angle generally exceeds 7%, or wetland is mostly unvegetated.

Basis for Criteria

Flat, vegetated terrain with organic soil probably has the best chance of retaining toxicants and inorganic sediments. Organic soils are particularly effective under certain conditions for retaining metals such as lead (Hemond 1984). Brackish conditions enhance sedimentation by flocculation (conductivity 500-1000 uM/L). Increased sediment loading increases the opportunity for sediment retention and may increase the rate of sedimentation.

Short of conducting expensive sediment-dating and particle- distribution analysis, water quality monitoring provides the best practical means for examining a wetland's ability for improving the clarity of the water which passes through it. Nevertheless, this approach has limitations: (a) increases in turbidity as water passes through a wetland may be due to increased loading with sediment from adjoining uplands, rather than ineffectiveness of the wetland, (b) decreases in turbidity as it traverses a wetland may be due to dilation from cleaner runoff or ground water rather than genuine entrapment of sediment particles, (c) turbidity measurements represent only one point in time, rather than long-term equilibrium or episodic (storm) conditions.

Turbidity is perhaps not the best measure of sediment retention, but is the most convenient. Turbidity can be influenced by presence of organic acids which stain the water, as well as by presence of suspended algae which reduce water clarity but have only negligible adverse ecological effects. Turbidity is used as a proxy for total inorganic suspended solids, as the correlation is very strong in Alaskan streams (Lloyd et al. unpublished). We did limited sampling of "total solids" and "total non-dissolved solids" and found the latter (in July) to comprise from 0 to 77% of total solids, with greatest proportions in the Mendenhall River and Fish Creek.

Most toxicants are normally present in only very small concentrations. Although hydrocarbons and other EPA priority pollutants might be the most ecologically and socially important water quality concerns (Rice et al. 1984, Karinen 1983), they are extremely expensive and difficult to measure. Thus, we used lead, which is widely accepted as an indicator of human contamination (Table 5) and which probably accompanies contamination by hydrocarbons in most Juneau instances. Retention of many toxicants also is correlated with turbidity reduction, because many toxicants adhere to very fine sediment as they settle, are buried, and perhaps eventually removed from zones where they might otherwise be mobilized and recycled into food chains.

Statistical correlation analysis of turbidity in Juneau streams indicated decreased turbidity (better water clarity) in the most heavily shaded stream reaches, and in streams with slow water areas occupying a large portion of their total upstream area. In both tidal and nontidal waters, increased turbidity was associated with increased iron staining of the stream sediments. Turbidity in fresh water was highly and positively correlated with flow, and total phosphorus. The following tended to decrease with increasing turbidity: chlorophyll-a (a measure of photosynthesis), magnesium, sodium, silica, and nitrate. In salt water, turbidity increases were accompanied by increases in total phosphorus, available phosphorus, and ammonia, and by a decrease in calcium. Maximum concentrations for Juneau areas we studied are shown in Table 5.

TABLE 5. Heavy metal concentrations in sediment samples.
March 1987.

HIGHEST CONCENTRATIONS

Lead Cue/g)	zn (ua/g)	Location
466	394	Mendenhall River below Duck Cr. mouth
269*	831	Duck Cr. below Super Bear mall
129	194	Honda Hut area—emergent wetland
110	766	West Duck Cr. near Nancy St.
79	134	pond, S. of Montana Cr. Rd. on Loop Rd
78	176	Duck Cr. at Aspen St.
77	54	Moraine Pond above Taku Blvd.
72	248	Duck Cr. at Super Bear Mall
69	260	Duck Cr. pond above El Caraino Ave.
5	257	Airport Fire Station area
21**	217	Switzer Creek at Glacier Hwy.
	152	Valley Blvd. ditch (upper Duck Cr.)

* Surface water samples were 24 ug/L here.
** Surface water samples were 15 ug/L here.

LOWEST CONCENTRATIONS

Lead (ug/g)	Location
2	tidal channel abatting, end of runway
5	Lemon Cr. shoreline, above Egan Dr.
6	Smith-Honsinger Pond, w. end
6	tidal channel abutting e, end of runaway
6	runway tidal flats
8	“island” at end of runway tidal flats
8	Float Plane Pond-tidal flats

NOTE: For comparison purposes, the mean value for lead from hundreds of relatively uncontaminated soils (collected in western parts of the lower 48 states) is 17, with a range of less than 10 to over 700 ug/g; the mean for zinc is 55, with a range of 10-2,100 ug/g (Shacklette and Boerngen 1984). Thus, levels in Juneau appear to be generally elevated.

TABLE 6. Greatest turbidity levels measured in nontidal waters by this study, July-November 1986.

Turbidity

NTU	Location	Months
180	Mendenhall River	October
72, 56	Duck Cr. at Nancy St. (WT7)	Oct., Nov
46	Duck Cr. by power station (WDC2)	November
42	Duck Cr. at mouth (WDC1)	November
40	Duck Cr. below Aspen Ave. (WM9)	November
36	Duck Cr. at outlet of upper pond (WD2)	October
30	Duck Dr. at Taku Blvd. (WM10)	November

Note: Of 982 samples collected from Juneau tidal and nontidal waters, July-November, 50 (5%) exceeded 25 NTU) and 119 (12%) exceeded 5 NTU.

2.2.4 Nutrient Transformation/Export

Definition, Function Rationale, General Results: This function concerns a wetland's ability or potential ability for transforming and/or exporting organic forms of nitrogen and phosphorus.

In some regions of the United States, the Femoral or retention of nitrogen and phosphorus by headwater wetlands is viewed as a positive attribute. This is because downstream lakes and estuaries have become so enriched that algae flourishes at nuisance levels, and consequently causes deoxygenation of water and increased costs for water treatment.

This appears not to be the case in southeast Alaska, as no adverse economic effects of overenrichment have been specifically documented. To the contrary, some of the highest densities of wintering coho reported from southeast Alaska occurred in the study area's most nitrogen-enriched and phosphorus retentive stream (Vanderbilt), perhaps due to a richer food source there. February coho densities in the study area overall were correlated with nitrate concentrations the previous November. High concentrations of nutrients, in the absence of excessive/turbidity shade and low flows, may be a key factor for salmon food production (Dill et al. 1981), and the result (even in urban areas) may be increased growth and biomass of cutthroat (Scott et al. 1986). Hence, nutrient retention/removal per se is not viewed as a necessarily positive function for Juneau wetland management.

Excessive algal growths, however, may clog interstitial spaces in the stream gravels and limit spawning (Chamberlain 1982). Also, some researchers have speculated that if pink salmon fry grow too fast (as may happen in over-enriched streams), they may leave the stream too soon and encounter cold nearshore waters, slowing their growth and increasing their vulnerability to predation (Hargreaves and LeBrasseur 1986). A difference in out-migration timing of 30 days may cause an eight-fold difference in survival (Taylor 1977).

In many regions of the United States, the most important water quality function of wetlands is sometimes considered to be their role in transforming inorganic forms of nitrogen and phosphorus to organic forms. This has two likely consequences:

1) These nutrients become less available for supporting growth of algae downstream (Heath 1986), and,

2) Especially if the organic forms are particulate (i.e., not dissolved or in colloidal suspension), they become available for repeated recycling within food chains important to many commercial fisheries (Elder 1985). At the same time, the conversion of inorganic to organic forms comprises de facto evidence of strong biological activity within the wetland, major leaching, and/or of significant physical export capacity. Export of inorganic nitrogen (nitrate and ammonia) is usually more typical of disturbed watersheds than export of organic nitrogen.

Which form of nutrients — organic or inorganic — is best overall for sustaining this study area's fish and wildlife? A definitive answer would require years of study of the requirements of many local food chains, so it is only conjecture whether the loss or major disruption of a food chain linkage or microhabitat would actually result in a decline in a particular population (Simenstad 1983). The "preferred" form of nutrients ultimately would depend on season, the species or aquatic communities which themselves were most valued, and their life stage. However, the following discussion may shed some light on this topic.

A. Auke Bay/Mendenhall Estuary

This estuary provides major habitat for starry flounder, tanner and king crab, walleye pollock, bay scallops, herring, salmon, and numerous other species (e.g., eulachon, mollusks) which ultimately support the estuary's rich bird life and fisheries. Some of the highest densities of fish larvae (September) and fish eggs (October) in southeast Alaska were collected from Auke Bay (Mattson and Wing 1972). Local, quantitative data are not available regarding the food habitats of these fish. Data from elsewhere suggest that chironomids (midge larvae), copepods and amphipoda are important foods for the estuarine-rearing salmon — chum, pink, coho (Healey 1962, Koski and Kirchhofer 1984, Levy and Northcote 1981). Wetland plants (e.g., Carex lyngbyei) which are a primary food of Canada Geese are not likely to be influenced by concentrations of waterborne nutrients. However, to the extent that waterborne nutrients become incorporated into the sediment, they may enhance sedge production.

The base of the deepwater food chain — phytoplankton (suspended algae) — is limited primarily by available nitrogen in Auke Bay (Bruce et al. 1977, DeManche 1974). Phytoplankton peaks occur in spring, and again to a lesser degree in the fall when nutrients are brought to the surface by wind. The response to nutrients is not immediate, however. Conversion of organic to inorganic forms may proceed more slowly for nitrogen than for phosphorus (Bruce et al. 1977). During winter months, nutrient concentrations in Auke Bay are relatively high, but phytoplankton low, and physical processes are controlling (Bruce et al. 1977).

B. Freshwater Environments

Organic forms of phosphorus, if dissolved or colloidal, may be less available to food chains than inorganic forms (Heath 1986). When phosphorus is complexed with organic matter (as mediated by iron), the overall productivity of the wetland may suffer. Such reactions are likeliest to occur in environments with considerable amounts of humic acids and dissolved organic carbon (DOC), such as muskegs (Koenings et al. 1985). However, if dissolved oxygen levels are low (as are sometimes indicated by high

ammonia levels), then phosphorus will not be tied up so severely by iron (Koenings and Hooper 1984). Moreover, DOC itself may sometimes provide a nutritional source (Salonen and Hammar 1986), and organic forms of phosphorus may be very important for stimulating growth of algae in the spring (Heath 1986). Also, frequent fluctuation of water levels or soil saturation levels (as occurs in many muskegs subject to high evapotranspiration and little ground water discharge) may lead to increased release of nutrients. The roles of organic forms of nitrogen are poorly understood, but organic nitrogen can be used directly by algae. Muskegs may increase the denitrification process, resulting in increased ammonia (Stednick 1981), an effect not disproved by our data.

C. Influence of Freshwater Wetlands on the Estuarine Nutrient Concentrations

Numerous studies elsewhere in the United States have documented the importance of freshwater wetlands to the biological productivity of the estuary (Elder 1985, Kirby-Smith and Barber 1979). Freshwater wetlands may help regulate estuarine productivity by:

a) Regulating the timing and duration of freshwater inflow (see Section 2.2.2);

b) Regulating the type and amount of carbon (especially in the form of decaying plant matter) which reaches the estuary (see Section 2.2.5);

c) Regulating the type and amount of sediment which reaches the estuary (see Section 2.2.3);

d) Regulating the type and amount of phosphorus and nitrogen which reach the estuary (this section).

Salmon may be the major nutrient linkage between freshwater and saltwater wetlands in many parts of Alaska (Richey et al. 1975; Duncan and Brusven 1985a). In the only published nutrient flux study for a Southeast Alaskan estuary, Sugai and Burrell (1984) measured significant increases in exported ammonia and phosphorus following salmon spawning, and crudely estimated nitrogen and phosphorus inputs (per decomposing fish) as 0.1 ug/L for nitrogen and 29 ug/L for phosphorus. These inputs occurred at an ideal time for maximizing primary production, since humic acids (which otherwise inhibit production through phosphorus complexation and decreased light penetration) were at their seasonal lowest. In addition to supporting phytoplankton blooms necessary to herring and other coastal fishes, salmon-sourced nutrients may support the growth of periphyton (algae attached to stream rocks) the following spring or early summer; in non-salmon streams this growth occurs later in the season (but before fall storms) (Walter 1984, Richey et al. 1975). Periphyton helps sustain production of salmon food organisms.

D. Nutrient Inputs to the Mendenhall Estuary from Juneau Fresh Wetlands

Kirk (1973) concluded that "fresh water sources provide only negligible amounts of nutrients11 for summer phytoplankton production in Auke Bay. In the Stikine River marshes, offshore waters are 2 to 5 times richer in nitrate and their penetration in winter of intertidal areas may be the primary fertilizing influence on estuarine wetlands there (Beak Ltd, 1981). Similarly, saltwater in the Juneau area was generally richer in nutrients than was freshwater, especially in winter.

It is not possible to state definitively that freshwater nutrient runoff does or does not directly control the productivity of the Mendenhall estuary. To do so would require constructing a nutrient budget based on simultaneous measurements of stream discharge and tidal currents at numerous points and times of year — clearly beyond the scope of this study. Nevertheless, some gross comparisons can be made by reviewing nutrient concentration data from the mouths of the principal tributaries — the Mendenhall River (Table 28), Jordan Creek (Table 30), Duck Creek (Table 29), Douglas Island streams (Table 26), and Auke Bay streams (Table 27) — as well as data from the Lemon Creek estuary and other parts of the Mendenhall estuary.

In August, we sampled our estuarine water quality stations just before low and high tide (the same day), and some differences were striking (Table 7). Concentrations of total phosphorus filterable reactive phosphorus (FRP), total filterable phosphorus (TFP), nitrate plus nitrite, and particularly ammonia were higher on the falling tide (ammonia by an order of magnitude). Because of the large ammonia influx, inorganic nitrogen prevailed over organic forms on outgoing tides, while the opposite was true on incoming tides, an effect noted elsewhere by Wissner 1986. The N:P ratio increased an order of magnitude on outgoing tides.

D(l). Available Nitrogen. The mean nitrate concentration for all Juneau surface water samples (July-Nov.) is 100 ug/L, the mean ammonia concentration is 38 ug/L, and the mean Kjeldahl nitrogen (organic N+NH3) is 370 ug/L. Thus, available nitrogen averages 332 ug/L and total N is 470 ug/L. Means for freshwater samples are much less than for estuarine ones.

For ground water, the nitrate averaged 70 ug/L in mineral soils, 164 ug/L in peat, and 231 ug/L in the Montana fen. Ammonia averaged 378, 1696, and 733 ug/L respectively in ground water.

Table 7. Nutrient concentrations in the Gastineau-Mendenhall Estuary, July 1986 - February 1987.

	Inside tip of Mendenhall Peninsula (WE1)					Engineers Cutoff (WT12)					
	12 Aug.(4)	13 Sept.	14 Oct.	20 Nov.	5 Feb.	17 July	10 Aug.	13 Sept.	15 Oct.	19 Nov.	5 Feb.
NO3+NO2	18.2-23.	20.6	36.0	118	222	64	108	129	13	170	215
NH3+NO3	32.9-510	62.1	70.1	256	270	113	165	194	29	343	331
TKN	95-142	40	119	2358	75	352	261	392	-	354	110
ON/IN(1)	2.4-0.3	0.6	1.7	8.7	0.1	2.7	1.2	1.7	-	0.5	0.1
N/P(2)	7.8-66.2	11.7	8.6	48.3	14.9	14.8	9.6	7.9	1.4	7.9	10.5
TP	91-87	51	196	29	60	68	56	132	-	110	64
FRP	4.2-7.7	5.3	8.1	5.3	18.1	7.6	17.2	24.6	20.6	43.5	31.4
TFP	4.5-8.9	6.3	8.6	4.3	17.5	10.7	22.0	32.1	28.5	44.7	30.9
Si	--	0.5	0.6	3.7	--	3.3	4.3	5.0	2.4	5.7	--
Fe(3)	--	0.03	0.10	0.17	--	0.89	1.05	1.28	0.44	3.60	--
Al	--	0.03	0.4	0.15	--	0.03	0.05	0.09	0.22	0.13	--
DOC(3)	--	--	--	--	--						
Chl-a(3)	--	--	--	--	--	0.94		1.02			
Conduct.	1694-1219	1912	3550	20000	27500	5460	3820	59		9900	8640

(1) organic/inorganic N
(2) (NO3+NH3)/FRP
(3) in mg/L
(4) first number = incoming (high) tide
second number = outgoing (low) tide

	Channel west of Ninemile Cr. (WE3)					Channel at Vanderbilt Mouth (WE4)			
	12 Aug.	13 Sept.	13 Oct.	21 Nov.	3 Feb	13 Sept.	13 Oct.	21 Nov.	3 Feb.
NO3+NO2	13.3-32.8	40.1	48.2	212	209	75	202	442	251
NH3+NO3	16.7-241	142	105	225	226	105	233	460	285
TKN	110-174	226	223	58	43	156	150	64	78
ON/IN(1)	6.5-0.7	0.9	1.8	0.2	0.1	1.2	0.5	0.1	0.1
N/P(2)	1.9-13.6	5.7	4.6	11.7		9.5	31.1	54.7	15.8
TP	30-43	107	73	24	22	33	26	13	36
FRP	8.8-17.7	25.0	22.8	19.2	26.2	11.1	7.5	8.4	18.0
TFP	11.5-20.3	29.4	23.6	18.9	24.7	13.5	9.3	7.2	36.0
Si	--	208	222	124	43	2.1	2.2	2.9	--
Fe(3)	--	0.22	0.28	0.11	--	0.08	0.20	0.13	--
Al	--	0.11	0.33	0.10	--	0.05	0.07	0.02	--
DOC(3)									
Chl-a(3)						10,420	4800	523	1520
Conduct.	13700	23500	22500	13310	11980				

	Switzer Cr. Mouth (WE5)				Mouth of Lemon Cr. (WE2)				
	13 Sept.	13 Oct.	21 Nov.	5 Feb.	12 Aug.	13 Sept.	13 Oct.	20 Nov.	3 Feb.
NO3+NO2	403.	386.	312	357	15.7-20.6	28.3	55.6	143	298
NH3+NO3	417	407	354	384	49.7-271	37.2	58.8	313	321
TKN	66	88	107	46	23-26	37	25	495	43
ON/IN(1)	0.1	0.2	0.2	0.1	0.5-0.1	0.9	0.4	1.0	0.1
N/P(2)	42.1	36.0	52.8	40.8	18.4-108	24.8	26.7	184	61.7
TP	13	20	38	21	43-93	14	21	9	9
FRP	9.9	11.3	6.7	9.4	2.7-2.5	1.5	2.2	1.7	5.2
TFP	11.3	20.9	6.2	8.5	2.6-2.5	1.9	2.1	1.7	4.9
Si	2.9	3.4	2.7		--	0.7	0.8	1.9	--
Fe(3)	0.14	0.23	0.23		--	0.02	0	0.64	--
Al	0.03	0.03	0.03		--	0.01	0.01	0.02	--
Conduct.	437	305	1822	3610	23-22	483	142	3260	5590

Available nitrogen (N03+N02+NH3) had the following correlates:
<u>positive correlates</u> (* = .01, ** = .001, *** = .0001 level of significance)

*** calcium (at both estuarine and freshwater stations)
*** magnesium (fresh only)
*** potassium (fresh only)
** sodium (fresh only)
* silica (estuary only)
*** % of immediate upstream area as aquatic vegetation
** % of immediate upstream area as overhanging vegetation
** degree of potentially disturbing land uses upstream

<u>negative correlates</u> (decrease as available N increases)

*** Kjeldahl (mainly organic) nitrogen — (fresh only)
*** iron (fresh water)
*** total phosphorus (fresh only)
** total filterable phosphorus (both)
* aluminum (estuary only)
* flow (fresh only)

The percentage of total N as ammonia was also examined, with the following results:

<u>positive correlates</u>
*** total phosphorus (fresh only)
*** total filterable phosphorus (fresh only)
* potassium (estuary only)

<u>negative correlates</u> (decrease as % NH3 increases)

*** calcium, alkalinity (fresh only)
*** pH (fresh only)
** iron (fresh only)
*** % of immediate upstream area as aquatic vegetation
** degree of potentially disturbing land uses upstream

Levels of available nitrogen (from August to November) were greatest in November in the estuary, and at the mouth of the Mendenhall River, Jordan Creek, Montana Creek, and Vanderbilt Creek, but on Duck Creek available nitrogen peaked a month earlier and on Switzer it showed no clear trend. Based on absolute levels (not adjusted for flow) of available nitrogen, the streams can be ranked as follows, based on measurements near their mouths but beyond tidal influence:

July: Vanderbilt>Fish>Mendenhall>Johnson>Montana>Ninemile>Lemon

August: Duck>Vanderbilt>Fish>Montana>Jordan>Lemon>Ninemile>Johnson

September: Vanderbilt>Jordan>Duck>Fish>Montana>(Lemon, Neilson)> (Mendenhall, Ninemile)>Johnson

October: Vanderbilt>Duck>Jordan>Fish>Lemon>Montana>Mendenhall>(Bay, Ninemile)> (Neilson, Waydelich, Johnson)

November: Vanderbilt>(Mendenhall, Jordan)>Fish>(Duck, Montana)>Waydelich> (Bay, Johnson)>Ninemile

February: Duck>(Jordan, Vanderbilt)>Lemon>Montana>(Neilson, Ninemile, Johnson)

March: Duck>Jordan>Neilson

D(2). Organic Nitrogen

The mean ratio of organic to inorganic nitrogen for all Juneau surface water samples (July-Nov.) is 2.17 (freshwater) or 2.40 (saltwater); in other words, organic nitrogen averages 69% of total nitrogen in freshwater, and 71% in saltwater in Juneau surface water samples. Correlation analysis also showed increasing organic nitrogen with increasing conductivity in saltwater, but the opposite effect in fresh water. The ratio of organic to inorganic nitrogen was also correlated (July-Feb.) with the following (* = .01 level, ** = .001 level, *** = .0001 level):

<u>positive correlates</u>

*** total filterable phosphorus (both fresh and estuarine stations)
*** iron (fresh only)
*** % of slow shallow area immediately upstream
** aluminum (both)
* TFP/TP (both)

<u>negative correlates (decrease as organic N increases)</u>

*** potassium (fresh only)
*** magnesium (fresh only)
*** calcium (fresh only)
*** pH (fresh only)
*** conductivity, alkalinity (fresh only)
*** ratio of available N to available P (fresh only)
* silica (estuary only)
* % of banks with aquatic vegetation
* % of banks with alders
* land disturbance upstream

Kjeldahl nitrogen (TKN), which is mainly organic nitrogen, was also used in the correlation analysis due to possible statistical biases that may have resulted from using the ratio data above. Additional correlates with TKN were as follows:

<u>positive</u>
** % of slow shallow area in entire upstream channel system
*** total phosphorus (both, but stronger correlation in fresh)
* conductivity

<u>negative (decrease as organic N increases)</u>
*** pH (fresh only)
* Ca, Mg (fresh only)
* flow

Based on their ratio of organic to inorganic nitrogen, the streams can be ranked as follows (boldface indicates organic N prevails) :

July: Ninemile>Montana>(Mendenhall, Vanderbilt>Fish>Johnson>Lemon

August: Ninemile>Jordan>Johnson>(Fish, Montana, Vanderbilt)>Lemon

September: Ninemile>Neilson>Fish>Mendenhall>Duck>(Jordan, Montana)>Vanderbilt> (Lemon, Johnson)

October: Waydelich, Ninemile, Johnson)>Bay>Neilson>Montana>Mendenhall>Duck>Jordan> (Duck, Fish)>(Vanderbilt)> Lemon

November: Ninemile>(Johnson, Bay)>Waydelich>Mendenhall>Duck>(Jordan, Fish)>Vanderbilt

February: Ninemile>Johnson>Neilson>Jordan>(Montana, Duck)>Vanderbilt>Lemon

March: Neilson>Duck>Jordan

D(3). N:P Ratios.

Based on their N:P ratios (see Section 2.1.3 for definition), the stream mouths can be ranked as follows:

July: (Vanderbilt, Fish, Mendenhall)>Montana>(Lemon, Johnson)>Ninemile

August: Duck>(Montana, Fish)>(Lemon, Vanderbilt)>Jordan>Johnson>Ninemile

September: Duck>(Vanderbilt, Fish)>Jordan>Waydelich>Lemon>Montana> Mendenhall(Ninemile, Johnson)

October: Duck>Jordan>(Vanderbilt, Fish)>Lemon>Montana>Mendenhall>Neilson> (Bay, Waydelich)>Johnson>Ninemile

November: (Vanderbilt, Fish, Lemon)>Jordan>Montana>Waydelich>Duck>Mendenhall>Bay> Johnson>Ninemile

February: Duck>Lemon>Vanderbilt>Jordan>Montana>Neilson>(Ninemile, Johnson)

March: Duck>Neilson>Jordan

The mean ratio of total nitrogen to total phosphorus in the study area was approximately 12.3, and was generally less in the estuary than in freshwater (suggesting classical estuarine nitrogen - limitation), but seasonal variation was great. Correlation analysis of the freshwater samples indicated increasing N:P ratio with increasing iron (perhaps due to iron- phosphorus complexation and removal), shade, silica, calcium, magnesium, pH, and conductivity, but decreasing N:P ratio with increasing aluminum (a proxy for dissolved organic carbon). Low N:P (generally less than about 16) suggest nitrogen supply is limiting the growth of aquatic plants, while high N:P ratios (particularly those greater than about 35) indicate phosphorus limitation.

D(4). Phosphorus.

The mean concentration of phosphorus for all Juneau surface water samples (July-Nov.) is 38 ug/L, and for total filterable phosphorus, is 11 ug/L. Available phosphorus (FRP) was not analyzed statistically due to a systematic problem in the data entry, but concentrations were approximately 23% of total phosphorus. Correlates for total phosphorus are as follows:

<u>positive (TP increases as these increase)</u>

*** % of slow shallow area immediately upstream
*** Kjeldahl nitrogen (estuary, fresh)
*** turbidity (both)
** flow (fresh)
* salinity

negative (TP increases as these decrease)

*** % of deep-slow channel immediately upstream
*** calcium (estuary, fresh)
*** magnesium
*** pH
** conductivity
* % of banks with alders immediately upstream
* % of banks with shade immediately upstream

In freshwater, the ratio of total filterable phosphorus (TFP) to total phosphorus increased with increasing amounts of vegetation (overhanging or aquatic), slow-shallow areas, organic nitrogen, iron, and silica. It decreased with increasing turbidity. In the estuary it increased with increasing aluminum and organic nitrogen.

Based on their concentrations of available phosphorus (FRP), the streams just above their mouths can be ranked as follows:

July: Vanderbilt>Lemon>Montana>Mendenhall>Ninemile>Johnson>Fish

August: Vanderbilt>Jordan>(Montana, Duck)>Lemon>Ninemile>Fish>Johnson

September: Vanderbilt>Montana>Jordan>Mendenhall>Neilson>Duck>(Lemon, Ninemile, Johnson)>Fish

October: Ninemile>Vanderbilt>(Bay, Johnson) >Mendenhall>(Montana, Waydelich)>(Neilson, Jordan, Duck)>(Lemon, Fish)

November: Mendenhall>Ninemile>Duck>Vanderbilt>(Jordan, Johnson, Bay, Montana)> (Neilson, Fish, Waydelich)

February: Ninemile> Jordan> (Duck, Johnson) >(Neilson, Montana)>Lemon

March: Jordan>Duck>Neilson

Although peatlands are generally thought of as being nutrient-poor, note the relatively high concentrations of phosphorus in Ninemile in winter.

E. Nutrient Sources

Opportunity for nutrient retention or transformation is provided by several possible sources:

- Municipal Waste Treatment Plant. This facility, on the Mendenhall River above Duck Creek's mouth, is potentially responsible for a large amount of nutrient loading of the estuary.

- Faulty Septic Systems. Particularly in unsewered areas west of the Mendenhall River and on the Mendenhall peninsula, septic systems may leach nitrogen and phosphorus into adjoining wetlands. The most likely sources within these areas are locations having some of the following conditions (Parke et al. 1983): organic (peat) soils, gravels without fines, fractured bedrock, rockslides, less than 2 feet of permeable sediments over bedrock, slope greater than 20 percent, flooded at least seasonally. An increase of 1-2 orders of magnitude in nitrogen entering Auke Bay is attributed by Kirk (1973) to septic systems.

- Animal Wastes. Salmon add major amounts of nutrients to some streams (e.g., Fish Creek) when they move in from offshore, spawn, die, and decay. Horses are pastured near the mouth of Fish Creek and in a few areas of the Valley (though less so than formerly). Domestic dogs are an inevitable accompaniment of suburbia, and waterfowl are present in large numbers seasonally on tidal wetlands. All these provide potentially significant inputs of N and P, even in the absence of faulty septic systems.

- Precipitation. A single rainwater sample was found to contain no measurable nitrate and 2.6 ug/L ammonia. Kjeldahl nitrogen was 4 and 62 ug/L in two rainwater samples. Precipitation is a potentially important source of nitrogen (particularly ammonia) in Southeast Alaska (Stednick 1981).

- Other Sources. Nitrogen fixation by alders, ground water discharge, and road salt are other possible sources of nitrogen. Values of nitrate in our ground water samples ranged upwards to 1300 ug/L, with a mean of 164 ug/L in peat soils, 70 ug/L in mineral soils, and 231 ug/L in the Montana fen (wetland ML1).

Criteria

Wetlands were rated for Nutrient Export/Transformation by the following:

HIGH

(1) Data from all monitored months suggest possible export of total nitrogen and total phosphorus from the wetland, i.e., concentrations at the wetland outlet are greater than at the inlet, or

(2) If no monitoring data are available, the wetland is connected by channel flow to a stream which, at its estuarine outlet, appears to have the highest nutrient concentrations relative to those in the estuary generally, i.e., Vanderbilt, Duck, Engineers Cutoff, or Jordan; or the greatest loading due to great flow rates combined with at least moderate concentrations i.e., Mendenhall River, Fish Creek, .Montana; and wetland is not likely to be recharging ground water,

TABLE 8. Wetlands determined to export or retain nutrients (nitrogen and phosphorus).

RETAIN Consistently (rated "Low")

Wetland #	**What and when***
D2	P-10
D5	N-8
D8	N-8
L14	P-7
J3	N-2, 7
M5	N-2, 3, 8, 9, 11; P-8
M19	P-8
M51	N-8
UM1	N-7, P-10

EXPORT Consistently (rated "High")

D4	N-8, 9, 10, 11; P-10
D6	N-8, 10
L6	N-7
J4	P-9, 11
J5	P-8, 10
M7	P-8
ML1	N-7, 8, 9, 11
MW2	P-7, 8, 9, 11
MW3	N-2; P-10
MW5	N-9

* n = total nitrogen, P = total phosphorus, 7 = July, 8 = August, etc.

MODERATE

(1) Data from all monitored months indicate inconsistent export of total nitrogen and total phosphorus from the wetland, or

(2) If no monitoring data are available, wetland is mostly vegetated and has an outlet (intermittent or permanent) to the estuary, or directly abuts and runs off into the estuary.

LOW

(1) Monitoring data show consistent retention of FRP and total nutrients, or

(2) Wetland has no surface water outlet (not even intermittent) to the estuary.

Basis for Criteria for Nutrient Export

As noted in the introductory discussion of this function, downstream and estuarine environments in the study area do not appear to suffer from excessive amounts of nutrients (eutrophication). Thus, in the above criteria, nutrient export to downstream areas is considered desirable, and nutrient retention (or possibly removal, in the case of nitrogen) is judged undesirable. Further, retention of phosphorus is considered undesirable only if the retained phosphorus is not undergoing transformation to forms (i.e., FRP) more available to food chains. Causes of sustained nutrient surpluses in wetlands include nitrogen fixation, ground water discharge, immigrating wildlife, erosion or leaching of enriched bottom sediments, or human sources located between inlet and outlet. No value judgments are made regarding the type of source, only whether the wetland is exporting.

This is not to completely deny the value of nitrogen and especially phosphorus on-site, as there may be wetlands where these nutrients, as they are being retained, support growth of important aquatic plants and animals within the retaining wetland. Such situations were detected in the data by the fluctuating pattern of retention (during the growing season) and export (other seasons) and resulted in a rating of Moderate in monitored wetlands. Wetlands which transform nutrients may be ecologically important.

In this study, 39 wetlands were considered to have sampling stations in close enough proximity to both their inlet and outlet to provide simultaneous estimates of input and output concentrations. Of these

wetlands, 10 consistently exported nitrogen and/or phosphorus, 9 consistently retained/ removed nitrogen and/or retained phosphorus, and 15 fluctuated seasonally or had no effect (Table 8). As noted in Section 2.1.3, two significant limitations are (a) concentrations were not always flow-adjusted, (b) seasonal coverage was not comprehensive at all stations. i.e., some wetlands which seem to "consistently" export (or retain) may not actually do so during some of the months not sampled. Nonetheless, it was felt that even this minimal data collection effort would improve on mere speculation as to whether areas exported or retained nutrients.

In order to assign ratings to non-monitored wetlands, we assumed Low export if surface outflows were physically restricted. We assigned a rating of High if the wetland is connected to or part of a concentrated-nitrogen stream (Duck, Casa del Sol, Jordan, Vanderbilt) or a concentrated-phosphorus stream (Vanderbilt, Montana, Jordan, Ninemile). Estuarine wetlands and wetlands within the Fish Creek and Mendenhall River system were also rated High because, although typical nutrient concentrations are low, flow rates are high, resulting in relatively great overall nutrient loading of the open water estuary. No assumptions are made as to the effect of development on this function; certain types of development could conceivably substitute for the nutrient export capacity of filled wetlands in these stream systems.

2.2.5 Riparian Support

Definition and Function Rationale; Even those wetlands which are themselves poor fish habitat may critically influence the quality of habitat for fish and their aquatic invertebrate food in downstream areas and estuaries. The role of wetlands in regulating the quantity and chemical composition of runoff is considered elsewhere (under the functions Surface Hydrologic Control and Nutrient Transformation/Export, respectively). Under the Riparian Support function, we consider the often in direct positive influence wetlands may have on water temperature and export of detritus (decaying plant material). The following two assumptions are made:

1. Maintaining naturally-occurring water temperatures (or restoring heated or super-chilled waters to more natural temperatures as they flow downstream from open lands) results in less metabolic stress to aquatic life and thus a more productive fishery. This addresses both an amelioration of the absolute maximum annual temperature, the frequency of warm "spikes" in a season, and a flattening of the diurnal and dally fluctuation in water temperature.

2. Maintaining a phenologically diverse assemblage of vegetation types in a watershed results in optimal capacity for sustaining productive populations of indigenous species downstream and in the estuary. This assumes that by staggering the organic inputs to an estuary (as occurs when different plants bloom or drop their leaves or decay at different times and rates), the "boom and bust" cycles of organic export can be flattened and greater overall nutrient recycling and stability among secondary consumers results.

Criteria

HIGH: (1) If upslope or downslope nontidal areas are mostly urban/openland, stream (if any) contains several reaches rated "4" for shade (densely shaded), OR, (2) if upslope or downslope areas are mostly forested, stream (if any) contains several reaches rated "1 or 2" for shade (unshaded), OR, (3) estuarine emergent wetland.

MODERATE-HIGH: Wetland contains or is within 50 feet of a mostly permanent stream, lake, or estuary.

MODERATE-LOW: Wetland is drained by intermittent streams (excluding artificial ditches) or has a strong component of lateral flow or ground water discharge (rated High).

LOW: Wetland is, hydrologically, relatively isolated from streams and estuaries. Results of the application of these criteria are shown by wetland in the map appendix.

Basis for Criteria:

Thermoregulation: Our limited data from 1986 (Table 9) indicates that maximum summer temperatures of Juneau streams do not routinely exceed levels severely stressful to salmonids, i.e., 68 degrees F. However, temperatures are often more than the 40-50 degrees F necessary during coho spawning or the 46-52 degrees best for summer coho rearing (McMahan 1983). Occasional "spikes" above lethal limits (75-85 degrees F) would probably be more harmful than higher average temperatures or greater fluctuations (Thomas et al. 1986). Thus, part (1) of the criteria for High recognizes the importance of the interspersed shaded areas for maintaining optimum stream temperatures.

Carbon Export. The remaining parts of the criteria for Riparian Support deal with the potential for exporting particulate organic matter, or carbon cycling. Criteria for Moderate-High, Moderate-Low, and Low are all based on the degree of hydrologic connection, assuming that in the Juneau context, export of carbon to open water is more important than on-site carbon recycling.

Table 9. Temperature fluctuations and maximums at water quality monitoring stations. See map appendix for locations.

Station	Period	Range (F°) of Air Temp.	Range (F°) of Water Temp.	Air Max.	Water Max	Max A-Max W
WT1	9/3-24	33	9	69	51	18
	9/24-10/14	26	7	59	49	10
	10/14-11/18	39	18	54	49	5
WT2	7/14-9/12	37	27	76	65	11
WT3	7/14-7/22	27	8	76	52	24
	7/22-9/12	33	10	72	52	20
	9/12-9/24	33	5	69	47	22
WT4	7/14-7/22	27	2	76	47	29
WT7	7/11-7/22	27	11	76	70	6
	7/22-8/6	22	8	67	66	1
	8/6-8/26	31	11	72	64	8
	8/26-9/8	27	6	68	62	6
	9/8-9/12	27	9	66	61	5
	9/12-10/13	36	13	69	60	9
WT9	7/16-7/23	26	6	76	43	33
	7/23-7/31	22	8	67	44	
WT11	7/17-7/23	26	7	76	43	23
	7/23-9/8	31	4	72	38	34
WT12 1/	7/13-7/23	27	31	76	73	3
	7/23-7/31	22	28	67	68	-1
	7/31-9/10	31	30	72	67	5
WT13	7/16-7/23	26	13	76	58	18
	7/23-8/10	28	5	72	52	20
	8/10-9/12	29	7	68	53	15
	9/12-10/15	36	6	69	47	22
WT14	7/23-7/31	22	4	67	52	15
	7/31-8/6	14	6	61	56	5
	8/6-8/10	28	4	72	52	20
	8/10-9/10	27	4	68	52	16
WT15	7/16-7/23	26	4	76	55	21
	7/23-7/31	22	8	67	57	10
WT16	7/23-7/31	22	8	67	58	9
	7/31-8/10	28	10	72	60	12
	8/10-9/3	27	14	68	61	7
WT17	7/16-7/23	26	8	76	50	26
	7/23-7/30	22	8	67	50	17
	7/30-9/8	31	6	72	50	

1/ Tidally influenced

WT19	7/29-9/30	39	10	72	50	22
WT20	7/12-7/29	31	11	76	54	22
	7/29-9/8	31	6	72	50	22
WT22	7/17-7/23	26	7	76	62	14
	7/23-8/8	25	3	69	63	6
	8/8-8/24	31	12	72	56	16
WT27	7/23-8/6	22	9	67	67	-0-
	8/6-9/8	31	8	72	67	5
WT28	7/18-7/30	31	4	76	48	28
	9/3-10/13	36	4	69	42	27
WT29 1/	7/18-7/30	31	9	76	54	22
	7/30-9/8	22	9	67	52	15
	9/8-9/12	27	10	66	52	14
WT30 1/	9/8-10/13	36	10	69	52	17
WA2	9/3-9/10	27	20	68	66	2
WD5	9/3-9/10	27	1	68	54	14
WDC1 1/	9/3-9/10	27	3	68	53	15
	9/10-11/19	58	21	69	52	17
WDC2	9/1-9/3	17	5	62	58	4
	9/3-9/10	27	1	68	52	16
	9/10-9/23	33	11	69	54	15
	9/23-10/13	24	8	57	53	4
	10/13-11/19	43	10	54	43	11
WNML	9/3-9/5	27	6	68	52	16
	9/5-9/11	27	14	68	58	10
	9/11-9/23	33	13	69	54	15
	9/23-10/13	24	9	57	49	8

1/ tidally influenced

Part (2) of the criteria for High is based on differences in the degree of light penetration and differences in the rate of decay of different types of riparian/wetland vegetation. Rapid cycling of carbon and nutrients appears to be promoted by open- canopied deciduous or herbaceous vegetation, but this may need to be balanced by lesser inputs from evergreen species with longer decay times, to maintain a sustained release of nutrients. The more rapid cycling of decaying deciduous and herbaceous vegetation (vs. evergreen) is supported by research specific to Southeast Alaska. Duncan and Brusven (1985b) found that leaves of red alder, black cottonwood, and salmonberry had significantly faster processing rates than western hemlock. Nutrient inputs from these leaves may be especially important in chronically turbid waters (e.g., Duck Creek) where diminished light penetration reduces the growth and contribution of benthic algae. Riparian deciduous and herbaceous vegetation (especially alder, willow) also supports more terrestrial insects than riparian evergreen vegetation (Chapman 1966; R. Kynard, USDA Forest Service, Juneau—unpublished report), and such insects, as they fall into streams, can be an important food for rearing salmon. The greater presence of organic carbon in non-evergreen wetlands is documented by Turner et al. (1985).

Algae, which flourish best in unshaded, low velocity stream reaches (Walter 1984, Duncan and Brusven 1985a) rapidly decays and provides readily-assimilated food and habitat for a number of major fish food organisms, e.g., chlronomids (Sedell and Swanson 1984). Moderate-sized (third order) streams and tidal flat streams tend to have the greatest amount of algae. Algae in one Southeast Alaska location was most prevalent in the fresh- water areas in summer, in the estuarine areas in late summer- fall (coincident with shorebird and waterfowl concentrations and upstream salmon spawning), and in the estuarine-freshwater transition in winter and spring (Walter 1984, Murphy 1984). The high wintering salmonid densities we found in Vanderbilt and lower Switzer Creeks (as opposed to freshwater Montana and saltwater Engineers Cutoff) may reflect such high production of algae (and thus fish food organisms) in winter just above the fresh-salt ecotone, although artificially high nutrient inputs to Vanderbilt could have biased this observation. Regardless, salmonid food production in some estuaries related more to nutrients released by stream algae than to nutrients originating in emergent vegetation (e.g., Carex), overhanging upriver vegetation, or phytoplankton (Simenstad and Wissraar 1985). Mussels, an important food of Juneau's seabirds, also appear to derive most of their nutritional needs from algae.

It is unclear how important is wetland-originated detritus (decaying plant material) and dissolved organic carbon (DOC) for ultimately supporting the offshore salmon fishery and other deepwater biological resources. The importance of detritus and DOC as a carbon source within streams and open water areas of estuaries is well-documented in other regions. The upper peat layer of muskegs is also known to be an

important contributor of DOC (McKnight et al. 1985). In the Nanaimo River in British Columbia, river-borne DOC was the greatest source of estuarine carbon (Nalman and Slebert 1978). In Southeast Alaska, the Wilson River has DOC export rates comparable to the Nanaimo despite its smaller size (Sugal and Burrell 1984), probably because its gradient is low and much of the watershed is below tree line. Total organic carbon (TOG) levels in the Stikine River were less than in the Nanaimo (Beak Ltd. 1982). DOC levels measured during our Juneau study are summarized in Table 10. DOC (actually, its correlate, aluminum) was most concentrated in slow, shallow areas. Such areas are often "sinks" for organic matter which is densely colonized by fish food organisms (McDowell and Nalman 1986).

In a study of suspended sediment transport, Sidle and Campbell (1985) found that organic substances comprised 35% of all suspended sediment (SS) in a Southeast Alaska stream. In most cases, the export of organic (either as total amount or as a percent of SS) was not related to stream discharge, and did not vary according to whether water level was rising or falling. However, organics comprised the greatest percentage of TSS when the discharge in the particular study stream was generally below 17 cfs. Moreover, substantially increased inputs to the Stikine estuary of organic carbon were measured during fall storms by Beak Ltd. (1982). Levels were still less than for offshore waters. Water sampling also suggested that large quantities of organic carbon moved from intertidal marsh to mudflat and offshore locations. The principal contribution was believed to be the same sedge (Carex lygbyei) which dominates the Mendenhall Wetlands, with an estimated net primary production of 500 gC/m2/yr. In the Juneau area, Bruce et al. (1977) found no relation between estuarine phosphorus levels and storm events, but our data showed a correlation between the two in fresh water.

In addition to direct importance to food chains, there are other reasons for concern about organic carbon and associated humic acids. Organics may make potentially toxic metals less available to estuarine food chains, while making iron (a potentially limiting nutrient in marine waters) more available (Sugal and Burrell 1984). They may also control metal availability by controlling pH (McKnight et al. 1985).

Another effect is that excessive quantities of organic matter increase color of drinking water beyond ADEC limits. While this is primarily an aesthetic problem, the organic matter may reduce the efficiency of chlorine disinfectant in the process of treating drinking water, causing taste and odor problems and forming halogenated organics such as trihalomethane (THM), which is a disputably carcinogenic substance. However, few if any of the drinking water sources in the study area are presently chlorinated, so this is not a current problem.

Table 10. Dissolved organic carbon from Juneau streams, 1986.

Month	Location	DOC (mg C/L)	Instantaneous Discharge (cu-m/S)
June	Duck Cr. (mouth)	0.8	
	Jordan Cr.	1.2	
	(Ketchikan*)	2- 4	
July	Montana Cr. (Upper Bridge)	11.4	
	(Ketchikan)	2- 4	
Aug.	Lemon	7.0	
	Switzer – upper	4.2	0.09
	Montana – Loop Road	3.5	
	Montana	2.4	3.01
	Switzer – lower	12.9	0.16
	(Ketchikan)	1- 3	
	Mendenhall Peninsula tip	1.7	
	Fish Cr. Mouth	2.4	
	Lemon	0.7	
	Montana	1.3	
	Switzer	3.4	0.18
	Vanderbilt	3.8	0.16
	(Ketchikan)	1- 4	

* "Ketchikan" values are from Wilson River area studied by Sugei and Burrell (1984).

2.2.6 Salmonid Habitat

Definition and Function Rationale. The function, Salmonid Habitat, deals with the existing suitability of Juneau's wetlands for producing any of the salmonid fishes. The principal species are coho (silver), pink, chum, and sockeye salmon; cutthroat and steelhead trout; and Dolly Varden char.

Particularly in an era of economic insecurity, Southeast Alaska's salmon fishing industry provides a continuing relatively stable source of income for Juneau citizens. The tourism industry also provides a stable or increasing source of income during hard times, and is primed by the easy success of visitors and residents of Juneau who attempt sport fishing or salmon-viewing (e.g., Mendenhall Glacier sockeye area). In fact, the number of angler-days of sport fishing in the Juneau area increased from 82,000 trips in 1978 to approximately 110,000 in 1985. The proximity of excellent fishing opportunities to an urban area like Juneau highlights both the resource use which occurs and the sensitivity of the resource to development impacts. However, the relative contribution of Juneau's fishery to the economy is difficult to discern, as other areas of southeastern Alaska may have larger charter boat fleets and more sought-after species (e.g., King salmon).

Not all citizens fully understand that a salmon they catch today would not have been caught if, years ago and perhaps many miles away, certain wetlands had been severely altered or polluted. Although the individual fish which are displaced may sometimes survive elsewhere, the next generation will be smaller because productive habitat has been lost. Salmon use of riverine areas is obvious, but only recently has research highlighted the dependence of salmon on the tidal marshes and backwater sloughs which may be accessible only part of the year (Bryant 1984a, 1984b, Burger et al. 1983, Healey 1982, Levy and Northcote 1981, 1982, Peterson 1982a, 1982b, Thedinga and Koski 1984, Narver 1978).

Juneau salmonids can be classified as being either anadromous or resident. Anadromous fish are those that are hatched in freshwater, eventually migrate to sea for some portion of their adult life, and return to freshwater to spawn. Resident fish are hatched in freshwater and live their entire life in fresh water. Some species, e.g., Dolly Varden char, cutthroat trout, have both anadromous and resident components.

In general, anadromous species can be categorized as rearing or non-rearing depending on the length of time they remain in freshwater after they emerge from the gravel. Rearing species, such as coho salmon and steelhead trout, spend 1 to 3 years in freshwater before they emigrate to the ocean. Streams containing these species are often referred to as "rearing" streams. Non-rearing species, e.g., pink and chum salmon, emigrate to sea almost immediately upon emerging from the gravel. Because the non-rearing species use the streams primarily for spawning, these streams are often referred to as "spawning" streams.

Certain assumptions or caveats are made in this report:

1. Only existing conditions are evaluated. However, many Juneau streams and wetlands have considerable opportunity for habitat enhancements well as for enhancement of other wetland functions, at some cost.

2. Wetlands not inhabited by salmonids (e.g., due to barriers) may nonetheless be critical to salmon downstream. This is because they may modify the quantity and quality (particularly temperature and food sources) of the water which sustains downstream salmonids. This indirect benefit is addressed under the "Riparian Support" function.

3. Salmonids may be most directly linked to the economy, but other fishes (e.g., eulachon, sculpin, stickleback), are important to the food chain of other highly-visible species (e.g., bald eagle, herons, some waterfowl) which are part of Juneau's quality of life, and others (e.g., flounder) may contribute economically as well. Habitat suitability for these species was not considered directly by this assessment effort, but may sometimes be inferred by the presence of large concentrations (or frequent visits by) fish-eating birds, as partly addressed by the ratings for Disturbance-sensitive Wildlife.

4. The criteria below emphasize the importance of wetlands for adult spawning and overwintering of juveniles (parr). Recent research suggests that overwintering area suitability may be the weakest link in the life cycle of Pacific Northwest salmonids (Bustard and Narver 1975, Hartman et al. 1982, Heifetz et al. 1986). Rearing potential during non-winter months was also considered. Criteria for spawning habitat were not developed in this report because direct observational data were available from ADF6 and out own field work during spawning season.

5. Utilization of the streams for fishing (e.g., whether regulations allow or disallow fishing) is not reflected by the ratings for this function.

6. Low numbers in some of our samples may reflect mortality due to other factors, rather than low habitat values.

7. Even wetlands considered to be poor habitat for salmonids are nonetheless subject to State and Federal laws if anadromous salmonids are present.

Criteria

VERY LOW. No salmonid access to any part of the wetland, even during the highest water levels in an average year. Salmon and other fish may find rich food sources in such areas during very infrequent flood events,

LOW. Access restricted* and poor** rearing habitat even for resident salmonids (if any).

MODERATE-LOW. (1) Access restricted*, but rearing habitat is at least fair*** for resident salmonids, which are known to be present; or (2) access is not restricted but habitat is poor.

MODERATE-HIGH. Primary use is for passage. Some documented use by anadromous salmonids for rearing and/or spawning but numbers are apparently weak or habitat (particularly if numbers unknown) is fair.**

HIGH. Good** habitat for anadromous salmonid rearing and/or spawning. Documented use, winter and/or summer.

VERY HIGH. Excellent** habitat for anadromous salmonid rearing and/or major spawning. Documented use in both winter and summer.

(Footnotes)

* Restricted access means salmonids have occasional access, but the stream reach or wetland is inaccessible to salmon a majority of the year due to low or intermittent streamflows, waterfalls, dams, or similar obstructions.

** Poor rearing habitat has:

(a) less than 2% of the stream's surface area occupied by woody debris and less than 20% occupied by deep (greater than 50 cm) pools (i.e., low pool volume), and

(b) less than half the streambanks (both sides) occupied by partially submerged (aquatic) vegetation and less than 10% occupied by overhanging vegetation (within 1 vertical meter of the water surface).

Roughly equivalent to expected wintering densities of fewer than 0.2 coho per square meter.

*** Fair rearing habitat has conditions that are neither "good" nor "poor".

Good rearing habitat has over 30% of the streambanks occupied by overhanging vegetation, plus ANY of the following:

(a) aquatic vegetation occupies more than 60% of the streambanks, or

(b) Slow water areas occupy more than 80% of the surface area (i.e., great pool volume).

Roughly equivalent to expected wintering densities of 0.2-3 coho per square meter.

Excellent rearing habitat has over 90% of the streambanks occupied by overhanging vegetation, and more than 80% of the banks are undercut and slow water areas occupy more than 70% of the surface area. Roughly equivalent to expected wintering densities of more than 3 coho per square meter.

Basis for Criteria

Published fisheries research from elsewhere in Southeast Alaska was used to select the habitat characteristics inventoried by the fish habitat survey, and to support their use in the criteria above. Actual numeric thresholds of the criteria were baaed on analysis of data from our winter salmonid population surveys of 21 reaches on 7 Juneau streams, as well as our incidental checks of many other reaches. Still, this sample size is relatively small considering the large number of candidate habitat variables. Further validation and stratification of the criteria is urged before widespread application throughout Southeast Alaska. Data from our own spawning surveys supplemented the much more comprehensive spawning data of Alaska Fish & Game, and were used in the above criteria.

The section below describes each habitat feature we inventoried or calculated. Those with an asterisk (*) are included in the criteria above. For each feature, we describe:

a. what it is, how it was measured
b. research substantiation of its importance
c. range of conditions present in Juneau.

a. Cumulative Habitat Totals

Measurement: After all reach data had been computerized, cumulative totals for various habitat features were calculated and graphs were plotted (Appendix A). Inflection points in the curves for a particular feature suggest the relative importance of the feature within the stream, regardless of its absolute quantity.

Table 11. Fish habitat database: cross-referenced reach numbers of maps, graphs, field sheets.

NOTE: By using this table, reaches shown on the graphs (Appendix A) can be located in the maps (Figure 5), computer database, and field sheets.

Stream	Assigned Reach No. (graphs)	Coded Reach ID No. (printout, maps)	Field Sheet Number
Jordan	1-19	JT1-19	TM1-19
	20-33	JK1-14	KK1-14
	34-54	JE1-21	EF1-21
	55-79	JW1-25	WE1-25
	80-105	JP1-26	CP1-26
	106-109	JC8-5	JC8-5
	110-207	JN98-1	NC98-1
	208-242	JD1-35	ND1-35
	243-296	JC4-1	JC4-1
	297-327	JB1-50	OB1-50
	328-368	JY1-31	EG1-31
	369-370	JG1-41	GH1-41
	371-373	JA1-2	APW1-2
	374-398	JR1-3	APE1-3
	399-405	JX1-25	YD1-25
		JL1-7	Ll-7
Duck	5-65	DA1-61	DA1-61
	66-119	DB1-55	DB1-55
	120-137	DX1-18	DX1-18
	138-151	DC11-1	DC11-1
	154-184	D3-33	D3-33
Montana	1-79	MB	79-1
	80-83	MA	4-1
	97-161	M	65-1
Fish	1-11	FK1-11	Same
	12-21	FA10-1	
Ninemile	1-4	NU1-4	Same
	5-21	HM17-1	
Casa del Sol	1-38	KK1-38	Same
Vanderbilt	1-90	V90-1	Same
Switzer	1-19	K19-1	Same
	20-38	SB19-1	
	39-141	SA103-1	
	149-163	S15-1	

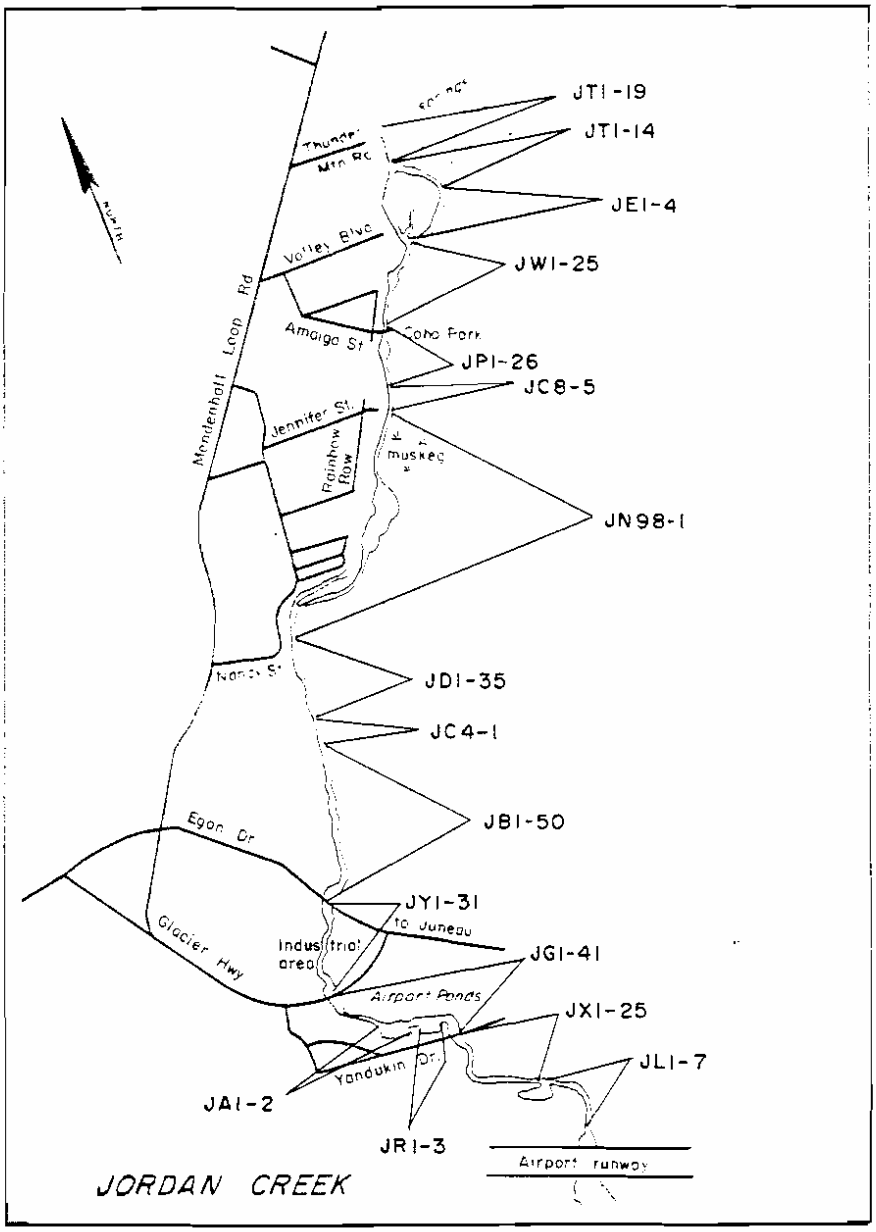


Figure 5. Locations of fish habitat surveys referenced to field map codes.

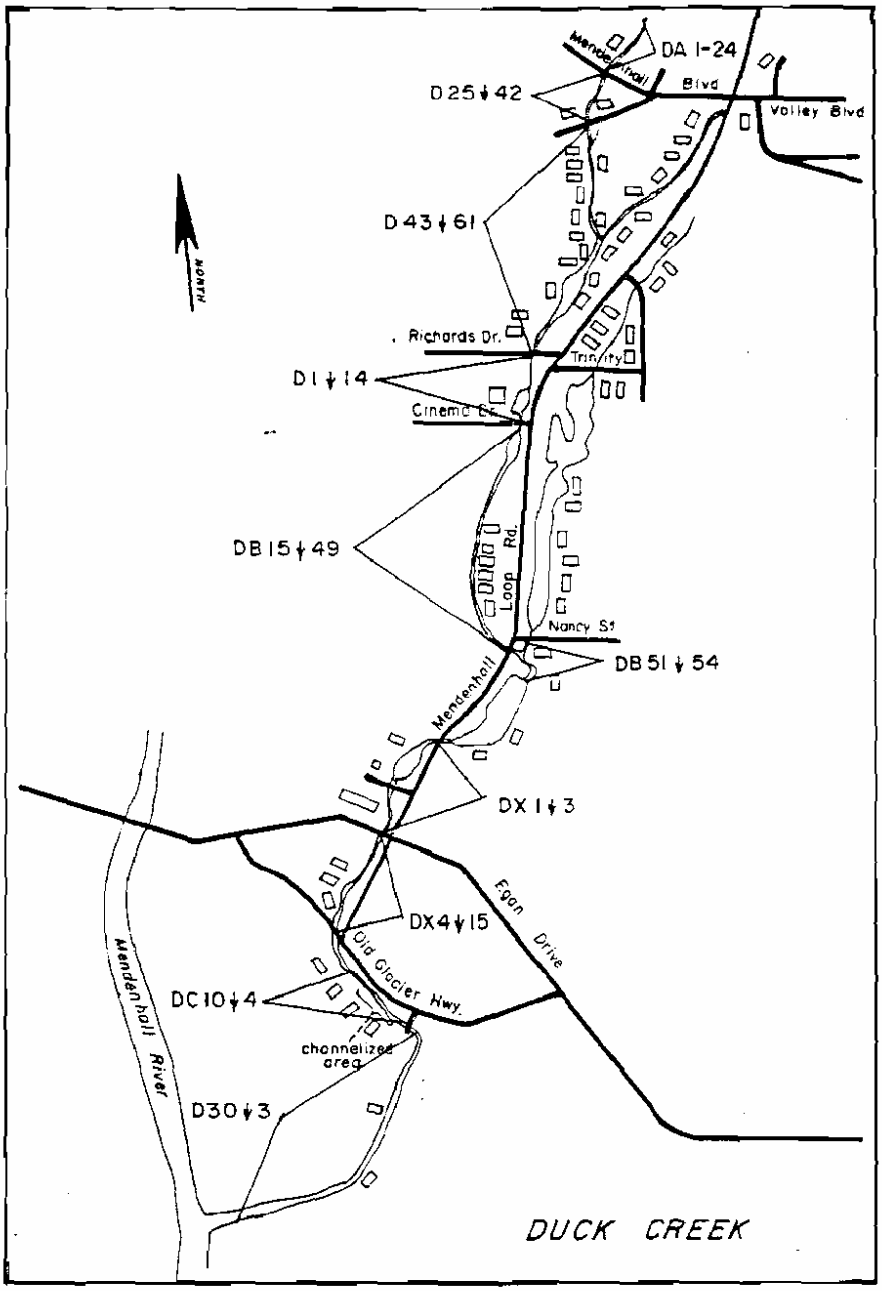


Figure 5 (cont'd). Locations of fish habitat surveys referenced to field map codes.

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b. Total Area

Measurement*: Using the diagrammatic method, each stream reach was sketched on gridded paper. Width was measured every 10 feet in the 50-foot reaches. The average of these widths multiplied by reach length gave total square feet.

*See also Section 2.1.4 for overall description and rationale of habitat mapping.

Importance: Even streams with poor habitat, if large, may support a substantial total escapement of salmon. Larger streams (third order and higher) in Southeast Alaska support greater productivity of algae (and ultimately, by inference, of salmon) than smaller ones (Walter 1984).

Juneau Conditions: The surface area of the 1237 reaches we mapped (from7 streams) averages 732 square feet (Table ___), for a mean width of about 12 feet. Ordered by mean width, from widest to narrowest, they are Montana, Duck, Jordan, Johnson, Switzer, Vanderbilt, and Casa del Sol. Jordan has approximately 7 acres of stream habitat, Duck has 3.5 (excluding ponds), Switzer 1.4.

c. Depth. Velocity Classes and Maximums

Measurement: The following depth-velocity classes were mapped in each reach: shallow slow (velocity <0.7 ft/s, depth <0.5m), shallow fast (velocity 0.8-1.7 ft/s, depth <0.5m), shallow rapid (velocity >1.7 ft/s, depth <0.5m); deep slow, deep fast, deep rapid (corresponding velocities but depth >0.5m). After a few days of experience, depth and velocity thresholds could be estimated vlsually, sufficient for showing the proportional distribution of classes on the maps. Nevertheless, a few point checks of depth and velocity were made in each reach. Where accessible, the point in each reach having the greatest depth, and the point apparently having the greatest velocity at this season, were measured.

Importance: Deep areas provide access, refuge for fish during extreme flow conditions, and reduced vulnerability to predation (Peterson 1982). However, shallower streams (if they do not dry out) produce greater densities of fish food organisms. Deep plunge pools are particularly preferred by cutthroat (Bryant 1984, Barber et al. 1982). Wintering coho in Southeast Alaska prefer depths greater than 65 cm; wintering Dolly Varden (fry) prefer 10-34 cm or (parr) greater than 47 cm; wintering steelhead prefer depths greater than 71 cm. Maximum pool depth significantly influenced pool occupancy by coho and Dolly Varden parr studied by Heifetz et al. (1986). Total pool volume was one of the two best predictors of the summer biomass of coho and of total salmonids (Murphy et al. 1984). Summer depths preferred by juvenile coho, as identified by different studies, range from 9 cm to 38 cm Weache and Rechard 1980, Bovee 1978).

Spawning occurs mostly in depths of less than 12 inches and velocities less than 1.7 ft/s (Orsborn 1982); fry occur mostly at depths less than 3 feet (Bovee 1978). Cutthroat spawning occurs mostly at depths of 12 inches and velocities of 1.3 ft/s. Riverine sloughs and ponds (especially beaver-formed ones), as well as side-channels seem to be particularly important for coho both in such habitats themselves and in areas immediately downstream (Bryant 1984, Narver 1978, Bustard and Narver 1975, Burger et al. 1983, Elliott and Reed 1974, McDowell and Naiman 1986, Meehan et al. 1985, Peterson 1982a,b). Coho parr prefer velocities less than 3 ft/s and especially less than 0.5 ft/s (Wesche and Rechard 1980) or 0.2 ft/s (Burger et al. 1983). Steelhead spawn in the range of about 1.2-3.3 ft/s velocity. Other depth-velocity preferences are given by Bovee (1978).

Juneau Conditions: An average 50-foot stream reach in the Juneau area has 2 or 3 depth-velocity classes (e.g., some slow shallow and some deep fast). Montana has the greatest variety of classes per reach; Casa del Sol and Duck have the least (Table 12). Less than 2% of the 1237 reaches have all 6 potential classes, about 61 have 5 classes.

Jordan's fish have the shortest distances to travel, on the average, to reach predominantly deep areas, while fish in Johnson and Casa del Sol have the farthest. Deep, shallow areas are similarly most prevalent in Jordan, an average of 154 square feet of such pools being present in each reach, occupying an average of 21% of each reach's total area. Approximately 5% of all reaches are more than 30% comprised of deep, slow areas. The average maximum depth in Jordan is second only to Montana's, which is accompanied by the fastest velocities of the 7 streams (3.19 ft/s, mean maximum per reach), thus limiting its value as compared to Jordan's.

From a management perspective, reaches which occur at inflection or deflection points on either of the curves (Appendix A, curves A and E) should be considered most important for salmonids, other habitat factors being equal.

d. Overhanging Vegetation, Aquatic Vegetation

Measurement: Aquatic vegetation (AV) was considered to be any macrophytic vegetation partly or totally submerged by water at the time of sampling. Overhanging vegetation (0V) included aquatic vegetation, and in addition included streambank vegetation not submerged by water but nonetheless overhanging the stream within 1 vertical meter of the water's surface. Both AV and 0V were estimated as the % coverage of the reach's stream- bank (reach-50 ft, so half-coverage on one bank would equal 25% for the reach).

Importance: The importance of partly submerged or low overhanging vegetation to juvenile salmonids in Alaska has been documented by Burger at al. (1983), Barber et al. (1982), Thedlnga and Koskl (1984)

and Merrell and Koski (1979). Such vegetation (e.g., undercut sedge mats fringing small channels) provides large numbers of food organisms (Kirchhofer 1984) as well as protection from extreme cold, extreme heat, wind-chill, and predators. Such vegetation occurs most often where streams wind through flat floodplains, through tidal areas, through freshwater emergent marshes formed by beaver or ground water discharge, or through some types of cut-over second-growth areas.

Juneau Conditions: An average Juneau stream reach has overhanging vegetation (0V) on half of its two banks, and aquatic (partly submersed) vegetation on 20% of the total length of the banks. About 10% of the reaches have aquatic vegetation entirely covering both banks, and a majority have overhanging vegetation entirely covering both banks. Aquatic vegetation is most prevalent in Duck Creek (mean distance to AV is 1.65 reaches, or 83 feet) and least prevalent on Montana and Johnson Creeks (Table 12). Aquatic vegetation is more prevalent than overhanging vegetation on Jordan and Duck; overhanging vegetation (which may include AV) predominates elsewhere. Spatial distribution of AV and 0V within each major stream is shown in Appendix A, curve B.

e. Undercut Banks:

Measurement: Undercut banks (UC) are areas where a stream has eroded a channel beneath a bank, which is generally covered by grasses or other vegetation. Although the extent of undercut incision (horizontally) may be important, such a measure would have been too time-consuming for this study. Undercut was measured similar to AV and 0V as described above.

Importance: In forested reaches of four southeast Alaskan streams, Heifetz et al. (1986) found the amount of undercut bank did not significantly affect pool occupancy by any salmonid. However, in reaches where pools or other cover are lacking, undercut banks may be very important.

Juneau Conditions: Undercut banks, on the average, occupy 18% of the two banks (combined) of any Juneau stream reach (Table 12). A majority (58%) of the 1237 reaches have no undercutting; about 10% are undercut over at least 85% of their length. Undercutting is least extensive in Duck and Casa del Sol; most extensive in lower Switzer and Vanderbilt (tidal areas were mostly excluded). Spatial distribution of UC within each major stream is shown in Appendix A, curve F.

f. Woody Debris

Measurement: All nonliving woody material larger than 4-inch diameter was mapped. The type (root wad, log, or branched log) was noted, but volumes and diameters were not determined. Material not submerged and not overhanging within 3 feet of the water surface was ignored.

Importance: The amount of woody debris is a key determinant of salmonid rearing densities and survival in Southeast Alaskan streams (Bryant 1983, 1984, Blsson et al. 1982, Barber et al. 1982, Reifetz et al. 1986, Bustard and Narver 1975, Lestelle and Cedarholm 1982, Meehan et al. 1985, Murphy et al. 1984, 1985, Sedell et al. 1984, Thedlnga and Koskl 1984, Lisle 1986, Johnson et al. 1986). Woody debris provides cover, allows for smaller fish territories (i.e., higher densities), provides shelter during scouring flows, creates pools which serve as refuge during low flows, maintains channel stability, detains spawned salmon carcasses and thus allows important localization of the recycling of nutrients, and retains suspended sediment. Helfetz et al. (1986) reported steel head preferred more than 54 sq. ft. of woody debris, coho fry and Dolly Varden preferred more than 22 sq. ft., and coho parr preferred more than 10 sq. ft— per pool. Bryant (1983) considered 1 debris accumulation per 400 feet to be a relatively large amount, and 1 per 800 ft to be relatively small. Lisle (1986) considered 1 per 20 feet to be a relatively large amount and 1 per 80 feet to be small. On a weight basis, levels in natural streams in Southeast Alaska are 3-13 kg/m2 and in clearcut streams are 16-62 kg/m2 (Lisle 1986). Murphy et al. (1985) found old growth streams to have about 1 woody debris accumulation per 10 feet, and suggested that 1 to 5 downed trees to be present per 10 feet for optimal salmonid habitat. They noted largest densities of wintering coho in streams with 175 cubic feet of debris per 10 ft of stream and (better yet) with 312 cubic feet of debris per 10 ft of stream. Sedell et al. (1984) reported about 1 debris dam per 20 feet.

Juneau Conditions: Juneau streams contain an average of about one large woody debris item per 20 feet of stream, occupying 3% of the stream reach's surface area, or approximately 31 square feet of woody debris per 50 foot reach. Approximately 15% of the reaches have large accumulations, i.e., more than 10% of their surface area is occupied by woody debris. About 25% of the reaches have no woody debris. This situation is particularly acute on Jordan and Duck Creeks, perhaps due to overzealous clean-up efforts. The general location and spatial distribution of woody debris within each major stream is shown in Appendix A, curve C.

g. Sediment Type, Soft Sediment Depth

Measurement: Sediment on the stream bottom was classified simply as cobble-gravel (CG, larger than 0.25-in diameter) or fine (F, less than 0.25 in diameter), and as "predominant" (2), "present" (1), or "nearly absent" (0). For example, reach A was assigned a 2 for CG and a 1 for F, and reach B was CG-2 and F-0.

Part way through the inventory (the last 59% of the reaches) we began checking depths of soft sediment. In a given reach, we would manually drive a half-inch iron rebar pipe into the softest-appearing, accessible point in the reach and estimate the depth it reached before encountering impenetrable sediment.

Importance. The presence of coarse sediments is essential for spawning of many species, particularly chum and pink salmon (McNeil 1966, Swanston, et al. 1977, Sheridan et al. Orsborn 1982, 1984, Bovee 1978). These species prefer sediment particle sizes of 1-10 cm with less than 5% fines (Hale et al. 1985, Raleigh and Nelson 1985). Cobble-gravel sediment also tends to support higher densities of fish food organisms than fine sediment; however, fine sediment often supports dense growths of aquatic plants which in turn support even higher invertebrate densities than are found on coarse sediments. Fine sediment deposition can reduce ground water inflows beneficial to salmon, and can cause water quality problems. Elliott (1985) provides more a detailed account of salmon-substrate relationships.

Juneau Conditions: Juneau study area streams primarily contain cobble-gravel-sized sediments. Of the 7 major streams, coarse sediments are especially prevalent in Montana and Casa del Sol Creeks, and generally prevalent in Switzer and Johnson creeks. Fine sediments are especially prevalent in Vanderbilt, but are more prevalent than cobble-gravel in Jordan and Duck Creeks. About one quarter of all reaches have no appreciable amounts of cobble-gravel. The general location and spatial distribution of cobble gravel (CG) within each major stream is shown in Appendix A, curve G. Soft sediment, when measured, averaged 10 inches depth at this season. In order of decreasing soft sediment depth, streams are ranked as Duck, Jordan, Casa del Sol, Switzer, Montana, Johnson.

h. Iron Staining

Measurement. Average extent of iron staining throughout the reach was noted on a 0 to 3 scale (0=no iron stain, 3=extensive).

Importance: The effects, if any, of iron deposition on fish are unknown. On one hand, iron deposits often occur in proximity to ground water discharge, which is usually a positive habitat factor. On the other hand, severe iron deposits clog interstitial sediment spaces, probably reducing the numbers of fish food organisms and lowering gravel usefulness for spawning. In some backwaters, severe oxygen deficits were measured where iron bacteria growths were extensive.

Juneau Conditions: On the scale of 0 to 3 for iron staining, Juneau stream sediments have a mean value of 0.9. The most intense stains (rated 3) occur in 13% of the 1237 reaches, but many reaches (45%) have

TABLE 12. Summary averages for fish habitat characteristics in Juneau streams. See text for explanation of abbreviated characteristics.

	Stream							
	All	**Jordan**	**Duck**	**Switzer**	**Vanderbilt**	**Johnson**	**Casa del Sol**	**Montana**
Area/reach (sq. ft.)	731.94	693.60	796.03	366.71	213.81	535.43	153.34	1626.18
Ovrhg. Veg. (% / reach)	50.23	63.20	18.94	72.75	72.78	34.14	59.74	28.16
Ovh. Alder (% / reach)	13.68	17.21	17.54	10.65	6.22	15.43	0.00	26.08
Aq. Veg. (% / reach)	19.67	34.04	45.45	4.89	2.64	1.11	5.00	0.39
Aq. Veg. (dist. To)	2.55	2.55	1.65	4.44	5.24	---	4.36	---
Undercut (% / reach)	17.92	9.89	.67	40.45	52.89	33.00	26.24	15.51
Wood Debris (# / reach)	2.77	1.32	1.38	1.54	2.31	1.47	7.58	
Root Wade (% presence)	29	8	3	32	21	31	24	99
Deep Slow (area/reach)	82.15	154.19	100.05	1.63	6.32	6.51	0.00	95.78
Deep Slow (% / reach)	10	21	11	0	2	1	0	0
Deep>Shallow (dist. to)	3.09	2.31	3.52	4.33	5.00	5.24	---	3.98
Slow>Feet (dist. to)	1.35	.54	.34	2.47	1.55	2.57	0.05	4.46
Depth (x max)	1.73	2.20	1.48	1.11	1.04	1.57	0.80	3.19
Velocity (x max)	1.87	1.44	.97	1.89	1.40	2.90	n.d.	3.39
DV Classes (# / reach)	2.56	2.44	2.01	2.29	2.11	3.06	1.05	4.46
Gravel (2=most)	1.22	1.02	.93	1.20	0.67	1.26	1.76	1.94
Fines (2=most)	1.15	1.41	1.55	1.08	1.62	0.40	0.39	0.64
Soft Sediment Depth	0.86	1.15	1.43	0.60	0.33	0	0.63	0.47
Development (dist. to)	7.21	8.37	6.37	0.55	2.92	6.26	6.32	20.59
Shade (4=most)	2.29	2.55	1.53	2.88	3.13	2.97	3.50	1.55
Shaded (dist. to)	1.22	0.96	3.92	0.57	0.26	0.71	0.42	4.34
Max. Depth (ft)		6.0+	3.0+	4.0+	2.3+	4.0+	1.0+	5.5+
Max. Veloc. (ft / s)		3.9+	2.6+	4.5+	3.4+	5.0+	--	9.0+

no stain. The general location and spatial distribution of iron staining (Fe) is shown in Appendix A, curve G.

i. Shade

Measurement. Average shading of the water column by overhanging grasses, roots, logs, banks, bridges, culverts, and canopy was vlsually estimated on a 5-point scale (0=no shade, 4=almost totally shaded).

Importance. Open, relatively unshaded reaches may have higher production of algae and associated fish food organisms. (Walter 1984, Murphy and Hall 1981), especially if nutrients, cover, and elevated temperatures are not limiting. (See also Section 2.2.5). The beneficial effect of canopy openings (for coho) may be significant only if pools or deep channels prevail (Murphy et al. 1984).

Juneau Conditions: On the scale of 0 to 4 for shade, Juneau streams (essentially nontidal) have a mean value of 2.3, and the rating of "2" has the highest frequency. About 28% of the reaches have essentially no shade, while about 21% are very densely shaded. For the reaches we examined, the streams ranked as follows (most to least shade): Casa del Sol (due to extensive overhanging banks), Vanderbilt, Johnson, Switzer, Jordan, Montana, and Duck. The general location and spatial distribution of shade is shown in Appendix A, curve D. Inflection points on the curve are important because they signify the passage of a possibly warmed stream reach into shaded area. Such shaded areas are particularly essential on streams such as lower Duck.

j. Bank Stability

Measurement. The bank stability conditions present in any reach were vlsually rated on a scale of 1 (unstable) to 4 (stable). Criteria given in Section 2.2.9 were used. Stream power (conveyance) was not accounted for.

Importance. Erosion and collapse of undercut banks reduces available cover, degrades water quality, and reduces the suitability of coarse sediment for spawning, at least temporarily. Lessened bank stability is commonly associated with increased urbanization of watersheds (Whipple et al. 1981), either directly (e.g., traffic in streams and along banks) or indirectly (e.g., higher peak flows; disruption of sediment equilibrium by culverting, increased sediment content of runoff, and woody debris removal from streams). On the scale of 1 to 4 for bank stability, most Juneau streams were assigned a "3." About 6% of the 1237 reaches were rated as unstable ("1"). The general location and spatial distribution is shown in Appendix A, curve D. Flattened areas of the curve suggest problem areas with regard to bank stability.

k. Land Use

Measurement. Each reach was rated as to its likelihood of being affected by sediment runoff, on a scale of 1 (no impact) to 7 (most severe). Three factors were considered a) distance to nearest house, road, or similar feature (particularly, whether within 50 feet of the stream), b) extent of an intervening vegetation buffer zone, c) steepness of intervening slopes.

Importance. Land-clearing and construction too close to a stream can excessively decrease water clarity, raise water temperatures, and introduce pollutants. It can also provide a possibly beneficial nutrient regime (See Section 2.2.4) and enhance primary production through shade removal (see "1" above).

Juneau Conditions: About 48% of the reaches we examined presently are not adjoined (as defined above) by potentially impacting land uses. Potentially very severe ("7") activities occur near 5% of the reaches, and an additional 18% have potentially severe activities nearby.

l. Distance to Nearest Habitat Feature

Measurement. After all reach data had been entered on the computer, a search routine was written such that the database user could specify a condition, say, logs in a reach with less than 20% deep slow. Then the program would review the stream data sequentially upstream and downstream from a given point until a reach was found which had the condition. Then, the program indicated the number of reaches (50-foot reaches) away the named feature was located at.

Importance. The relative values of particular reaches cannot be judged in isolation, but only by considering the context of surrounding reaches. An intrinsically moderate-quality reach, if surrounded upstream and downstream by low-quality reaches, may be equally or more important in terms of salmonid dependence than a monotonous series of "good" reaches.

2.2.7 Disturbance-sensitive Wildlife

Definition and Technical Rationale: Some wildlife species, although not necessarily rare, are especially sensitive to repeated presence of humans on foot. The sensitivity of wildlife to such disturbance is roughly proportional to the body size of the wildlife species and their propensity to use open, sparsely vegetated areas. For example, species such as bear, deer, heron, waterfowl, and hawks are more sensitive

Table 13. Juvenile coho wintering densities and habitat in most productive reaches.

Parenthesized estimates are based on inadequate recapture rate. See Section 2.2 for definition of variables.

STREAM REACH	# of fish	Std. Dev.	#/ft	#/m	% of banks aquatic vegetation	% of banks overhanging vegetation	% of banks undercut	% of area w. woody debris	# of logs per 50 ft.	shade	% slow shallow	% slow deep	Total % slow	# of D-V Classes	Cobble-gravel	Root wads?	Land use rating	Distance (est) sl (ft)
Vanderbilt (lower)	214	17.1	4.28	8.89	50	100	100	0	0	1.00	25	54	79	4	1.00	no	0	4
Jordan (Aunige St.)	154	8.6	1.54	1.73	85	50	0	0	0	1.00	41	24	65	3	1.00	no	7	0
Switzer (mud trib.)	56	11.4	1.12	6.02	100	100	100	0	0	3.50	100	0	100	1	0	no	7	n.d.
Jordan (mid-beaver U)	220	29.4	1.10	1.26	9	50	68	4	2	3.50	61	37	98	5	0.25	yes	0	0
Montana (slough)	157	28.7	.78	1.08	20	40	25	8	7	2.50	100	0	100	1	0	yes	0	1
Switzer (gravel meadow)	79	15.5	.79	0.72														
Jordan (Nancy)	148	13.7	.74	0.67	52	83	14	2	0.5	1.25	11	7	18	5	1.25	yes	7	1
Jordan (Egan)	75	8.8	.75	0.58	10	100	14	5	3	3.00	48	20	68	3	1.67	yes	0	1
Vanderbilt (upper meadows)	97	3.6	.49	4.97	0	100	100	0	0	4.00	76	0	76	2	0	no	4	2
Montana (DR channel)	118	16.6	.59	0.41	0	20	10	0.5	0.3	2.00	17	16	33	5	2.00		1	2
Jordan (Sand Bar - L)	99	15.9	.49	0.55	15	100	20	6	1.5	2.00	18	43	61	4	1.75	no	7	0
Switzer (below pond - U)	84	4.9	.42	0.74	0	69	68	8	3.75	3.50	26	0	26	2	1.50	no	6	0
Little Auke Cr. (Windfall)	41	8.5	.41	0.92	0	10	50	6	4	3.50	44	0	44	2	2.00	yes	6	n.d.
Jordan (Sand Bar - U)	75	13.8	.38	0.36	25	99	20	2	0	1.00	12	45	57	5	2.00	no	7	0
Jordan (Nugget Dr.)	62	6.5	.31	0.38	50	93	18	8	0.4	2.60	42	10	52	5	1.60	no	4	0
Jordan (Airport)	58	5.4	.29	0.31	30	66	10	1	0.25	2.00	36	32	68	4	2.00	no	7	1
Montana (by mouth)	111	23.3	.28	0.08	0	42	17	4	0.3	1.00	23	7	30	5	1.75	yes	0	0
Engineers Cutoff (WT13)	27	3.6	.13	0.25	0	46	30	4	9	3.50	63	1	64	3	1.50	yes	1	n.d.
Johnson Creek (upper)	24*	1.4	.12*	0.12*	0	22	54	6	1	3.75	40	11	51	5	0.75	yes	0	0
Switzer (below pond - L)	(381)	10.4	(1.91)	(2.26)	0	95	19	4	1.5	3.00	42	0	42	3	2.00	yes	6	
Jordan (mid-beaver - L)	(305)	104.8	(1.52)	(1.35)	15	56	30	1	3	2.50	42	32	75	4	0.25	yes	0	2

*includes cutthroat (22 in Johnson Ck.).
**= 3.24 per ft^3, approximately.

TABLE 14. Juvenile Dolly Varden wintering densities in most productive reaches.

Only a few estimates are statistically meaningful; ones in parentheses are not. See Table 14 for associated habitat.

STREAM REACH	# of fish	Std. Dev.	# / ft	m^2
Jordan (Sand Bar – L)	151	36.7	1.51	0.8
Vanderbilt (lower)	35	15.8	.70	1.453
Switzer (below pond – U)	50	13.4	.25	0.409
Vanderbilt (upper meadow)	26	23.5	.13	1.334
Jordan (Airport)	37	17.0	.19	0.194
Montana (slough)	(370)	87.5	(1.85)	(2.615)
Jordan (Nancy)	(202)	45.6	(1.01)	(0.915)
Jordan (Egan)	(140)	49.5	(1.40)	(1.088)
Montana (DR channel)	(181)	50.0	(.91)	(0.635)
Jordan (Sand Bar – U)	(147)	27.3	(.74)	(0.710)
Jordan (mid-beaver – U)	(75)	47.4	(.38)	(0.430)
Switzer (gravel meadow)	(43)	5.2	(.43)	(0.387)
Switzer (below pond)	(72)	18.1	(.36)	(0.409)
Jordan (mid-beaver – L)	(72)	29.4	(.36)	(0.323)
Montana (mouth)	(60)	32.9	(.15)	(0.043)
Johnson Cr. (upper)	*			
Jordan (Nugget Dr.)	*			
Jordan (Amalga)	*			
Little Auke Cr. (windfall)	*			
Engineers Cutoff (WT 13)	*			
Switzer (mud meadow)	*			

* no recaptures

than small songbirds, which are better able to conceal their movements with vegetation. Some individuals of large species can adapt to human disturbance. However, large species also tend to have larger territory sizes, thus making them more vulnerable to individually small but cumulatively important impacts to their habitat. Also, in contrast to songbirds, many feed "higher on the food chain" and have only a few offspring annually making them especially sensitive to pollution effects on their fish and aquatic invertebrate foods. Thus, those wetlands in which disturbance-sensitive species congregate the most should be rated the highest for this function.

Criteria

Juneau's wetlands were assigned the following ratings for Disturbance-sensitive Wildlife, if they met the associated criteria:

HIGH

(1) If located within the USFVS survey area (see section 2.1.6, methods), the wetland had, at any season of the year in 1986, the greatest total number of waterbirds per visit or the greatest number per visit of Canada Goose, Mallard, or Bald Eagle. These species were chosen for special attention because of their particular visibility to the public and (in the case of the Vancouver Canada Goose and the Mallard) well-documented declines in their continental populations.

OR, (2) If not necessarily within the USFWS survey area, the wetland has, or recently had, an active Bald Eagle nest.

OR, (3) Location and data from the vegetation survey indicates potentially productive habitat for Sitka black-tailed deer. Specifically, all of the following must be present:

(a) located on Douglas Island or Lemon Creek area

(b) contain favored winter foods (Sambuscua, Vaccinium, Alnus, Salix, or Cornus)

(c) over 50% total tree canopy closure, primarily evergreen

(d) over 50% herbaceous ground cover

(e) maximum visibility (chest height) exceeds 50 feet in all directions

(f) not isolated from National Forest System land.

Documentation for these criteria is given in section 2.2,

OR, (4) The wetland contains more than 2 contiguous acres of permanent standing fresh water or permanently flooded fresh emergent marsh (or is within 300 feet of such), and is connected by forest to National Forest System land.

MODERATE-HIGH

(1) If located within the USFWS survey area, the wet land had, at any season of the 1986 year, any disturbance-sensitive species which used this wetland area more than any other area (i.e., highest individuals/visit for the species).

OR, (2) Wetland contains potential deer habitat (b-f above) but is not located in the areas named above, or is located there but lacks one of the characteristics.

OR, (3) Permanent standing or permanent emergent fresh marsh water is present, but is 0.1-1.0 acres in area, and wetland is connected to National Forest land.

OR, (4) Breeding bird surveys indicate at least occasional use by any of the following disturbance-sensitive species: Red-throated Loon, Great Blue Heron, Mallard, Green-winged Teal, Greater Yellowlegs, Least Sandpiper, Common Snipe, Spotted Sandpiper, Solitary Sandpiper.

MODERATE-LOW

(1) If located in the USFWS survey area, the wetland had, at any season of the year in 1986, any documented use by Canada Goose, Mallard, or Bald Eagle.

OR, (2) The wetland contains or abuts a permanent stream, lake, or estuary, or is within 300 feet of such, and is connected by forest to National Forest System land.

LOW

Wetlands not meeting any of the above criteria were rated Low for their likelihood of regularly supporting Disturbance-sensitive Wildlife. This includes no estuarine wetlands, but some isolated, relatively dry wetlands.

Results of the application of these criteria are shown by wetland in the map appendix.

Basis for Criteria

"Disturbance-sensitive wildlife" was defined as all waterbird species listed in Appendix B, but excluding gull species, Northwestern Crow, Common Raven, and passerines. Many mammals are sensitive to human disturbance, but Sitka black-tailed deer was singled out because of availability of habitat information. Habitat criteria were based on the U.S. Fish and Wildlife Service's (unpublished) "HEP" model and the work in Southeast Alaska of Eck (1984). Wallmo and Schoen 1980), Bloom (1978), Hanley and McKendrick (1985), Kirchhoff et al. (1983), Schoen et al. (1985), and others reported in Wallmo and Schoen (1979). Douglas Island and the Lemon Creek watershed were given greater weight due to reportedly higher deer populations there.

In addition, there are many instances of black-tailed deer venturing briefly into developed areas. Such areas alone cannot sustain viable populations, however. The most nutritious forage in winter is usually most available and abundant in old-growth stands with mature canopies. Vegetation in many scrub-shrub wetlands may be so dense that movement is restricted (Schoen and Kirchhoff 1983). Wetlands isolated from suitable habitat (i.e., no suitable corridors) and smaller than about 200 acres are unlikely to meet all needs of black-tailed deer. Low-altitude wintering areas are preferred.

This is not to deny that other mammals might be disturbance- sensitive. Those most likely to use Juneau study area wetlands include:

Masked Shrew	Muskrat
Dusky Shrew	Northern Bog Lemming
Water Shrew	Norway Rat
Little Brown Myotis	House Mouse
Snowshoe Hare	Porcupine
Red Squirrel	Gray Wolf
Northern Flying Squirrel	Black Bear
Beaver	Brown Bear
Deer Mouse	Marten
Northern Red-backed Vole	Ermine
Capper's Red-backed Vole	Mink
Meadow Vole	River Otter
Long-tailed Vole	

2.2.8 Regional Ecological Diversity

Definition and Function Rationale: Protecting the "regional ecological diversity" means protecting all the indigenous species of a region, i.e., the richness of its natural flora and fauna. This objective can be achieved by placing highest protection priority on those wetlands containing species which are regionally the rarest and thus usually the most habitat-specialized. This is not the same as protecting the individual

TABLE 15. Selected species / group totals for estuarine waterbirds observed by ADFG in 1981.

See Section 2.1.6 for methods used. Totals based on 21 visits.

	Canada Goose	Mallard	Wigeon	Teal	Scaup	Merganser	Scoters
ES 1	0	19(2)	14(1)	0	18(2)	11(3)	0
ES 1, 2, 19	7(1)	12(2)	15(1)	0	0	1(1)	16(1)
ES 2, 5, 26, 27	266(1)	45(1)	15(1)	40(1)	0	0	0
ES 7	64(2)	0	0	0	0	0	0
ES 11, M 2	93(2)	0	0	0	0	0	0
ES 14	55(4)	13(3)	0	6(1)	0	0	0
ES 16	1,519(7)	532(14)	71(3)	50(3)	20(1)	0	0
ES 17	0	268(5)	0	0	82(2)	8(2)	0
ES 18	771(8)	478(4)	0	10(1)	0	0	52(1)
ES 22, 23, DW 16, 17, 18	0	27(1)	0	0	240(2)	11(2)	29(1)
ES 19, 24	0	0	0	0	0	0	3,023(6)
ES 29	0	0	0	0	0	0	0
ES 40, L 8	0	1	14(1)	0	0	0	0
ES 42, L 6	40(1)	197(2)	9(1)	6(1)	15(1)	50(1)	0
M 10, ES 2	822(8)	703(13)	4(2)	13(2)	8(1)	0	158(2)
M4	190(3)	95(10)	33(3)	14(1)	279(4)	6(2)	0
MW 1, 2, 3, 3A, 4	465(3)	0	0	0	6(1)	0	0
MW 6, 21	87(2)	0	0	0	0	0	0
TOTAL	4,379	2,390	175	139	668	87	3,278

TABLE 16. Summary totals by period – total individuals (waterfowl only).

Data collected in 1981 by David Zimmerman and others, Alaska Dept. of Fish and Game

Wetland #	Late Winter[1]	Spring[2]	Early Summer[3]	Late Summer[4]	Fall[5]	WATERFOWL TOTAL
ES 1	33	33	5	0	0	71
ES 1, 2, 19	16	149	0	0	0	163
ES 2, 5, 26, 27	0	0	0	103	0	103
ES 7	10	48	0	0	0	64
ES 11, M 2	143	0	0	0	0	149
ES 14	14	57	2	0	6	69
ES 16	1,832	339	0	38	50	2,259
ES 17	349	0	0	0	0	349
ES 18	1,047	254	0	10	0	1,311
ES 22, 23, DW 16, 17, 18	0	328	0	0	0	328
ES 19, 24	0	2,400	600	0	123	3,123
ES 29	0	0	0	0	0	0
ES 40, L 8	1	0	0	14	0	15
ES 42, L 6	73	324	0	0	0	397
M 10, ES 2	1,294	495	92	96	3	1,880
M4	332	367	20	46	20	785
MW 1, 2, 3, 3A, 4	276	195	0	0	0	471
MW 6, 21	57	30	0	0	0	87
TOTAL	5,428	3,025	719	307	202	

[1]5 counts: Feb. 11, 27. March 6, 12, 24
[2]6 counts: Apr. 17, 29. May 14, 22, 29. June 5.
[3]4 counts: June 15, 19, 26. July 10.
[4]3 counts July 24. Aug. 18, 31.
[5]3 counts: Sept. 11. Oct. 8, 28.

TABLE 17. Selected species/group totals by wetland for estuarine and estuarine fringe waterbirds observed by ARA, Inc. survey.

Parenthesized numbers indicate number of visits at which species was present. All visits were combined. See Section 2.1.6 for methods used.

	Canada Goose	**Mallard**	**Wigeon**	**Scaup**	**Bald Eagle**	**s-e Owl Harrier**	**Snipe Shorebird**	**Kingfisher/ Tern/ Heron/ Merganser**
L 5	0	6(1)	0	0	0	0	0	0
L 6	0	0	0	0	0	2(2)	0	1(1)
L 8	0	0	0	0	0	1(1)	23(6)	5(3)
L 12	0	0	0	0	0	0	8(2)	3(2)
M 1A	0	0	0	0	0	0	5(1)	0
M 1B	0	0	0	0	0	0	4(1)	0
M 1C	0	4(1)	0	0	0	0	32(3)	0
M 2	0	12(1)	0	0	2(2)	0	20(4)	6(3)
M 3	0	0	0	0	0	0	0	0
M 4	0	45(3)	40 (1)	0	0	0	29(4)	9(2)
M 7	0	0	0	0	0	0	0	0
M 26	0	2(1)	0	0	0	0	1(1)	0
M 27	0	0	0	0	0	0	2(1)	0
M 51	0	0	0	0	0	0	0	1(1)
M 53	0	0	0	0	0	0	27(4)	0
MW 1	68(2)	0	0	0	0	5(2)	0	0
MW 2	40(2)	0	0	0	0	0	7(3)	0
MW 3, 4	0	0	0	0	6(1)	9(3)	18(2)	1(1)
MW 6	0	0	0	0	0	0	0	3(3)
ES 1	0	0	0	9(4)	1(1)	0	74(8)	4(3)
ES 2	0	0	0	0	0	0	0	0
ES 11	0	0	0	0	0	0	0	0
ES 12	0	0	0	0	0	0	0	0
ES 40	0	0	0	0	3(3)	0	24(10)	4(2)
ES 42	0	1(1)	0	0	0	0	38(11)	3(1)

TABLE 18. Summary totals by period – total individuals (all waterbirds, ARA survey).

	TOTAL INDIVIDUALS			WATERFOWL ONLY		
Wetland #	**Late Spring[1]**	**Late Summer[2]**	**TOTAL**	**Late Spring[1]**	**Late Summer[2]**	**TOTAL**
L 5	11	18	29	11	14	25
L 6	13	0	13	0	0	0
L 8	13	35	48	1	4	5
L 12	4	7	11	0	0	0
M 1A	0	9	9	0	0	0
M 1B	0	77	77	0	4	4
M 1C	0	36	36	0	4	4
M 2	0	66	66	0	13	13
M 3	0	0	0	0	0	0
M 4	0	129	129	0	87	87
M 7	0	0	0	0	0	0
M 26	3	0	3	2	0	2
M 27	5	0	5	0	0	0
M 51	0	1	1	0	0	0
M 53	0	29	29	0	0	0
MW 1	71	3	74	68	0	68
MW 2	36	53	89	32	10	42
MW 4	3	45	48	0	0	0
MW 3	6	119	125	0	80	80
MW 6	0	43	43	0	0	0
ES 1	128	114	242	59	69	128
ES 2	0	0	0	0	0	0
ES 11	0	0	0	0	0	0
ES 12	0	0	0	0	0	0
ES 40	14	179	193	0	98	98
ES 42	80+	57	137	0	3	3
Mendenhall R. (by Egan)	18	0	18	2	0	2

[1]3 counts: May 2, 22, 21
[2]5 counts: July 25. Aug. 1, 7, 14, 21

TABLE 19. Birds per visit (Total Waterbirds)* in Juneau Estuarine/Airport wetlands, 1986-87. Date courtesy of U.S. Fish and Wildlife Service.

	19 Feb – 8 Apr	14 Apr – 11 Jun	15 Jun – 7 Jul	15 Jul – 27 Aug	9 Sep – 20 Nov	28 Nov – 2 Jan	8 Jan – 10 Feb	TOTAL
M1	61.53	32.06	17.83	9.22	12.77	8.40	10.60	26
M1A	5.26	13.87	6.50	23.83	5.86	---	12.50	10
M1B	17.20	25.14	20.5	11.50	2.93	7.83	7.88	14
M1C	.533	18.08	8.75	8.38	10.73	4.00	9.29	11
M2	87.53	37.25	4.25	29.63	10.87	7.43	69.11	41
M4	152.73	27.28	7.25	19.62	43.73	15.80	9.83	52
ES1	224.26	59.26	8.60	13.20	11.37	72.38	59.92	71
ES2	133.86	163.00	108.16	188.5	37.89	111.67	358.25	150
ES5	87.53	48.40	28.00	46.08	11.32	82.33	175.08	66
ES7	45.80	19.23	24.50	38.50	5.14	43.22	104.82	27
ES10	3.00	9.44	8.25	12.78	11.33	110.50	3.25	14
ES11	5.06	12.909	3.00	13.67	2.17	13.50	59.00	7
ES12	5.33	7.923	3.00	6.00	5.38	9.40	10.75	41
ES14	129.93	54.923	5.20	43.67	16.19	140.13	234.91	104
ES15	.13	2.909	1.00	7.25	2.20	13.60	5.20	4
ES16	85.06	33.64	11.80	57.70	40.67	68.00	96.64	59
ES17	94.00	173.40	2.00	345.33	157.50	16.67	72.50	148
ES18	224.66	.50	14.00	---	7.00	30.00	99.50	65
ES19	216.00	294.00	8.00	---	123.67	---	219.50	173
ES21	112.75	20.00	38.00	36.50	1.00	4.67	.82	76
ES22	97.00	53.000	70.00	66.50	47.80	115.33	28.00	68
ES23	49.50	21.00	78.00	161.00	48.50	38.50	40.67	55
ES24	321.00	226.33	96.00	50.50	67.20	113.33	253.33	171
ES25	94.00	215.00	2.00	19.00	36.00	73.00	321.67	121
ES26	173.50	262.33	42.00	62.00	130.25	617.00	793.67	329
ES27	51.50	8.33	8.00	61.50	39.80	242.67	150.00	83
ES28	10.00	2.50	---	---	4.67	5.67	67.00	19
ES29	60.25	2.60	2.00	22.00	27.75	22.67	63.00	34
ES30	14.00	11.00	4.00	19.00	2.00	25.67	38.33	18
ES31	28.00	.50	1.00	29.50	61.75	5.50	10.67	26
ES32	11.33	5.00	---	29.50	25.25	28.67	36.33	23
ES33	45.33	56.0	5.00	---	113.00	56.33	47.00	34

* "Waterbirds" here includes crow, raven, swallows, harrier, kestrel, short-eared owl, pipit and red-winged blackbird, as well as birds typically considered waterbirds. It excludes songbirds.

wetlands which have the most species or greatest "diversity index," because such wetlands may contain only a large variety of common, widespread species. Thus, within-wetland species richness is not used as a criterion in this project; the emphasis (in scientific terms) is on "gamma diversity," which scientists now generally believe to be the most ecologically significant measure of faunal diversity (Format! and Godron 1986, Sidle 1985).

Criteria

Juneau's wetlands were assigned the following ratings for Regional Ecological Diversity, if they met the associated criteria:

HIGH

(1) The breeding season survey found a non-nomadic species in the wetland which was found in fewer than 5 of the 820 bird stations visited (see section 2.1.6 for methods). Such species are as follows: Western Tanager, Warbling Vireo, Western Wood Peewee, Brown-headed Cowbird, Red-breasted Nuthatch, Water Pipit, McGillvrey's Warbler, American Redstart, Green-winged Teal, Least Sandpiper, Pine Grosbeak, Common Flicker, Fox Sparrow, Spotted Sandpiper.

OR, (2) The survey found a number of uncommon species, none of them necessarily as rare as stated in (1) above, but together giving the wetland sufficient faunal uniqueness to attain a bird scarcity index value (see section 2.1.6, methods) of less than 3.

OR, (3) The vegetation survey found a plant species which was found at only one of the 820 stations at which plants were identified and which is considered generally uncommon in the Juneau area, or, found a plant community type (see section 2.1.6, methods) found at only one of the 820 stations. These are as follows: Carex laeviculmis, Chara sp., Eleocharis uniglumis, Fissidens adiantholdes, Myrica gale. Petasites hyperboreus. Ranunculus hyperboreus. Communities: Burreed.

OR, (4) If time limitations prevented visiting the wetland to inventory its birds or vegetation, then maps pre pared by the Corps of Engineers indicated presence of a wetland type (as defined by Cowardin et al. 1979, to the subclass and hydroperiod level) for which fewer than 5 exist in the study area. These types and their associated wetlands are as follows: Needle-leaved evergreen seasonally flooded scrub-shrub (M5), Needle-leaved evergreen semipermanently flooded scrub-shrub (DM). Nonpersistent emergent saturated (DW8), Nonpersistent emergent permanently flooded (DE4), Floating vascular aquatic bed (A2), Needle-leaved evergreen seasonally flooded forested (A6t J7f MW21).

OR, (5) The wetland is tidal (estuarine) emergent and directly abuts a nontidal (palustrine) emergent wetland, or is nontidal emergent and abuts a tidal emergent wetland.

MODERATE-HIGH

(1) The wetland contains a bird species found at 10 or fewer of the 820 stations visited. Such species include the following: Killdeer, Mallard, Northern Waterthrush. Red-breasted Sapsucker, Common Snipe, Yellow Warbler, Red-winged Blackbird.

OR, (2) The bird scarcity index has a value of less than 4.

OR, (3) The vegetation survey found a plant community type known from fewer than 3 of the 820 stations. These are as follows: Broadleaf Woodland -Poplar (IB3b), Open Alder-Willow Scrub (IIB2d), Low Open Shrub-Sweet gale (HC2J).

OR, (4) The bird-habitat survey (see section 2.1.6, methods) found the wetland to contain exceptional quantities of a special habitat feature, "exceptional" meaning that of the 820 sites with habitat measurements, fewer than 1% had the feature in such quantity.

These particular habitat features are shown in Table 19, and Justification for their use is presented in Section 2.1.6. This concept is included as a criterion, despite its seeming redundancy with (1) above, because habitat is often a better prediction of rare species presence than is a one-visit biological survey.

OR, (5) If time limitations prevented visiting the wetland, then any wetlands not isolated from natural landcover and classified by the Corps as having a scrub-shrub component bordering (or existing as) a stream or pond were rated Moderate-High. In this case, "bordering" a stream or pond was interpreted to mean wetland occurrence within 300 feet of permanent water.

OR, (6) The wetland is an intertidal emergent wetland but is unconnected (except for a narrow channel(s)) to a nontidal wetland.

MODERATE-LOW

(1) The wetland contains at least one species which in Southeast Alaska is more characteristic of wetlands than of non-wetlands, although it may use both. This includes the following mostly freshwater species: Red-winged Blackbird, Pine Siskin, Northern Waterthrush, Violet-green Swallow, Cliff Swallow, Tree Swallow, Western Flycatcher, Northwestern Crow, Orange-crowned Warbler, Yellow Warbler, Wilson's Warbler, Darkeyed Junco, Dipper, Northern Yellowthroat, Song Sparrow, Lincoln's Sparrow, Rufous Hummingbird, and Belted Kingfisher. It also includes all typical waterbirds which inhabit estuarine areas (i.e., all remaining estuarine wetlands are rated Moderate-Low for Regional Ecological Diversity).

OR, (2) The wetland contains unusual (but not exceptional) quantities of a special habitat feature shown in Table 20, with "unusual" meaning that fewer than 5% of the other 820 sites had the feature in such quantity.

OR, (3) If time limitations prevented visiting the wetland, then any wetland classified by the Corps as having a forested component bordering a stream or pond were rated Moderate-Low. However, if such wetlands were found to be isolated from major forest tracts (e.g., no continuously wooded corridors connect them to National Forest lands), then they were rated Low.

LOW

Wetlands not meeting any of the above criteria were rated Low for their contribution to Regional Ecological Diversity. This included, for example, wetlands without open water and many isolated wetlands, if they had no other special features.

Basis for Criteria

Freshwater-saltwater transition zones are more likely to have botanical features uncommon in Southeast Alaska, due to the regional scarcity of this habitat, and are valuable for certain small mammals vital to birds-of-prey.

Work of Sidle (1985) and ourselves indicates that shrub-riparian wetlands have slightly more wetland-restricted bird species and more total bird species than do forested wetlands and non-wetland types. Species richness of nesting birds was greatest in riparian scrub-shrub wetlands, followed by muskeg and saltwater wetlands, then streams and lakes, and lowest in nonriparian stands (especially clearcuts and shrub-forb meadows) (Hogan and Tande 1983, Kessler and Kogut 1985).

TABLE 20. Thresholds for "exceptional" and "unusual" amounts of special habitat features in Juneau freshwater wetlands (n=820 plots, approximately).

Feature*	% of stations having feature: Less than 1%	Less than 5%
Number of logs	>20	>10
Number of snags	>15	>8
Number of upturned trees (root wads)	>4	>2
Diameter of largest tree (inches dbh)	>45	>40
Percent evergreen canopy	>98	>90
Percent deciduous canopy	>98	>80
Dominance by deciduous trees taller than 24 ft.	x	
Dominance by deciduous trees 18-24 ft.		x
Presence of herbaceous vegetation taller than 6 ft.	x	
Number of pools (larger than 16 sq. ft.)	>4	>3

*per 3000 ft^2 (approximately) circular plot along transect.

TABLE 21. Apparent habitat preferences of Juneau freshwater wetland birds, June-July 1986, from field data.

NOTE: The left column contains measured bird habitat variables which in some cases are followed by a listing of numerical ranges that were examined. In the right column are species which appear to be correlated or causally related to the variable (the presence of a relationship in the data was evaluated vlsually, rather than statistically). For variables 5-11, each related species is followed by parentheses. The first number (or range) indicates the condition of the variable which received disproportionate use, and the second number or range (if given) is the condition seemingly most strongly favored by the species in our study area. For example, under "Percent Deciduous Canopy Cover", the listing for Wilson's Warbler (>20, >80) means this species occurred disproportionately at covers greater than 20%, and especially at covers greater than 80%. It is hoped this information will be useful for future construction of Habitat Suitability Index models for southeast Alaska. See text for description of measurement procedures.

Habitat Feature	Species Occurring Disproportionately*
1. Number of Fallen Logs (increasing)	Golden-crowned Kinglet Chestnut-backed Chickadee Hermit Thrush Red-breasted Sapsucker Rufous Hummingbird Townsend's Warbler Varied Thrush Western Flycatcher Winter Wren Western Wood Pewee
2. Number of Pools (increasing)	Greater Yellowlegs Hermit Thrush Junco Lincoln's Sparrow Mallard Solitary Sandpiper Song Sparrow Western Wood Pewee Yellow-rumped Warbler Yellowthroat Yellow Warbler Northern Waterthrush Snipe
3. Number of Upturned Root Wads (Increasing)	Blue Grouse Chestnut-backed Chickadee Golden-crowned Kinglet Spotted Sandpiper Townsend's Warbler Varied Thrush

	Western Flycatcher Winter Wren
4. Number of Snags (Increasing)	Chestnut-backed Chicakdee (>3) Greater Yellowlegs Hermit Thrush Hairy Woodpecker (>5) Junco Northern Waterthrush Red-breasted Sapsucker (>5) Rufous Hummingbird Steller's Jay Spotted Sandpiper Tovnsend's Warbler Western Flycatcher Yellow-rumped Warbler
5. Percent Evergreen Canopy Cover (Of 1-5, 6-20, 21-49, 50-80, 81-100)	Chestnut-backed Chickadee (>5%, >50%) Golden-crowned Kinglet (>20%, >50%) Hermit Thrush (>5%, >50%) Junco (1-50%) Pine Siskin (6-80%) (6-20%) Robin (6-80%) (21-49%) Rufous Hummingbird (1-20%) Steller's Jay (>6%, >20%) Townsend's Warbler (>20%, >50%) Varied Thrush (>50%, >80%) Western Flycatcher (>20%, >50%) Winter Wren (>20%, >80%) Yellow-rumped Warbler (0-80%)
6. Percent Deciduous Canopy Cover (0, 1-5, 6-20, 21-49, 50-80, 81-100)	Hermit Thrush (>5%) Orange-crowned Warbler (>80%) Pine Siskin (6-50%) Robin (>20%, >80%) Red-br. Sapsucker (20-80%) Ruby-cr. Kinglet (>5%, >20%) Am. Redstart Song Sparrow (>50%) Western Flycatcher (>1%) Wilson's Warbler (>20%) (>80%) Warbling Vireo (20-80%) Western Wood Pewee (20-80%) Yellow Warbler (1-20%)

7. Percent Herbaceous Ground Cover (0-5, 6-50, 51-65, 66-75, 76-89, 90-94, 95-100)	Alder Flycatcher (>90%) Golden-cr. Kinglet (5-90%) Greater Yellowlegs (5-75%) Junco (5-65%) Lincoln's Sparrow (>95%) Least Sandpiper (>95%) Pine Siskin (0-75%) Savannah Sparrow (>95%) Varied Thrush (65-75%) Western Wood Pevee (>95%) Yellow-rumped Warbler (5-65%)
8. Maximum Tree Diameter (Inches) (0, 1-6, 7-12, 13-20, 21-36, >36)	Alder Flycatcher «12f 0) Chestnut-backed Chickadee (>12, >36) Golden-crowned Kinglet (>20) Hermit Thrush (6-20) Junco (1-20) Orange-crowned Warbler (0-12) Pine Siskin (>20) Robin (12-20) Ruby-crowned Kinglet (12-36) Rufous Hummingbird (0-20) Steller's Jay (6-20) Townsend's Warbler (>12) Varied Thrush (>12, >36) Western Flycatcher (>20) Yellow-rumped Warbler (1-20) Yellow Warbler (6-12)
9. Distance to Stream (ft) (0-40, 40-80, 80-240, 240-400, 400-500,>500)	Junco (80-500) Lincoln Sparrow (40-400) Orange-crowned Warbler (>240) Rufous Hummingbird (<400) Western Flycatcher (<40) Wilson's Warbler «40) Warbling Vireo «240) Northern Yellowthroat (<200)
10. Distance to Upland (ft)	Golden-crowned Kinglet (<240) Lincoln Sparrow (>240) Rufous Hummingbird (>80) Western Flycatcher (<400)
11. Minimum Visibility (ft)	Orange-crownd Warbler (>40)

Forested wetlands with old-growth timber, particularly in proximity to estuaries or muskeg, are sometimes important as nesting, feeding, molting, and brood rearing sites for Vancouver Canada Goose (Lebeda and Ratti 1983).

Contiguous expanses of tidal emergent wetlands are uncommon in Southeast Alaska and thus are more likely to enhance Regional Ecological Diversity.

In the course of our wildlife investigations (see Section 2.1.6 for methods) the following habitat characteristics were inventoried:

a. Ecotones; Distance to Stream, Upland, other Wetlands, Open Water

b. Number of Snags, Downed Logs, Root Wads, Length of Internal Wetland Channels

c. Fools

d. Largest tree

e. Vegetation type

f. Vegetation structure

g. Wetland size, wetland continguity with undeveloped land, distance to house or road

These are described below, in terms of a) how measured, b) importance (based on literature review), c) Juneau conditions. Their importance to individual bird species is shown in Table 21.

a. Ecotones; Distance to stream, upland, other wetlands; Length of internal channels

Measurement. The "edge" between two landscape types nearest to each station was noted, using airphotos. Ecotones were defined as the edge between any combination of the following landscape types. Also, the distance of each station to a permanent stream was measured from the airphotos, as was the distance from each station to non-wetland (upland) and to other wetlands. Length of internal (mostly permanent) channels was also measured.

Importance. Although riparian zones in Southeast Alaska do not provide as much contrast with surrounding habitat as is the case in regions with drier forest types, they do contribute essentially to regional bird diversity by virtue of their snags, deciduous trees, lush growth of shrubs and herbaceous plants, and access to water. Proximity to streams reportedly has a positive effect on breeding species listed above, part (1) under "Moderate-Low." Areas near the estuarine shoreline are more valuable to a

wider range of species (Meehan 1974) — use by mink is focused on areas within 30 feet of shore and seldom is substantial in Southeastern Alaskan muskegs or streams (Johnson 1985). Deer use in winter is often focused on areas within 5 miles of the shore (Shoen and Kirchhoff 1985).

Juneau Conditions: Many stations (27%) were directly along streams, but 29% were more than 500 feet from streams. Many (15%) directly abutted upland; fewer than 20% were more than 450 feet from upland,

b. Number of Snags, Downed Logs. Root Wads

Measurement. At each station, we briefly estimated the number of fallen logs larger than 4-inch diameter, the number of standing dead trees of at least the same diameter and taller than 5 feet, and the number of root wads (upturned trees). Estimates were based on a circle of about 100-feet radius at each station (not rigorously delineated).

Importance. The potential importance of snags in Southeast Alaska is reviewed by Sidle (1985).

Juneau Conditions: Snags provide essential denning and nesting sites for some species. Snags were present at 42% of the stations, and 3% of the stations had ten or more snags (minimum diameter = 4 inches). Rootwads from fallen trees were at 8% of the stations, with only two stations having more than five. Fallen logs were at 32% of the stations, and 4% of the stations had ten or more fallen logs.

c. Pools

Measurement. The number of pools was estimated within the same radius of each station. Pools were considered to be isolated bodies of standing water of any size.

Importance. Open water areas may reflect increased structural diversity of vegetation, which results in greater wildlife diversity (Hogan and Tande 1983, Kessler and Kogut 1985).

Juneau Conditions: About 30% of the stations had ponds or small pools at the time of the visit, only 1% of the stations had more than four scattered pools.

d. Largest Tree

Measurement. Within 100 feet of each station, the diameter (dbh) of the largest tree was measured.

Importance. Maximum tree diameter is a superficial but easily-measured parameter for highlighting potential old-growth areas.The following wildlife species seem particularly dependent on such .areas elsewhere in Southeast Alaska (Sigraan 1985):

> Golden-crowned Kinglet, Chestnut-backed Chickadee, Townsend's Warbler, Varied Thrush, Western Flycatcher (especially near streams), Red-breasted Sapsucker, Hairy Woodpecker.

e. Vegetation Type

Measurement. We vlsually estimated the percent ground cover and percent canopy coverage of evergreens and of deciduous trees within 100 feet of each station. We also classified the wetland plant communities according to the system of Viereck et al. (1986) and noted actual species which appeared to be most dominant at this season. Species which seemed uncommon in the Juneau area were noted opportunistically.

Importance. Plant species determine the availability of food and cover for wildlife. Deciduous trees (not merely shrubs) may be especially uncommon in many areas of Southeast Alaska. Unusual plant communities may support regionally-rare wildlife species.

Juneau Conditions: A total of 135 species were found. An exhaustive search was not done at each wetland. Usually, only the dominant species were noted, but casual observations of rarer species were recorded opportunistically. Rarer species encountered included: Carex laeviculmis. Chara sp., Eleocharis uniglumis. Fissidens adlantholdes. Myrica gale, Petasites hyporboreus, and Ranunculus hyperboreus.

f. Vegetation Structure

Measurement. At each of the 820 stations, we indicated whether vegetation (evergreen, deciduous, herbaceous) was "dominant" or merely "present" within each of the following vertical layers (in feet): 0-0.5, 0.5-1, 1-3, 3-6, 6-12, 12-18, 18-24, 24+. We also estimated visibility at eye level in each of the four compass directions.

Importance. The type of vegetation, particularly its physical form, is a fundamental determinant of wildlife (especially bird) species richness. The greater the number of vertical vegetation layers in horizontally close Juxtaposition, the greater the number of species.

Juneau Conditions: A substantial 75% of the stations had no trees larger than four inches in diameter. Where larger trees occurred, most trees (12%) were 10-inch diameter, with other peaks occurring at 30 (9%) and 18 inches (9%). About 2% of the trees were larger than 40 inches. When evergreen trees were

present they typically (45%) occupied less than one-third the canopy, with only 2% of the stations having more than 90% ever green canopy closure. Most (65%) of the stations had some deciduous trees, and deciduous canopy was most frequently (44%) less than one-third closure. At many stations (31%) the mean visibility at eye level exceeded 100 feet (indicating lack of shrub cover), but at (deciduous trees, and deciduous canopy was most frequently (44%) less than one-third closure. At many stations (31%) the mean visibility at eye level exceeded 100 feet (indicating lack of shrub cover), but at 9% of the stations the brushy undergrowth limited mean visibility to less than 15 feet. Herbaceous ground cover was present at all but 3% of the stations.

Because of its relevance to habitat prediction, the vertical stratification of foliage was estimated. Foliage was most prevalent in the 1 -12 foot strata for evergreens and the 1-3 foot stratum for deciduous woody plants. Evergreens in the 25+ foot stratum were present at most (60%) of the stations, but prevalent only at 35%. Deciduous trees in this stratum were present at only 15% of the stations. Herbaceous vegetation taller than three feet was present at 32% of the stations, but in only 1% of the areas did it exceed six feet height.

g. Wetland Size, Contiguity, Distance to House/Road

Measurement. Acreage was determined by the dot-grid method using the 1 inch == 200 ft photomaps. Acreage subtotals by wetland community type (using the Cowardin et al. 1979 classification) were compiled for each wetland and all wetlands together. The distance of each wetland to the nearest house or public road was measured, and 4 contiguity conditions were defined as follows:

W = surrounded by major forest expanse (generally, National Forest land)

C = adjoins major forest expanse

F = separated from forest expanse roads

I = separated from forest expanse by roads and open land

These measurements were entered in the computer database.

Importance. Species richness is proportional to habitat size. However, because Juneau wetlands grade almost imperceptibly into uplands, habitat distinctions may be blurred, and acreage of all undeveloped, connected land may be as important as the acreage of the wetland itself. Species (e.g., bear, deer) with large territory sizes in particular seem to prefer wetlands in Juneau located closest to undeveloped land. Old growth stands of at least 400 acres may provide the best habitat for breeding birds generally in Southeast Alaska (Noble 1978). Isolated wetlands are generally less able to sustain species-rich bird and mammal populations over the long term (Fahrlg and Merrrlam 1985)

Juneau Conditions; Acreage summaries are given in Appendix D.

2.2.9 Erosion Sensitivity

Definition and Function Rationale: Construction and maintenance activities or recreational activity (and even severe natural events) may cause major sediment damage to areas downslope from some wetlands as well as to the wetland itself. Such activities in other wetlands may cause only local problems with soil mass movement or channel erosion. The soil- (or sediment-) stabilizing function of Juneau wetlands is rated by considering each wetland's vegetation cover (potential for stabilization by roots), its slope and soil type, and probable ground water situation.

Inclusion of this function is not intended to imply that erosion is always undesirable; indeed, erosion is a natural event which proceeds regardless of human presence. Rather, the function as used here assumes that accelerated erosion from human activity in some wetlands will often have undesirable consequences, and so should be minimized.

Criteria

HIGH: Wetland generally contains slope angles exceeding 20% (classes E, F).

MODERATE-HIGH: (1) Contains slopes of 3-20% (classes B-D) and not dominantly forested, and having either (a) ground water discharge conditions, or (b) soils considered to be more physically sensitive to erosion (Kupreanof, Kina, Kogish, Fu, Maybeso), OR (2) If stream data are available, mean bank stability was rated less than "2" (see below).

MODERATE-LOW: Contains slope angles of 3-20% and predominantly forested, OR, (2) If stream data are available, mean bank stability was rated 2-3* (see below)

LOW: (1) Contains slope angles generally less than 3% (class A), OR, (2) If stream data are available, mean bank stability was rated 3-4* (see below)

Results of the applications of these criteria are shown by wetland in the map appendix.

Stability Rating for Streams

rating = 1 A majority (5+) of the following conditions (a-h) are present:

a. **Upper Banks**. Slope angle exceeds 60%; or are composed of glacial till, highly weathered bedrock, or other fine sediments.

b. **Lower Banks.** Almost continuous bank cutting, or cutting at toe of slide areas at meander bends.

c. **Lower Bank Composition.** Sands, silt, clay (20% gravel).

d. **Streambed Substrate.** Sands, silt, clay, fine gravel.

e. **Channel Form.** Width-depth ratio is greater than 25 and channel is moderately to highly sinuous, gradient is less than 3%.

f. **Channel Deposits.** Gravel or sand bars present, unvegetated, and generally at least three feet high.

g. **Debris.** Logs and debris are positioned such as to cause scouring and bank cutting.

h. **Vegetation.** Alders, devil's club, bare ground, pavement, or open stands of spruce predominate on gentle floodplains.

rating = 2 Some (but fewer than 5) of the above conditions predominate in the 50-foot stream reach.

rating = 3 Some (but fewer than 5) of the following conditions predominate:

a. Upper Banks. Slope angle is less than 60% which appear stable, or bedrock.

b. Lower Banks. Few unvegetated banks (i.e., little or no continuous bank cutting).

c. Lower Bank Composition. Muskeg or grasses; or sediments larger than 2.5-inch in diameter.

d. Streambed Substrate. Coarse, unrounded rocks or bedrock, moderately to well-packed.

e. Channel Form. Width-depth ratio less than 15 and gradient greater than 5%.

f. Channel Deposits. Gravel bars absent or densely vegetated.

g. Debris. Incorporated into banks and streambed, influence >20% of channel.

h. Vegetation. Dense grass flats or muskeg, rating a 4 A majority of the above are present.

Basis for Criteria

The above criteria for streams were adapted from procedures developed and used by USDA Forest Service personnel in Southeast Alaska. Criteria for slope were tailored to available data from the Juneau soil survey (Schoephorster and Furbush 1974).

2.2.10 Ecological Replacement Cost

Definition and Function Rationale: Older plant communities are usually more difficult to replace, and thus represent a greater investment than younger plant communities. For example, a mature stand of deciduous trees in a river valley would take years to replace, since whole mature trees could not be transplanted and transplanted saplings would take many years to mature. In contrast, a clearcut willow stand might regenerate to its former condition within a few years, and thus represents a smaller replacement cost.

None of these considerations deal with replacing the hydrology of the wetland, or the function of the replacement biological communities. In most cases it will be very expensive and time-consuming (if not impossible) to replace community function and hydrology. For example, even though the regenerated willow stand may look like the original, it may not filter pollutants, recycle nutrients, or provide wildlife habitat as well as the original, at least not for decades. However, community structure (outward appearance) probably can be crudely correlated with the community's ecological functioning for the purpose of making relative comparisons of replacement cost. This characteristic (Ecological Replacement Cost) is not unique to wetlands. Many upland systems are difficult to replace.

Criteria

Juneau's wetlands were assigned the following ratings for Geological Replacement Cost, if they met the associated criteria:

HIGH: Forest (as shown on Corps wetland maps) occupies most of the wetland, and either (a) peat soils are present 115 (as indicated by soils maps) or (b) maximum tree diameter (dbh) is at least 40 inches.

MODERATE-HIGH: Forest occupies some of the wetland and (b) peat soils are present.

MODERATE:

(1) Soil is peat, and wetland contains exclusively non-forest vegetation.

OR, (2) Soil is non-peat, and forest vegetation predominates.

MODERATE-LOW: Soil is non-peat, and at least some of the wetland is forest.

LOW: Soil is non-peat and none of the wetland is classified as forested. Thus, many ponds, emergent, and scrub-shrub wetlands will be rated Low for Ecological Replacement Cost.

Results of the application of these criteria are shown by wetland in the map appendix.

Basis for Criteria

Peat wetlands have expanded vertically at their location for thousands of years, and thus represent the greatest time and energy investment. Although (given the proper hydrologic conditions) they may accrete rapidly over time (the peat layer near the Montana Creek shooting range has grown several inches vertically in just a few decades), they are not easily replaced or transplanted. Forested areas are also accorded highest ratings, particularly if they contain at least a few notably large trees.

2.2.11 Recreational Use (Potential, Actual)

Definition and Function Rationale: Recreational use of wetlands concerns human activities in wetlands which normally cause no major or irreversible damage to the wetland. Specifically, we have focused on wetland use for recreation and aesthetic enjoyment. These activities can be characterized as kinetic; that is, moving through the wetland via powered or non-powered vehicle; or situational — dependent on the specific site characteristics of the wetland. A subclass of situational experiences are educational. A major recreational use of wetlands is harvest or consumptive oriented where one is harvesting, gathering or collecting from the resource base and there is some degree of skill, strength or luck involved. The final class of recreation experience is aesthetic — where the individual does not physically take from the

environment but enjoys it indirectly via reproduction or observation. The following is a brief classification of human use values of wetlands:

gathering food plants
gathering non-food plants
fishing
hunting
hiking/walking
cross-country skiing
birdwatching
skating
jogging
picnicking
exercising a dog
educational use
seeking solitude
canoeing/kayaking/power boating
watching the glacier
nature walks
camping
wildlife observation

Opportunities for recreation in the Juneau area are varied. Included among Juneau's recreation facilities are campgrounds, marinas, local hiking trails, an alpine ski area, picnic shelters and neighborhood parks.

As the population of Juneau is increasing, participation in various outdoor recreation activities is increasing as well. Some of these include:

Camping and Picnicking. While most camping and picnicking takes place at undeveloped sites, existing campground and shelter facilities in the area are well used and often full. Picnic shelters are available at Sandy Beach, Douglas; Auke Village Recreation Area, and Eagle River picnic area. Campground facilities are found at the Auke Village Recreation Area and the Mendenhall Glacier Recreation Area.

Hiking. Opportunities are available for hiking on nearly two dozen trails in the area, most of which are maintained by the U.S. Forest Service. Included among these are trails along the beach trails to alpine areas, trails alongside the Mendenhall Glacier, and cross-country.

Boating. Boating appears to be one of the most popular outdoor recreation activities in the Juneau area; survey data indicates that nearly half of all Juneau residents own some sort of boat. Boating facilities in the area include boat harbors and marinas, boat ramps, and remote moorage floats.

Skiing. Cross-country skiing is possible on many local trails and along a track that is maintained at the Eaglecrest ski area. Opportunities for overland cross-country skiing are also available, particularly in the Spaulding meadows and Gastineau meadows areas. Downhill skiing is typically possible at the Eaglecrest ski area from November through June, with equipment rentals available.

Bicycling. Biking is becoming an increasingly popular recreation activity for people of all age groups in the Juneau area. Bicycle paths are presently being included in road construction projects with the ultimate aim of connecting al population centers.

Hunting and Fishing, Opportunities for hunting and fishing are abundant in the Juneau area. Fishing frequently involves use of boats and other facilities such as marinas and boat ramps. There are also a number of popular shoreline fishing sites in the North Douglas and Auke Lake/Bay areas. Hunting frequently involves use of shoreline and wetland areas, as well as uplands and forest areas.

Beach Recreation. Beach recreation opportunities include beachcombing, fishing, food gathering, hiking and nature study. Numerous beach recreation sites are available in the Juneau area including sites on North Douglas Island, Sandy Beach in Douglas, along the Glacier Highway, and several more within easy boating distance of Juneau.

Neighborhood Recreation. Opportunities for neighborhood recreation include walking, bicycling, outdoor sport facilities and playground facilities. The present demand for neighborhood recreation facilities is high in the Juneau area and may become even greater as travel costs increase.

Criteria and Results

A. Potential Use

The following criteria were used to assign a rating to potential for individual activities in each wetland:

Hiking/Walking
HIGH: Wetland is (a) within 200 yards of a road AND (b) larger than 200 acres or contiguous with undeveloped land AND Devil's Club is not widely present on site.
MODERATE: Wetland is (a) OR (b) AND (c).
LOW: Wetland is none of the above.

Cross-Country Skiing
HIGH: Wetland is (a) within 200 yards of a road AND (b) larger than 200 acres or contiguous with undeveloped land.
MODERATE: Wetland is (a) OR (b).
LOW: Wetland is none of the above.

Birdwatching/Wildlife Observation
HIGH: Wetland is (a) directly accessible by road AND (b) contains some emergent and open water wetland types AND (c) is larger than 200 acres or contiguous with undeveloped land.
MODERATE: Wetland has (b) and (a) OR (c).

Skating
HIGH: Wetland is (a) directly accessible by road AND (b) contains some permanent open fresh water.
MODERATE: Only (b) is met.
LOW: Neither (a) nor (b) is met.

Jogging
HIGH: Wetland is directly accessible by road.
LOW: Wetland is not accessible by road.

Plant-Gathering (Food and Non-Food)
HIGH:Wetland (a) is within 200 yards of road AND (b) contains combination of emergent and shrub vegetation types.
MODERATE: Wetland meets either (a) OR (b).
LOW: Neither (a) nor (b) is met.

Picnicking/Dog Exercising
HIGH:Wetland is (a) within 200 yards of a road AND (b) Devil's Club is not present 'on site.
LOW: Neither (a) nor (b) is met.

Educational Use
HIGH: Wetland is (a) directly accessible by road AND (b) within a half-mile radius of an educational facility.
MODERATE: Wetland la either (a) or (b).
LOW: Wetland is neither (a) nor (b).

Fishing
HIGH: Wetland (a) is within 200 yards of a road, (b) contains a permanent stream AND (c) is officially open to fishing.
MODERATE: Wetland meets (b) and (c) only.
LOW: Wetland meets none of the above.

Hunting/Solitude
HIGH: Wetland is (a) larger than 200 acres of contiguous with undeveloped land AND (B) Devil's Club is not present on site.
MODERATE: Wetland meets (a) only.
LOW: Wetland meets none of the above.

Vlsual Quality
HIGH: Predominantly open water, emergent, and/or floating aquatic vegetation.
MODERATE: Other conditions and not highly disturbed.
LOW: Highly disturbed.

Boating/Canoeing/Kayaking
HIGH: Wetland .is directly accessible by road, (b) has permanent open water body AND (c) open water is at least 100 acres in size.
MODERATE: Wetland meets (b) and (c) only.
LOW: Wetland meets none of the above.

Watching Glacier
HIGH: Wetland lies within the viewshed of the glacier.
LOW: Wetland does not lie within the viewshed of the glacier.

Nature Walk
HIGH: Wetland is (a) within 200 yards of a road and (b) Devil's Club is not present on site.
MODERATE: Wetland meets (a) only.
LOW: Wetland meets neither (a) nor (b).

Camping
HIGH: Wetland is a designated campsite.
LOW: Wetland is not a designated campsite.

B. Actual Use

Ratings for actual use were not based on gross criteria, but directly on results from the public survey. Actual human-use ratings were established by assigning rankings to individual wetland activities based on mean frequency of occurrence. Activities with mean frequencies of 65-68 were rated HIGH; 21-65 MODERATE; and 0-20 LOW. Ratings for individual activities were then compiled into an overall unweighted rating for actual use in a manner similar to Potential Use synthesis.

Basis for Criteria; Results of Public Meetings and Survey. The criteria for potential use were based primarily on physical limiting factors present on the wetland sites. In order to apply these systematically to all wetlands, criteria had to be based on readily-measured characteristics, such as gross vegetation type. Such characteristics do not always have great predictive reliability, but short of conducting intensive use surveys of individual areas, cannot be substantially improved.

Concerns arising at the public meetings were as follows:

Basic Definitions:

- Definition and delineation of wetlands many people are not sure of what a freshwater wetland is; and

- What is the meaning of development, conservation and preservation?

Basic Function of Wetlands:

- Maintain critical wildlife habitat; long term sustained productivity for fish; biological diversity;
- Maintain clean water; effects of development on water quality?; absorption of excess runoff; regulation of flooding;
- Retain undisturbed samples of every vegetation, habitat and landscape type. Retain upland meadow/freshwater marsh complex; and
- Retain freshwater feeder streams to provide needed freshwater, invertebrates, and fish for water birds.

Effect of Physical Development on Wetlands such as:

- Should gravel extraction from active stream channels be allowed?
- Borrow pits and gravel extraction areas;
- Effects of pollution, filling, channelizing on wetlands habitat;
- Decline in fisheries;
- Fill and development; and
- Litter – relationship to high rates charged for use of landfills.

Amount and Location of Development such as:

- Loss of Mendenhall Refuge to development (land affected due to rebound goes to upland area);
- Development in new areas such as second channel crossing objection to the second crossing seems frequently to lie with the perception that it will cross to the Mendenhall wetlands;
- Develop, but preserve wetland values; scenic, fish/wildlife, and hydrology;
- Population pressures housing density and cost. Population level is declining why is there a need to develop when there are 300 houses for sale? and
- The effect of incremental change – how to manage it.

Development Costs and Accountability such as:

- Who is going to pay for development? If problems arise in the long run, who pays? As more houses go to city water and cap their wells, the water table will rise and potentially flood yards and crawl spaces of houses in the Valley. Who is responsible for hydrology changes?

- Taxes are being collected but development opportunity is being restricted. Government control in conflict with private ambition;

- Rights to inverse condemnation where an owner's restricted rights lead to a demand that the public acquire the land;

- Anger over the number of actors (agencies) contacted in order to get a permit. Streamline the permitting process!

- Equity government should be held to all the regulations and permit problems experienced by private
- landowners;

- Concern about city government are strong suggestion that mayor and city assembly stay out of wetlands study until last possible moment;

- The public should have nothing to say about privately owned land it is the American way to develop my property as I please.

Conflict Between Development and Preservation such as:

- Who gets to use the land flora/fauna or property owners;

- Political control/conflict between environmental and landowners/developers;

- Economic development vs. wildlife and habitat values;

- Development vs. recreation potential and biological productivity;

- Development vs. keeping areas that help maintain Juneau's quality of life;

- Conflicts in growth areas:

  airport taxlway, heliport, float plane pond;
  industrial zone;
  second channel crossing;

deep water port;
fuel tank storage;
residential development;
road along the east aide of Jordan Creek;
road along west side of Mendenhall/Montana Creek;
new access road to the University beside Auke Lake.

Recreational issues such as:

- Education of the general public about the importance of wetlands;
- How/what do we educate our children in regard to wetland values?;
- People do not realize what a major part of their life's quality is related to wetlands; and
- Failure to treat the Mendenhall Valley wetlands as an integral system.

Resource Trade-Off-Issues such as:

- Willingness to travel to have the weekly wetland experience that is now next door; How much would it be missed (as a percent of income taxes);
- Alaska has a preponderance of wetlands something must give if people are to live/work here;
- Trade-offs with flood hazard; water quality/clarity;
- Suggestions concerning:
    - bonding of reclamation designs and for protection of neighboring wetlands;
    - performance requirements for development designs; trading-off the Mendenhall Valley for development;
    - restricting all future permanent development at Eagle River or Earner's Bay;
    - decreasing taxes of undeveloped wetland owners' lots, and increasing taxes for developed and dry land especially adjacent to wetlands;
    - public fee paid to wetland owners for public use/benefit;
    - land trades to wetland owners.

- The trade-off of subsistence food sources being removed;
    - what proportion of diet is caught, gathered or grown in the study area; and
    - is subsistence food harvesting done from necessity, enjoyment or an alternative?

Results from the public mall-out survey are summarized as follows:

Importance of wetland functions.

Residents place the highest value on having a litter free wetland (Table 22); one suspects this is directly in relation to the amount of trash in wetlands. The high value placed on wildlife and fisheries habitat indicates the perceived importance of wetland productivity. The next three attributes further support the apparent desire for visible indications that wetlands are healthy: clarity and condition of the water, scenic features, and undisturbed areas of wetlands. The need for public ownership of selected wetland areas is an additional indication of commitment to wetland values. The mean value is 145 points. Clustered around this mean are four generally quiet nature opportunities: solitude, nature walks, fishing, and passive recreation like bird watching. Flood protection, potentially a significant economic value, is significantly below this mean. So are wetland accessibility and the related general availability attributes: areas for children to play, open space and having wetlands near to one's home. Two recreation opportunities also have low importance values: hunting and food gathering. The wetland attributes of least concern to the surveyed citizens are as areas for economic and residential development.

Table 23 provides an indication of those potential wetland functions that residents think are important in the various wetland systems. In general, the Jordan-Duck wetlands system is thought to be a less important provider of these functions than the other areas. Overall, the most important functions are perceived to be provision of wildlife habitat, closely followed by scenic and recreation functions. In contrast, water supply, erosion control, water clarity, flood protection and water quality are perceived overall as only moderately important. "Importance" in this sense should not connotate "effectiveness."

Wetland recreation activities. Respondents were asked to indicate the frequency of participation in wetland areas of 20 recreation activities: once a year, once a season, every other month, monthly, every other week, weekly, twice a week, or daily. This descriptive scale is reinterpreted in Table 24 as a geometric progression of time to approximate mean annual days of participation for each activity. Observing wildlife and birds, hiking or exercising the dog, and watching the glacier or seeking solitude are the most common wetland activities. The least common are: camping, canoeing, collecting nonedible plants, gathering food, skating and hunting.

TABLE 22
Mean Wetland Attribute Values

Attribute	Mean Importance
Being free of litter	275
Wildlife habitat	260
Fisheries habitat	210
Water condition (clarity, color, litter, etc.)	202
Scenic features	187
Undisturbed areas of wetlands	169
Public ownership of select wetland areas	160
Opportunities for solitude	145
Opportunities for nature walks	143
Opportunities to fish	141
Opportunities for passive recreation like bird watching	136
Flood Protection	114
Accessibility of wetlands	110
Opportunities to hunt	108
Area for children to play	105
Open space	100
Having some wetlands near to your home	98
Food gathering opportunities	86
Area for economic development	74
Area for residential development	67

Note: All importance ratings are calibrated to an open space value of 100.

TABLE 23
Participation in Recreation Activities by Area of Recreationist's Residence

Activity	Mean Days							
	Douglas Island	**Mendenhall West**	**Auke Bay**	**Lemon Creek**	**Montana**	**East Valley**	**Other Areas**	**F-value**
Observe Wildlife	97	52	87	70	74	49	50	1.7 n.s.
Walk or Hike	42	41	61	43	36	40	39	.8 n.s.
Bird Watch	40	20	68	54	68	41	26	1.9 n.s.
Exercise a dog	51	34	41	61	28	23	28	1.2 n.s.
Watch the glacier	18	29	42	17	69	50	18	2.9**
Seek solitude	27	19	57	26	24	21	19	2.3*
Jog	17	13	31	15	1	18	14	.9 n.s.
Boating (sail or motor)	28	16	18	19	40	10	8	2.5*
Nature Walk	6	18	26	10	29	7	13	1.7 n.s.
Education	1	13	13	10	22	8	14	.4 n.s.
Fish	19	8	10	14	12	12	10	.8 n.s.
Ski	15	9	13	17	4	4	5	2.1*
Bike ride	8	8	6	12	6	8	11	.4 n.s.
Picnic	4	13	6	5	3	7	9	.4 n.s.
Hunt	10	12	1	7	2	4	4	3.2**
Skate	1	1	12	5	1	1	3	1.9 n.s.
Gather food	3	1	4	2	1	2	2	.3 n.s.
Collect non-edible plants	3	0	11	1	6	3	1	1.2 n.s.
Canoe/kayak	4	0	6	2	6	1	2	.8 n.s.
Camp	1	0	6	2	1	1	2	.8 n.s.

Note: Frequency is approximated by assigning the following number of days to the descriptive frequencies: daily (256), twice a week (128), weekly (64), every other week (32), monthly (16), every other month (8), once a season (4), and once a year (1). This forms a scale that is a geometric progression of 2^n. Probability levels: *** $p<.001$, ** $p<.01$, * $P<.5$, n.s. $p \geq .5$.

TABLE 24
Mean Frequency of Residents Participating in Recreation Activities and
Percent of Recreationists Using Various Wetland Areas

Activity	Approximate Days	Percent Recreationists Using					
		Douglas Island	Mendenhall West	Auke Bay	Lemon Creek	Montana	East Valley
Observe Wildlife	61	66	67	62	65	56	25
Walk or Hike	44	71	60	57	57	68	26
Bird Watch	40	48	66	50	62	43	17
Exercise a dog	33	52	56	57	62	69	26
Watch the glacier	31	30	23	38	38	43	7
Seek solitude	27	52	35	46	36	38	11
Jog	17	28	22	23	18	21	11
Boating (sail or motor)	15	65	31	87	25	18	3
Nature Walk	14	49	44	41	45	44	12
Education	11	24	25	24	23	18	9
Fish	11	62	18	63	19	43	4
Ski	10	85	19	40	7	53	11
Bike ride	9	30	15	29	26	25	16
Picnic	7	59	20	61	21	34	6
Hunt	5	55	39	34	29	24	4
Skate	4	4	7	55	14	3	1
Gather food	3	56	23	41	24	37	11
Collect non-edible plants	3	32	32	29	23	25	10
Canoe/kayak	3	26	16	39	11	18	1
Camp	2	31	4	22	5	18	2

Note: Frequency is approximated by assigning the following number of days to the descriptive frequencies: daily (256), twice a week (128), weekly (64), every other week (32), monthly (16), every other month (8), once a season (4), and once a year (1). This forms a scale that is a geometric progression of 2^n.

TABLE 25

Mean Agreement Ratings of Special Issues and Concerns for Juneau Wetlands by Residence of Respondent

	Area of Residents							
Special Issues and Concerns	**Douglas Island**	**Mendenhall West**	**Auke Bay**	**Lemon Creek**	**Montana**	**East Valley**	**Other Areas**	**F-value**
Recreational vehicles like three-wheelers and dirt bikes should not be allowed on wetlands areas.	8.0	7.0	8.0	7.3	7.5	7.7	8.2	2.0 n.s.
Litter in the Montana Creek wetlands is a problem.	6.7	6.3	6.6	6.3	6.5	6.8	6.8	0.5 n.s.
It is important to preserve wetlands for educational opportunities.	6.6	6.4	7.1	6.3	5.3	6.3	6.9	1.9 n.s.
There is sufficient and easy access to wetlands for recreational use.	7.5	7.5	6.0	6.3	5.8	6.4	6.7	2.1 n.s.
Access to the airport wetlands should be open to the public.	6.4	6.8	7.3	5.9	6.7	6.4	6.3	1.3 n.s.
Significant amounts of Juneau's wetlands are threatened by continued growth.	6.1	5.0	6.8	6.1	6.3	6.2	7.0	2.6*
Members of my household hunt and fish primarily for enjoyment.	6.0	6.1	6.0	6.8	5.3	6.6	6.2	0.8 n.s.

TABLE 25 (continued)

Mean Agreement Ratings of Special Issues and Concerns for Juneau Wetlands by Residence of Respondent

	Area of Residents							
Special Issues and Concerns	**Douglas Island**	**Mendenhall West**	**Auke Bay**	**Lemon Creek**	**Montana**	**East Valley**	**Other Areas**	**F-value**
The main reason I live in Juneau is because of its natural beauty.	7.0	5.7	6.2	6.0	3.8	5.7	6.7	4.5***
Erosion of the Mendenhall River banks is a problem.	6.1	5.8	5.8	6.4	6.0	6.3	6.6	1.1 n.s.
Residential development near wetlands harms them.	6.0	5.2	6.3	5.5	6.5	5.5	6.2	1.5 n.s.
Quality of life in Juneau depends upon protecting its wetlands from development.	5.6	4.8	6.4	5.4	6.0	5.6	6.3	1.9 n.s.
There is a shortage of flat well drained developable land in Juneau.	6.0	6.3	5.0	5.5	6.2	6.4	5.4	2.1*
Roads running right beside wetlands, like the proposed road along the east side of Jordan Creek, are harmful to the wetlands.	5.4	4.1	6.1	4.8	5.0	5.3	6.2	3.8**
The technology to build in wetlands without harming them is available and should be used.	5.2	5.6	4.3	5.4	5.4	5.4	4.7	1.8 n.s.
It is my right to develop my property in the way I desire.	5.0	6.5	5.1	5.2	5.7	5.5	4.2	4.0***

TABLE 25 (continued)

Mean Agreement Ratings of Special Issues and Concerns for Juneau Wetlands by Residence of Respondent

	Area of Residents							
Special Issues and Concerns	**Douglas Island**	**Mendenhall West**	**Auke Bay**	**Lemon Creek**	**Montana**	**East Valley**	**Other Areas**	**F-value**
A new access road to the University will disturb the Auke Lake wetlands.	4.8	4.0	5.1	4.6	4.2	4.4	5.1	1.5 n.s.
Noise from the airport is disruptive to nearby Mendenhall Peninsula residents.	6.0	3.9	4.7	4.2	4.9	4.7	4.9	2.0 n.s.
Environmental quality standards for wetlands should be set and enforced by the federal government.	3.9	4.3	4.6	4.6	3.9	4.6	5.1	1.1 n.s.
The second Channel crossing will put too much development pressure on Douglas Island.	4.2	2.5	4.7	3.2	4.2	3.9	4.7	3.1**
There are ample alternative wetland areas, so residential development in the Mendenhall Valley should continue.	4.3	5.2	3.5	4.1	4.5	4.4	3.4	2.6*
Duck Creek's red color is caused by pollution.	3.9	3.0	4.0	3.4	4.5	3.5	4.3	1.6 n.s.
Gravel extraction from streams should be allowed.	4.1	3.9	3.4	3.9	4.4	4.0	3.6	0.6 n.s.
The possibility of my house flooding worries me.	2.8	3.9	3.0	3.3	3.5	4.2	3.7	1.7 n.s.
Protecting Juneau's wetlands would hinder its economic growth.	3.3	3.8	3.1	4.0	4.5	4.1	3.3	1.6 n.s.

TABLE 25 (continued)

Mean Agreement Ratings of Special Issues and Concerns for Juneau Wetlands by Residence of Respondent

	Area of Residents							
Special Issues and Concerns	**Douglas Island**	**Mendenhall West**	**Auke Bay**	**Lemon Creek**	**Montana**	**East Valley**	**Other Areas**	**F-value**
Economic development is more important than protecting wetlands.	3.2	4.3	2.9	3.9	4.5	3.8	3.1	2.0 n.s.
Development in or near wetlands does not affect water quality.	3.9	4.1	3.5	3.6	2.9	3.6	3.1	0.9 n.s.
Hunting and gathering food in wetlands helps my household financially by reducing our cost of living.	4.0	3.2	3.4	4.0	4.2	3.4	2.9	1.4 n.s.
Homes and businesses can be built on wetlands without harming them.	3.8	4.0	2.6	3.2	3.8	3.4	2.9	1.6 n.s.
Providing new housing is more important than protecting wetlands.	3.3	3.3	2.6	3.5	3.8	3.1	2.7	1.2 n.s.
Approximate number of respondents	24	24	52	31	13	91	135	

Note: The rating scale ranged from 1 for strongly disagree to 9 strongly agree. Areas of residence approximate to the study area's wetland systems. Probability levels: *** $p < .001$, ** $p < .01$, * $p < .5$, n.s. $p \geq .5$.

Also indicated in Table 25 is the actual use by recreationists of each wetland. The Duck-Jordan area receives particularly little use compared to the other areas, as its functions were shown in Table 25 to be judged less important. Other recreation patterns are particular to the activity. For instance, most sail or motor boating is in Auke Lake or near Douglas Island. Skaters most commonly use the Auke Bay region but rarely the Montana, Douglas Island or Mendenhall West areas; skiers use Douglas Island but rarely Lemon Creek. Mendenhall West and Lemon Creek are also much less likely to be used for fishing, canoeing or camping. These patterns are reflected in the earlier discussion of the recreation ratings.

Special Issues and concerns. A list of thirty special issues and concerns were gleaned from the wetland workshops. These issues were presented as statements to which respondents indicated the extent of their agreement or disagreement. They are presented ordered in Table 26 by the strength of the respondents' agreement. The most highly agreed upon statements indicate that recreational vehicles should not be allowed in the wetlands and the most disagreed statement placed new housing as more important than wetlands. In general there is a very strong sentiment among the survey respondents for protecting wetlands even if it means restricting development. This is indicated by the high agreement with issues stated from an environmental protection perspective and the high disagreement with issues stated from the perspective of economic development at the cost of wetlands. Table 27 presents the extent resident from the various areas of Juneau agree or disagree with these statements. There is no statistically significant difference among residents for most issues. The exceptions are:

1. Residents living on Douglas Island are far more likely to indicate natural beauty is a main reason for their living in Juneau.

2. Residents living outside the wetland study area disagree that property owners have the right to develop their land any way they desire; Mendenhall West residents are far more likely to agree.

3. Residents from outside the study area and from the Auke Bay area are more likely to see roads as placing pressure on wetlands; residents of Mendenhall West are less likely to see such pressure.

4. Residents of Mendenhall west are more likely to think that there are ample alternative wetlands and that development should be allowed to continue in the Mendenhall Valley; Auke Bay and non-study-area residents are less likely to agree.

Although the numbers indicate that residents from outside the study area are somewhat more disposed to the environmentalist position, there are no statistically significant differences among these areas.

2.2.12 Downslope Beneficiary Sites

Definition and Function Rationale; Some of the services wetlands perform have an economic worth, either presently or in the future, which is, identifiable and clearly linked with a specific geographic area. For example, if wetlands generally are believed to reduce peak flows, then wetlands which have property downstream which could suffer economic damage from flooding should be rated higher than wetlands which have no such property. Thus, the strategic setting of wetlands with reference to cost-saving services they deliver (or could deliver, as the occasion arises) off-site has been used to assign one series of ratings.

It is recognized that wetlands also enhance off-site populations of fish and wildlife whose economic value may be quantified less easily. However, it is not possible (without extensive Harvest and tracking studies) to determine (1) which off-site areas generate the greatest income from fish and wildlife, and (2) which wetlands are the source areas for these particular individual animals. Such knowledge is a prerequisite for making distinctions .among wetlands with regard to their off-site ecological influence. Thus, fish and wildlife functions are accounted for elsewhere, under the functions "Disturbance-sensitive Wildlife", "Regional Ecological Diversity", and "Salmonid Habitat", rather than here.

<u>Criteria</u>

HIGH (1) Structures located downstream may potentially be damaged by nontidal overbank flooding. This includes structures below all nontidal wetlands in the Jordan, Duck, and Mendenhall River watersheds;
OR, (2) Local residents downslope are served by a community well.

MODERATE (1) Single residences downstream use surface water for drinking, <u>or</u> (2) The wetland receives runoff which at expected exposure Levels (at the wetland inlet) could occasionally be lethal to aquatic life, and the wetland is not a ground water recharge area.

LOW: Neither HIGH nor MODERATE above.

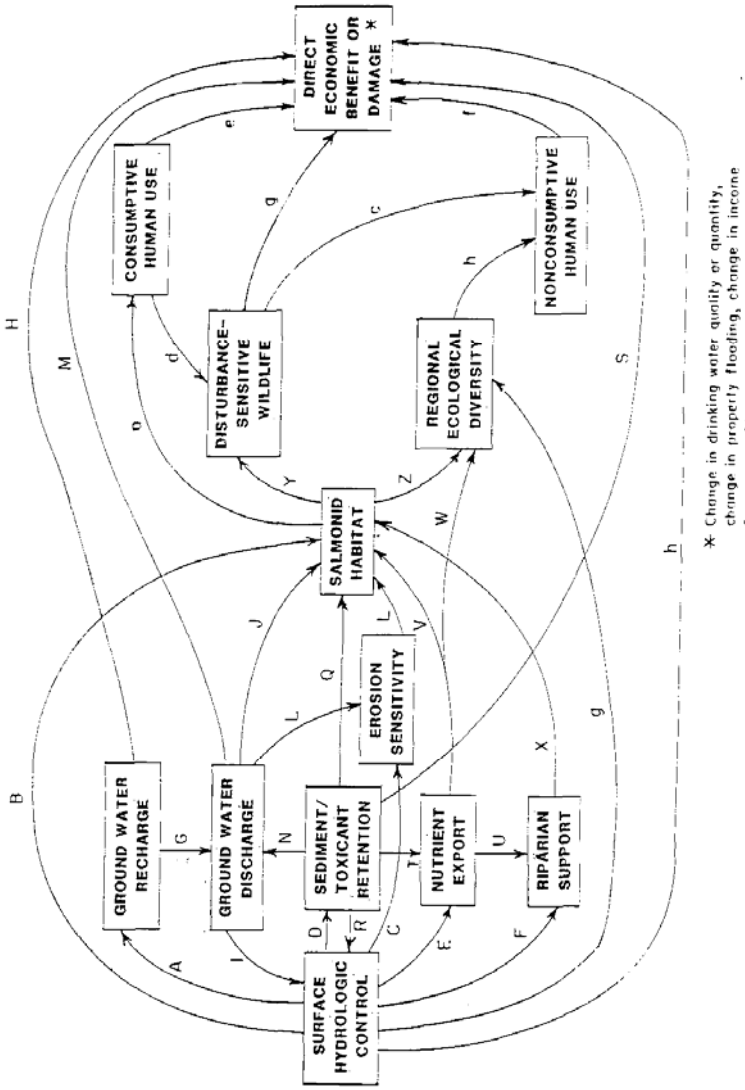


Figure 6. Potential interactions among functions of Juneau wetlands

Basis for Criteria

The 1981 Corps of Engineers maps were used for floodplain boundaries. Surface water drinking information came from files of ADEC and ADFG. The criteria for Moderate assume that (a) some wetlands retain toxicants and reduce them to harmless levels, and (b) it is preferable to retain toxicants as close to their source as possible rather than allowing them to spread downstream toward the estuary (i.e., localize any possible ecological damage). Since it was impossible to monitor all wetland inlets for all lethal substances (particularly during storm events, when most pollution runoff occurs), we partly relied on field observations of abutting land uses and discussions with knowledgeable local people, to determine where to assign this rating. The service, "toxicant retention" is only worthwhile if the wetland is not a recharge area (otherwise aquifiers could become contaminated). Although "toxicant retention" does not have an overt economic value, it la included partly under Passive Economic Services because of the identifiable relationship of its significance to strategic settings.

2.2.13 Function Interactions

Once each of the 13 functions has been rated in a particular wetland, we are faced with the difficult task of pooling the ratings together into a single rating for each wetland which, in a process apart from this report, can be used for land management decisions. This report does not provide such a synthesis process because such decisions have a sociopolitical context, as well as a technical one. Although it is tempting to simply "add up" the function ratings, giving each one equal weight, this is neither technically nor politically responsible, since many interactions occur. This section discusses such interactions.

Please refer to Figure 7. The major interactions are shown with solid lines, less certain ones with dotted lines. This diagram does not show all possible interactions. Interactions are theoretical and generally have not been proven for Juneau wetlands. Lettered pathways are discussed below.

Surface Hydrologic Control: Direct Linkages

A. This pathway leads from the Surface Hydrologic Control function to the Ground Water Recharge function. When runoff is slowed, there is often greater opportunity for on-site Recharge if geologic conditions are appropriate.

B. (effect on Fish Habitat). Fish movements may be keyed to timing and amount of runoff. If movements between streams, estuaries, and offshore waters are triggered at unnatural times, invertebrate foods may not be available or growth periods may be truncated.

C. (effect on Erosion Sensitivity). When runoff is slowed erosion damage may sometimes be reduced downstream.

D. (effect on Sediment/Toxicant Retention). Longer detention times increase the on-site retention of sediment and toxicants. Iron bacteria may become more prevalent;

E. (effect on Nutrient Transformation/Export). Shorter detention times may cause increased export, but exported nutrients may be in a form less valuable to food chains than if they had first been detained long enough to have been biologically recycled.

F. (effect on Riparian Support). Changing the extent and duration of flooding may change the wetland plant community and its influence on fisheries.

Ground Water Recharge: Direct Linkages

G. (effect on Ground Water Discharge). Decreased on-site recharge will result in decreased ground water discharge off-site.

H. (effect on Direct Economic Benefit/Damage). Decreased on-site recharge in wetlands may cause lowering of downstream water tables (of concern to well users) and may improve or degrade quality of well water.

Ground Water Discharge

I. (effect on Surface Hydrologic Control). Decreased ground water discharge allows soils to become unsaturated occasionally and may increase their capacity for absorbing runoff.

J. (effect on Fish Habitat). Decreased ground water discharge in streams may result in increased fish mortality (particularly during egg and fry stages) and more frequent dry-outs (low flows) resulting in less accessible habitat and higher juvenile mortality in rearing.

L. (effect on Erosion Sensitivity). Increased ground water discharge may “lubricate” unstable slopes, causing slides, or slumping of steep banks,

M. (effect on Direct Economic Benefit/Damage). Increased ground water discharge may result in greater property flooding.

Sediment/Toxicant Retention

N. (effect on Ground Water Discharge). Increased retention of fine sediments on-site may reduce on-site recharge and/or discharge of ground water, but may improve these functions downslope.

0. (effect on Nutrient Transformation/Export). Increased fine sediment retention on-site may result in burial of nutrients. Retention of toxicants may reduce biological transformation of nutrients on-site.

P. (effect on Riparian Support). Changes in sediment retention may cause changes in on-site plant communities and ultimately affect fisheries.

Q. (effect on Fish Habitat). Increased fine sediment retention may result in increased on-site fish mortality (or reduced growth), less access and on-site habitat space, but possibly improved downstream conditions.

R. (effect on Surface Hydrologic Control). Increased sediment deposition may block culverts and increase runoff detention, or may fill storage areas and increase the rate of runoff.

S. (effect on Direct Economic Benefit/Damage). Increased sediment or toxicant retention may damage drinking water supplies.

U. (effect on Riparian Support). Reduced ability for retaining nutrients on-site in a wetland may cause changes in the riparian plant community.

V. (effect on Fish Habitat). Reduced nutrient transformation is associated with smaller aquatic invertebrate communities, with less food being available to fish.

W. (effect on Regional Ecological Diversity). Reduced nutrient export to the estuary may result in less plant and invertebrate foods being available for waterbirds.

Riparian Support

X. (effect on Fish Habitat). Reduced streamside vegetation may have positive or negative effects on Fish Habitat as well as Disturbance-Sensitive Wildlife and Regional Ecological Diversity.

Fish Habitat (including other aquatic life)

Y. (effect on Disturbance-sensitive Wildlife). Reduced fish populations may cause a decline in use by some wildlife species (e.g., Great Blue Heron).

Z. Effect on Regional Ecological Diversity). Same as (Y) above.

a. (effect on Consumptive Use). A reduced fishery provides less sport, commercial, and subsistence fishing satisfaction.

b. (effect on Direct Economic Benefit/Damage). A reduced fishery provides less income from commercial fisheries.

Disturbance-sensitive Wildlife

c. (effect on Nonconsumptive Use). Less wildlife offers reduced opportunity for aesthetic enjoyment of wetlands.

Consumptive Use

d. (effect on Disturbance-sensitive Wildlife). Hunting displaces waterbirds from productive wetland areas.

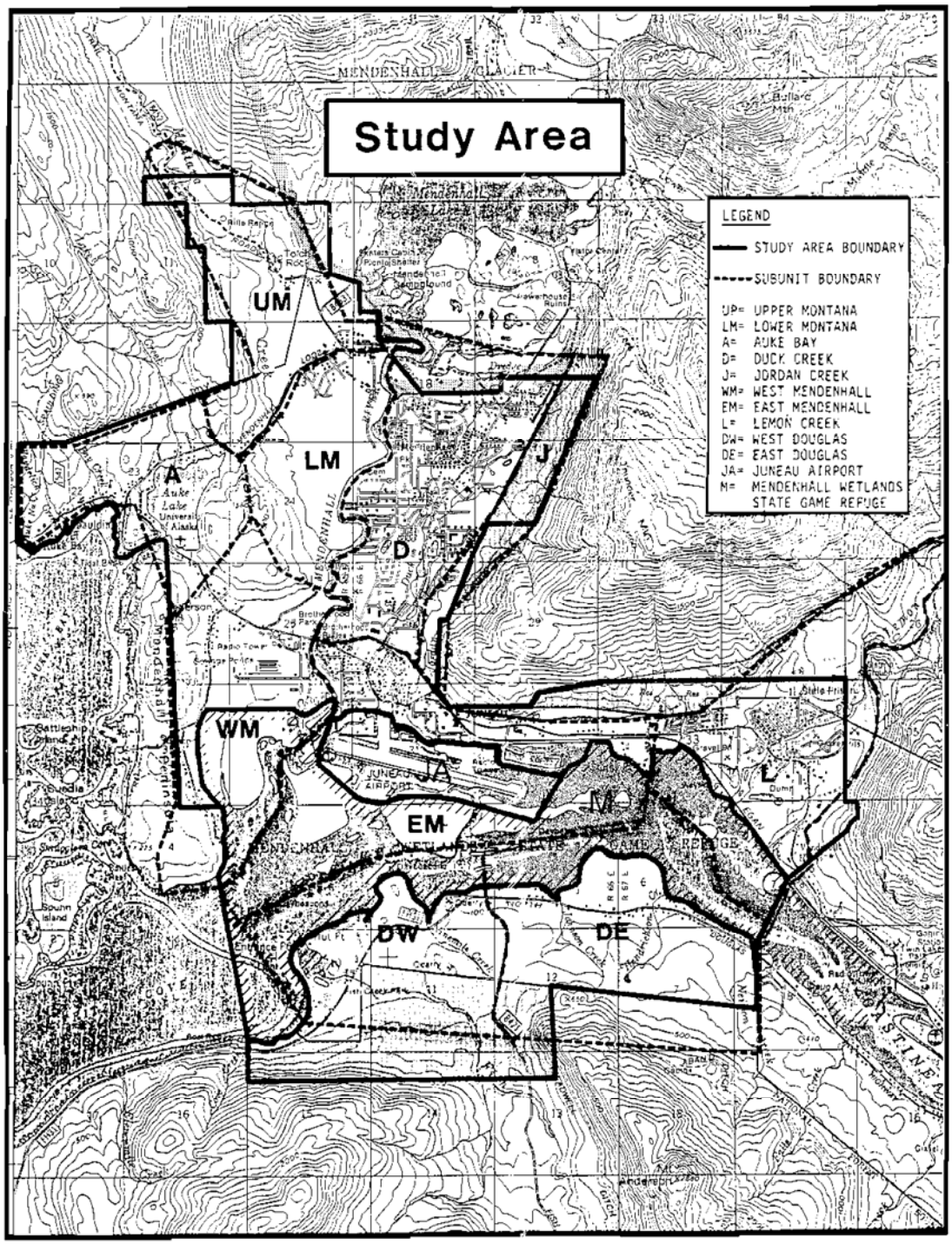
e. (effect on Direct Economic). Recreational opportunities attract tourism to Juneau. Venison supplements household foods.

Nonconsumptive Use

f. (effect on Direct Economic). Same as (e) above.

g. (effect on Regional Ecological Diversity). The timing and amount of runoff may affect locally rare plants and animals.

h. (effect on Direct Economic Benefit/Damage). Runoff storage may be economically detrimental on-site but beneficial downstream.


Study Area
LEGEND
STUDY AREA BOUNDARY
SUBUNIT BOUNDARY
UP= UPPER MONTANA
LM= LOWER MONTANA
A= AUKE BAY
D= DUCK CREEK
J= JORDAN CREEK
WM= WEST MENDENHALL
EM= EAST MENDENHALL
L= LEMON CREEK
DW= WEST DOUGLAS
DE= EAST DOUGLAS
JA= JUNEAU AIRPORT
M= MENDENHALL WETLANDS STATE GAME REFUGE
UM
LM
A
J
D
WM
JA
EM
M
L
DW
DE

ix

3.0 WETLAND OVERVIEWS BY SUB-AREA

3.1 Douglas Island

3.1.1 Ground Water

Wetlands in this subarea are mostly recharge zones or have groundwater moving laterally. Most of the wetlands are muskeg wetlands having acidic surface water. Detailed ground water data are available in a separate report (Siegel, unpublished).

3.1.2 Water Quality

Under each of the subarea headings is a narrative describing water quality like the narrative below for Douglas Island. Be aware that apace allowed only a discussion of selected water quality stations and parameters; considerable additional data points are available. When reading the narratives below, also be aware of several conventions that were used to conserve space:

- The lack of a discussion of spatial trends between two stations could mean either (a) data were not simultaneously collected at both anytime in July-November 1986 or February-March 1987, or (b) no distinct spatial trend was evident from the data.

- In the summary tables, zero's (0's) refer to concentrations below detectable limits (see section 2.1.3), not a complete absence of the substance.

- "Available nitrogen" is the sum of ammonia (NH^3) + nitrate ($H0^3$) + nitrite ($N0^2$), and is the form most readily available to algae.

- "Available phosphorus" is used as a synonym for filterable reactive phosphorus (FRP), even though FRP contains some phosphorus not readily available to algae.

- "Decreasing water clarity" is used as a more direct way of saying "increasing turbidity."

- "DOC" is dissolved organic carbon.

(a) Overview

Douglas Island streams (Table 26) generally have the lowest concentrations of available nitrogen and phosphorus of the study area streams. Fish Creek has a distinctly different nutrient regime than the others (Ninemile, Johnson, Neilson). Available nitrogen la much more prevalent and available phosphorus less prevalent, than in the other streams (July-Nov.). Only Fish Creek shows a pronounced seasonal spike of ammonia in August, coincident with maximum salmon spawning. Ammonia in the other streams (especially Ninemile) is high relative to nitrate-nitrite forms of N, but becomes more equal to nitrate-nitrite concentrations during November. Of the Douglas Island streams, only Fish Creek has higher levels of available nitrogen than the estuary, suggesting nitrogen subsidization during the months of August-October. The other streams, however, provide a greater subsidy of organic N. Available phosphorus is always more prevalent in the estuary than in these streams, and these streams appear to be nitrogen-limited (as opposed to phosphorus-limited in the case of Fish Creek) at this season.

In the summer (July-Sept.) organic N prevails over inorganic N only in Ninemile Stream, but this occurs also in Neilson and Johnson in October and November. The highly organic nature of Ninemile Stream is further evidenced by its generally lower Ca-Mg ratio, lower pH, and higher DOC (as inferred from aluminum concentrations). It also has the highest N:P ratio and greatest levels of available phosphorus of the Douglas Island streams. Presence of organic nitrogen in Johnson Creek and Fish Creek seem correlated with seasonal flow. Total precipitation input is generally least for Neilson Creek, followed perhaps by Johnson, Ninemile, and Fish.

(b) Role of Specific Areas

Because of the morphology of the Douglas Island muskegs, it was not possible to monitor water quality at distinct inlets and outlets. The difficulty of stream access further limited sampling to no more than two stations per stream, making difficult the identification of peatland roles in stream chemistry. Limited sampling showed no sharp spatial gradients in the chemistry of these streams; most constituents increased at a rate proportional to the increasing size of the watershed.

3.1.3 Salmonid Habitat

Most of the text on the following pages (and in sections 3.2.3, 3.3.3. 3.4.4, 3.5.4, and 3.6.3) comes from an unpublished manuscript prepared by the ADFG Sport Fisheries Division. Statements of relative value, however, are exclusively those of the principal investigator, as are many of those concerning habitat.

Table 26. Water quality above mouths of Douglas Island Streams, July-September 1986.

	NINEMILE						NEILSON CR.			
	19 July	10 Aug.	11 Sept.	13 Oct.	21 Nov.	5 Feb.	13 Oct.	21 Nov.	5 Feb.	Mar.
NO3+NO2	12.6	0	13.2	1.3	15.2	0	4.1	52.0	7.4	22.8
NH3+NO3	28.1	23.3	23.5	13.9	18.4	14.7	7.8	-	17.9	29.4
TKN	186	232	245	255	178	174	106	61	89	92
ON/IN	6.07	8.96	9.99	17.4	9.5	10.8	13.1	-	4.4	2.9
N/P	4.4	1.9	4.0	0.9	1.4	1.3	1.9	-	3.8	7.3
TP	17.2	19.0	16.8	22.6	12.3	20.0	9.8	3.3	5.8	8.8
FRP	6.4	12.4	5.9	14.7	13.2	11.4	4.2	2.8	4.7	4.0
TFP	9.3	13.9	6.5	13.7	12.9	10.8	4.4	1.7	4.1	4.6
Si	2.7	3.2	3.5	2.8	2.8	--	-	1.9	--	--
Fe(3)	0.50	0.45	0.77	0.73	0.61	--	-	0.05	--	--
Al	0.09	0.24	0.30	0.41	0.21	--	-	0.05	--	--
Ca-Mg	3.50	4.37	4.32	3.67	3.14	--	-	9.00	--	--
Conduct.	65.7	56.2	48.3	41.4	48.4	22.7	30.9	45.4	30.9	42.7
pH	6.9	7.0	7.0	6.7	6.8	6.2	6.8	7.2	7.2	7.0

	FISH				
	19 July	10 Aug.	13 Sept.	13 Oct.	21 Nov.
NO3+NO2	34.1	88.8	109.4	104.	177
NH3+NO3	45.3	121.0	115.2	109	187
TKN	33	93	55	67	48
ON/IN	0.51	0.46	0.90	0.58	0.20
N/P	25.2	17.8	42.7	37.6	62.3
TP	10.7	10.6	4.5	6.3	3.3
FRP	1.8	6.8	2.7	2.9	3.0
TFP	1.9	6.6	3.1	3.2	2.1
Si	1.0	1.7	2.3	2.1	2.2
Fe(3)	0	0	0	0.01	0.02
Al	0	0	0.02	0.05	0.03
Ca-Mg	5.71	8.37	6.87	6.27	5.86
Conduct.	36.8	--	--	46.7	67.0
pH	7.1	--	--	7.2	7.4

	JOHNSON						SHORELINE MUSKEG DEZ
	19 July	10 Aug.	13 Sept.	13 Oct.	21 Nov.	5 Feb.	5 Feb.
NO3+NO2	24.4	15.7	13.2	1.6	27.5	0	4.8
NH3+NO3	35.5	19.1	12.5	9.3	38.0	13.1	20.9
TKN	120	166	144	174	156	134	186
ON/IN(2)	0.37	0.64	0.12	17.9	3.8	9.2	8.1
N/P(1)	8.3	2.6	4.0	1.1	5.7	1.8	2.9
TP	13.1	8.0	2.5	15.8	5.1	19.1	12.9
FRP	4.3	7.3	5.9	8.1	6.7	7.2	8.1
TFP	5.2	6.4	6.5	7.4	5.0	5.7	6.1
Si	2.0	2.6	2.3	2.1	2.4	--	--
Fe(3)	0.27	0	0.17	0.33	0.39	--	--
Al	0.05	0.20	0.19	0.27	0.13	--	--
Ca-Mg	1.11	7.21	5.82	5.29	4.18	--	--
Conduc.	45.7	34.1	53.7	32.2	30.8	20.9	13.5
pH	6.8	6.9	6.9	6.6	7.1	6.9	5.5

(1) (NH3+NO3)/FRP
(2) organic/inorganic N
(3) in mg/L

FISH CREEK

Anadromous Stream Catalog Number: 111-50-10690

Habitat:

Fish Creek originates in Cropley Lake on Douglas Island. It flows approximately 6 miles, drains a watershed of about 14 square miles, and enters saltwater on the south side of Fritz Cove in the Mendenhall State Game Refuge. The stream has a fairly steep gradient, but there are numerous good pools in the first 2 1/2 miles above tidewater. The lower 1/4 mile downstream from North Douglas Highway is intertidal.

Three tributary streams feed into Fish Creek. The first is just above the highway and is about 300 feet long. It is slough-like with a silty iron colored mud bottom. The second tributary is about 1 1/4 miles upstream and has a fish barrier 25 feet upstream from its intersection with Fish Creek. The water in Fish Creek is clear.

Habitat surveys for this study were limited to a short stretch of lower Fish Creek, and no winter population surveys were conducted. The lower 2 1/2 miles of the streambed is essentially gravel of varying sizes. Spawning habitat is located from the stream mouth upstream for over 1/4 mile. More localized spawning habitat is interspersed between pools throughout the next 2 1/2 miles. Large pools, numerous logs, and trees provide overhead and instream cover for rearing. A narrow gorge approximately 3 miles upstream and a series of rapids form a barrier to upstream migration. Habitat for resident species is found above the barrier.

Fish Species Present:

Fish Creek has populations of coho, pink, and chum salmon, Dolly Varden char, and cutthroat trout. Fish Creek is a major local producer of pink and chum salmon. Salmon escapements and fish trap data are available from ADFG. There are no fish stocking records.

HENDRICKSON CREEK

Anadromous Stream Catalog Number: 111-40-10980

Habitat:

Hendrickson Creek originates in a muskeg area and runs for approximately 1 mile on Douglas Island before emptying into Gastineau Channel. The stream is 4 to 5 feet wide and has pools up to 2 feet deep. The stream has a gentle gradient and the water is clear with a. brownish tint. Two private residences use the stream as a water source. Most of the spawning habitat is located downstream from North Douglas Highway and above the intertidal area, in an old clearcut area. The spawning substrate above the highway is quite limited. Rearing habitat is present throughout the stream, but the intertidal area is very short. Cutthroat trout seem to prefer the upper reaches and Dolly Varden are found throughout the system. The stream has numerous pools, undercut banks, logs, and overhanging grass which provide cover in the lower reaches. Habitat was not surveyed as part of this study, nor were winter populations estimated.

Fish Species Present:

Hendrickson Creek has populations of coho, pink, and chum salmon, Dolly Varden char, and cutthroat trout. The stream has not been stocked. Juvenile fish trap data are available from ADFG. The creek's Dolly Varden population appears to be anadromous and the cutthroat appear to be resident. Few salmon escapement surveys of Hendrickson Creek have been conducted. A stream-side resident reported that approximately 200 pinks spawned in the stream in 1983 and 24 pinks spawned there in 1984. In 1984, 2 chum and 21 coho salmon were counted in the stream.

JOHNSON CREEK

Anadromous Stream Catalog Number: 111-50-10660

Habitat:

Johnson Creek flows approximately 2 1/2 miles in a northerly direction on Douglas Island and empties into Gastineau Channel. This stream is 5 to 8 feet wide and has pools to 24 inches deep. About 1 1/4 miles of the stream are located below North Douglas Highway. This section of the stream has a low

gradient and makes many meanders through the grasslands adjacent to Gastineau Channel. Upstream from the highway, Johnson Creek has a higher gradient and at least five small tributaries enter the mainstem. The water is clear, with a brownish tint. Further up, flatter gradients more suitable for rearing are present. A detailed habitat survey was conducted in lower reaches as part of this study.

Spawning habitat is found in the intertidal area and upstream to North Douglas Highway. Spawning habitat is found in pockets throughout the mainstem above the highway and, to a lesser degree, in the tributaries. The long intertidal area has many pools and undercut banks with overhanging grass which potentially provide rearing habitat. However, no fish were found there in winter 1986-87. Above the highway, the stream consists of many pools and riffle areas with overhead cover. Summer rearing potential is probably great, but winter population estimates were small even in the lowest-gradient upstream areas (Tables 13, 14).

Fish Species Present:

Johnson Creek has stocks of coho, pink, and chum salmon, Dolly Varden char, and cutthroat trout. Dolly Varden appear to be anadromous and cutthroat appear to be resident. There are no records of fish stocking for this stream. Trap data and escapement data are available from ADFG.

NEILSON CREEK

Anadromous Stream Catalog Number: 111-40-10960

Habitat:

Neilson Creek drains an area of about 2 square miles on Douglas Island. The stream runs for approximately 1 1/2 miles and flows into Gastineau Channel. The stream has a high gradient and is 5-12 feet wide at the highway crossing. The streambed substrate is mainly gravel and bedrock. The water color is clear, with a brownish tint. Only the habitat in the lower section of the stream was surveyed by this study, and no winter population surveys were conducted. The stream has a barrier falls approximately 300 yards above the stream mouth. Tidal influence extends upstream to the highway culvert. The overall rearing potential in Neilson Creek is low due to the short estuarine area, high gradient, fast water, and lack of pools and cover.

The main spawning habitat is located in the upper intertidal area. Surface drainage from a subdivision on the east side may potentially affect the estuarine reaches.

Fish Species Present:

Neilson Creek has populations of coho and pink salmon and Dolly Varden. It is presumed that a resident population of Dolly Varden exists above the barrier. The stream has not been stocked. Data collected on juvenile fish are available from ADFG.

NINE-MILE CREEK

Anadromous Stream Catalog Number: 111-50-10670

Habitat:

Nine-Mile Creek flows for approximately 1 1/2 miles in a northwesterly direction on Douglas Island before flowing into Gastineau Channel. The lower 1/2 mile of Nine-Mile Creek is intertidal and meanders through open grassy meadows adjacent to Gastineau Channel. The stream is approximately 3 feet wide at the highway culvert and has pools to 12 inches deep. The water is clear, with a brown tint. The streambed substrate in the upper section is primarily gravel; mud and silt dominate in the lower section. Only a limited habitat survey was conducted as part of this study, and no wintering population estimates were made. A fish barrier just above the highway culvert severely limits the stream's present value, as no fish were trapped above this point. Spawning habitat is restricted to the upper intertidal area. The stream has heavy moss growth on the bottom throughout, overhead brush cover in the upper reaches, and overhanging grass cover in the intertidal area.

Fish Species Present:

Nine-Mile Creek has coho and chum salmon, Dolly Varden, and cutthroat trout. Several marine species of fish are found in the long intertidal area. The stream has not been stocked.

Juvenile fish trap data are available from ADFG.

3.1.4 Wildlife

Freshwater wetlands are primarily forested wetlands and muskegs. These muskegs, compared to ones in other regions of North America, are unique in that they support stands of lodgepole pine (Pinus contorts),

a species which normally cannot persist in very wet situations. The survival of these stands may be due in part to the very localized presence of underground "pipes," i.e., natural tunnels through the deep peat which accelerates drainage and periodic lowering of the water table (P. Glaser, pers. comm.). A water line and water tank are presently being planned for location in wetland DE4 and parallel to the Eagle Crest Road.

Among the less common birds found during the breeding season were Common Flicker (wetland DE4), Red-breasted Sapsucker (DE4), Water Pipit (DE3), Greater Yellowlegs (DE2V DE3, DE4, DW1), and Red-throated Loon (DE4). Also, Bald Eagles have nested near the mouth of Johnson Creek (DW8). The most widely encountered summer birds in wetlands DE2, DE3, DE4, DE8 (and DW4 were Hermit Thrush and Junco. Orange-crowned Warbler was also prevalent in wetlands DE2 and DE4. Numerous mammals, in particular the Sitka black-tailed deer, use lower elevations of Douglas Island extensively.

In general, estuarine areas near Douglas Island support fewer species and individuals of migrant and wintering waterbirds than the opposite side of the channel. This is probably due to greater water depths and stronger tidal currents than are found on the north side of the estuary. The mouth of Fish Creek in late summer supports some of the highest concentrations of eagles in the study area. The ponds in this area are used by shorebirds, herons, ducks, and kingfishers. The Fritz Cove shoreline (extreme western end of our study area) is heavily used by Scaup in late fall. Just west of Fish Creek, Surf Scoters congregate in winter and Bald Eagles in early summer. Total numbers of waterbirds here are greater than anywhere else in the study area in late winter.

The shoreline Just east of Fish Creek's mouth is heavily used by mergansers in late winter and Surf Scoters in spring. Moving eastward toward the first peninsula, the estuarine area here is used heavily by Surf Scoter in late winter and spring, Oldsquaw and Common Goldeneye in winter, and Barrows Goldeneye in fall and late winter. Total numbers of waterbirds here exceed those elsewhere in the study area during late fall and winter.

Moving eastward to the area near the mouth of Ninemile (wetland ES27), we find heaviest winter use of all study area wetlands by Bufflehead and Common Merganser. In summer, the regionally rare Arctic Tern forages most frequently in this wetland and the preceding one. The estuarine wetlands east of here, at the foot of the Eaglecrest Road (ES29 through ES33) receive no exceptional degree of use, but are often visited by Bufflehead, Mergansers, Canada Goose, Mallard, Bald Eagle, and Scaup.

3.1.5 Recreational Use

Perceived biological functions include habitat for wildlife, fish, shore birds and waterfowl (Fritz Cove). Also included is eagle nesting near Fish Creek and fish rearing and spawning (Fish Creek). Perceived hydrologic functions include water quality maintenance and the only clear undisturbed streams feeding the game refuge. Negative aspects include very little public access to waterfront, and the beach not being properly protected.

Recreational uses included boating, kayaking and walking/hiking. Educational functions include deer and bird watching, nature walks and whale watching. Harvest recreational experiences include beachcombing, berry picking, hunting and shore fishing. Aesthetic functions include recreational beaches, good trails, serenity, open space, and glacier scenery. There is access to kayaking put-ins and boat launching. There are few negative aspects.

Consumptive uses include residential and low density housing or potential community expansion. Negative aspects of development include: houses need to be on pilings in the intertidal zone or float houses, threat of proposed industrial and port facilities from potential channel crossing from the mainland. The developed side is the winter (north-facing) side of the island, and there is a perceived need to develop the summer side (south-facing). Another concern is continued development of sub divisions in muskeg areas.

3.2 Auke Bay - Auke Lake

3.2.1 Ground Water

Near Auke Lake proper, there may be a small discharge function for wetlands in communication with the lake. Wetlands in this subarea are mostly recharge zones or have groundwater moving laterally.

3.2.2 Water Quality

(a) Overview

Concentrations of available nitrogen and available phosphorus are generally low. Available nitrogen is higher than in the muskeg streams of Douglas Island (Ninemile, Neilson, Johnson) but available phosphorus is lower. Waydelich Creek generally has more available nitrogen than Bay Creek (Sept.-Nov.), and both have more than the outlet of Auke Lake. Both show a sharp increase in the N:P ratio and organic-to-inorganic N ratio in October, coincident with high flows. Heightened organic export at this time is further suggested by seasonally highest DOC levels (inferred from aluminum levels). Organic forms of nitrogen prevail over inorganic forms in all months (Sept.- Nov.), unlike the situation in most other study area streams (except those on Douglas Island).

(b) Role of Specific Areas

None of the tributaries to Auke Lake was monitored at more than a single location. Thus the water quality role of muskegs in this area is difficult to discern. Limited data from Auke Lake tributaries and Auke Lake suggest the lake, as expected, acts as a sink for available nitrogen and available phosphorus (August- September). A more comprehensive analysis of Auke Lake water quality is being sponsored by the CBJ and conducted by the FRED Division of ADF6. Concentrations in Hanna Creek (a small tributary in the northeast corner of the lake) were greater (in August) than concentrations in the lake and its outlet (in Auke Creek) for organic nitrogen, total phosphorus, reactive phosphorus, and silica; concentrations in August in Hanna Creek were less than at the lake outlet for iron and aluminum.

3.2.3 Salmonid Habitat

BAY CREEK

Anadromous Stream Catalog Number: 111-50-10390

Habitat:

Bay Creek is located approximately 11 miles northwest of Juneau and is crossed by Glacier Highway immediately above tidewater. It enters the northernmost end of Auke Bay between DeHart's and Fishermen's Bend Marinas. Bay Creek ranges from 2 to 3 feet wide and to 16 inches in depth and is about 1/2 mile in length. Its gradient is 0.05 (steep to moderate) with numerous "stairsteps" caused by low dams. The water is clear, but has a brown tint. No detailed habitat surveys or overwintering estimates were made for this study.

TABLE 27. Water Quality of Major Tributaries to Auke Bay, 1986.

	Waydelich Cr.			Bay Creek			Auke Lake Outlet		
	12 Sept.	**15 Oct.**	**20 Nov.**	**12 Sept.**	**14 Oct.**	**20 Nov.**	**11 Aug.**	**22 Sept.**	**30 Oct.**
NO3+NO2	72.40	0	66.80	8.20	0	25.00	0	1.50	29.40
NH3+NO3	78.20	8.70	71.50	20.00	13.80	35.50	15.70	1.50	30.80
TKN	92.00	158.00	72.00	125.00	208.00	114.00	137.00	--	115.00
ON/IN (1)	1.10	18.20	1.00	5.70	15.10	2.90	8.70	--	3.70
N/P (2)	20.60	1.50	21.70	4.90	1.50	7.10	5.80	0.80	9.10
TP	6.40	15.10	6.30	7.70	9.80	5.10	10.60	--	6.60
FRP	3.80	5.80	3.30	4.10	9.40	5.00	2.70	2.00	3.40
TFP	7.30	5.70	3.10	5.70	8.00	5.60	7.50	5.30	5.70
SI	1.40	0.60	1.20	10.30	6.30	9.30	0.95	--	--
FE (3)	0	0.18	0.09	0.33	0.38	0.31	0.09	--	--
Al	0.13	0.31	0.09	0.12	0.32	0.10	0.10	--	--
Conduc.	18.00	13.00	17.00	63.00	29.00	64.00	32.00	30.00	28.00
Turbid.	0.07	1.40	0.10	0.46	1.20	1.60	--	--	--
Chl-a (3)	--	--	--	--	--	--	--	1.28	0.07

(1) organic : inorganic N
(2) (NH3+NO3) / FRP
(3) in mg/L

Most spawning habitat is found in the lower 50 yards of the stream and in the intertidal area. Small pockets of spawning substrate are found in the upper reaches of the stream. The stream has numerous pools, overhanging banks, logs, and dense overhead cover which provide habitat for rearing fish. There are several small dams (apparently man-made) that could be fish barriers at low water levels, and the highway culvert may also sometimes block fish movement upstream. At normal water levels, there are no barriers on Bay Creek.

The UAJ Student Housing complex is located directly above the headwaters of Bay Creek. Two private residences are located on the west side of the creek upstream from Glacier Highway. A sewer station is located alongside the stream downstream from Glacier Highway.

It is believed that water withdrawal is occurring in two locations, as two permits for water withdrawal are on file with the ADFG. Streamside vegetation was removed from the east bank of the stream adjacent to Auke Bay Elementary School. Intertidal areas adjacent to Bay Creek have been filled to provide uplands.

Fish Species Present:

Bay Creek has populations of coho and pink salmon and Dolly Varden char. There are no fish stocking records for Bay Creek. Trap and spawning survey data are available from ADFG.

LAKE CREEK

Anadromous Stream Catalog Number: 111-50-10420-2010

Habitat:

Lake Creek is the main tributary to Auke Lake (Wetland #A2) and Auke Bay. It drains an area of approximately 3 1/2 square miles, including parts of wetlands A5 and AS, and is about 4 miles in length. The stream is approximately 15 feet wide and 1 1/2 feet deep. The streambed substrate is mostly gravel with some bedrock. The gradient is moderate and the water generally runs clear but has a brownish tint during high flows.

No habitat surveys were conducted for this study, and winter populations were not estimated.

A barrier falls is located approximately 1 1/4 miles upstream from the mouth. The instream flow in Lake Creek has been very low the last several years and subsequently spawning success in the stream is believed to have been poor. There has been insufficient water in the stream to provide for spawner access in some summers and the stream is believed to have frozen-out the last several winters. The reduced instream flow may be due to a build up of gravel in the stream bed.

The lower section of Lake Creek has been channelized somewhat to prevent flooding of the adjoining private property. This actually confined the water to a single channel and may have had little, if any, negative impact on the fish habitat values.

Fish Species Present:

Lake Creek has runs of coho, pink, and sockeye salmon, Dolly Varden, cutthroat and rainbow trout. Lake Creek provides the primary spawning habitat in the Auke Lake drainage. The stream has a gravel base and most salmon spawning is known to occur in the lower 2,000 feet of the stream. Dolly Varden and cutthroat trout use habitat further upstream. The stream provides some rearing, but potential is limited by small pools, moderate gradient, and sparse cover. Salmon migration data, coho harvest data, and Dolly Varden and cutthroat migration data are available from ADFG.

LITTLE AUKE CREEK (also called Lake Two Creek)

Anadromous Stream Catalog Number: 111-50-10420-2004

Habitat:

Little Auke Creek is a small drainage of approximately 1 square mile just east of the Lake Creek system. The stream averages 4 feet wide, 6 inches in depth, and flows about 1 1/2 miles before entering Auke Lake. The streambed substrate is generally gravel and the gradient is moderate. The water color is clear, with a brownish tint. No habitat surveys were conducted for this study.

The creek provides excellent rearing and spawning throughout its length. Sockeye spawn in the lower half. The upper reaches are used by spawning coho salmon, Dolly Varden, and cutthroat. The stream basically consists of pools and riffles, with adequate overhead vegetative cover, overhanging banks, and a good amount of large woody debris. There are. no natural barriers on the stream. However, a gravel bar at the Loop Road culvert and an old water supply dam above the road could be barriers at low water. Daily stage measurements for 1986 are available from a landowner (M. Kirchhoff).

Fish Species Present:

Little Auke Creek has runs of coho, pink, and sockeye salmon, Dolly Varden, and cutthroat trout. The average catch per Juvenile fish trap fished on July 15, 1970, was 9.2 Dolly Varden, 7.8 coho salmon, arid 0.2 cutthroat trout. Additionally, over 330 rearing salmonids were observed in the stream. The creek itself has never been stocked, although the Auke Lake system has an extensive history of stocking. A summary of fish, fish migrations and coho harvest data for the Auke Lake system is presented under the Lake Creek Summary. Overwintering populations were estimated in February 1987 as shown in Table 13.

WAYDELICH (WADLEIGH) CREEK

Anadromous Stream Catalog Number: 111-50-10370

Habitat:

The creek flows in a southerly direction for approximately 2 miles before entering saltwater on the west side of Auke Bay. The stream drains a watershed of approximately 1 square mile. The stream gradient in the upper reaches is 0.08 (fairly steep) and a barrier to fish migration is located at the head of tide water. The water is clear with a brownish tint during high flows. The stream above Glacier Highway varies from 3 to 6 feet in width, with depths of up to 2 feet. Downstream from the highway, the stream is 10 to 20 feet wide, with depths to 1 foot.

The intertidal area of Waydelich Creek originally provided fair to good spawning habitat for pink and chum salmon. In 1983, a water reservoir for a streamside condominium complex was constructed near the site of a barrier falls. As mitigation for constructing the dam, the developers were required to enhance the spawning area downstream from the dam and provide minimum flows. The enhanced area is located upstream from the best natural spawning substrate and has substantially increased the spawning area in the stream. Wadleigh Creek was impacted by the crossing of Glacier Highway. There is a drop of approximately 2 feet at the culvert outfall which could be a barrier to upstream migration at lower water levels. Several water withdrawal permits are on file for the creek.

Upstream from Glacier Highway, the creek has many pools that provide rearing area for resident Dolly Varden. The streamside vegetation and abundant instream woody debris provide cover. There are numerous small falls above Glacier Highway that would be barriers to upstream migration.

Fish Species:

The creek has populations of Dolly Varden, pink and chum salmon. On February 9, 1983, two Dolly Varden were trapped upstream from the barrier in 4 Juvenile fish traps, and two Dolly Varden were trapped in three sets below the barrier.

The creek was stocked with 500 Eastern Brook trout in June 1953; it is not known whether they are presently found in the system.

A summary of salmon escapement data is available from ADFG.

3.2.4 Wildlife

Freshwater wetlands here are primarily forested and scrub-shrub muskeg areas. They were not extensively inventoried for plants or birds, but notable species during the breeding season were Vaux' Swift (wetland A8) and Great Blue Heron and Red-throated Loon (feeding in Auke Lake, wetland A2). Auke Lake is regularly used by Mallard, Mergansers, Bufflehead, Kingfisher, and other waterbirds.

The most widely encountered summer birds in the Auke Lake shore line wetlands were Robin and Varied Thrush. In the Little Auke Creek area (wetland A5), Steller's Jay and Winter Wren were frequent. In wetland AS (muskeg near Lake Creek) Hermit Thrush and Junco predominated. Near the UAJ campus (wetland A7) Townsend's Warbler and Winter Wren were frequent.

3.2.5 Recreational Use

Perceived biological functions and values of the general Mendenhall Peninsula/Auke Bay area include fish rearing and herring spawning in the tidal marsh areas, abundant waterfowl, seabird and bird habitat, eagle and heron nesting, marine mammal habitat, shell fish, large Sitka spruce on the peninsula and a forest-wetland ecotone area. There is some perceived water quality and storage function. Adverse ecological values include poor soils for percolation and the resultant need for city water and sewers to allow more residential development and water pollution from land use.

Recreation experiences include boating, kayaking, canoeing, hiking and ice skating. Educational values include birding, intertidal nature walks, nature study and education. Harvest uses include beachcombing, fishing, crabbing, duck hunting and berry picking. Aesthetic uses include: photography, scenic qualities and open area for tidal beach walking and shoreline access to Lynn Canal. Negative aspects include: loss of views and open space, insufficient access to shoreline and proximity to airport with attendant aircraft noise and lights.

Upper parts of Lake Creek receive little sport fishing pressure, but the mouth of Lake Creek is a favorite fishing site at Auke Lake. The Auke Lake drainage is closed to angling for sockeye salmon and Dolly Varden. Even though angling opportunities are restricted by regulations, 750 angler-hours of effort were expended in 1983 and produced a catch of 720 cutthroat trout during the summer.

Consumptive uses in this region generally include residential housing, a ferry terminal at Auke Bay and industrial and commercial development along the edge of the peninsula. Negative values associated with development includes shoreline development causing limited access, potential increase of boats and planes on Auke Lake, and lakeshore and beach shore development being too densely developed and causing excessive traffic.

3.3 Mendenhall West

3.3.1 Ground Water

No field data were collected, but lateral flow probably typifies most wetlands here.

3.3.2 Water Quality

Engineers Cutoff, Casa del Sol Creek (unofficial name)

(a) Overview

This system of tributaries begins in the Brotherhood Park area; flows through the open, emergent wetlands west of industrial Park; is fed by two forested tributaries originating in Mendenhall Peninsula

muskeg; and joins the Mendenhall River near the peninsula tip. Organic nitrogen exporting conditions prevail throughout nearly the entire system and are strongest at the outlet of wetland MW11 (October), Concentrations of avail able nutrients are among the greatest of all study area streams. Aluminum (and by inference, DOC) levels are relatively high.

(b) Role of Specific Areas

North of Egan Drive near Brotherhood Park, the westernmost of the two tributaries (WT16) receives runoff from a horse pasture and has substantially elevated concentrations (relative to the other tributary, WM5) of available nitrogen and available phosphorus, as well as a greater organic-to-inorganic nitrate ratio (10 in July, 20 in September). Phosphorus levels are sufficient to stimulate excessive growths of algae, and indeed profuse growths of filamentous algae are visible, but nitrogen and high turbidity (20 NTU) could be limiting downstream. Iron and aluminum levels are greater in the more "natural"1 tributary, while the Ca-Mg ratio is less than in the nutrient-loaded area (perhaps because of calcium-phosphorus interaction).

After passing under Egan Drive these tributaries join together. Samples collected in September next to the Engineers Cutoff Road (WC1) indicate a slight decline in the great nutrient concentrations. At this point the stream has been channelized and routed behind some buildings on the Engineers Cutoff Road. A tributary from the Pederson Ridge muskeg joins in, and a sampling station (WC2) just downstream from the junction (and downstream from the Cutoff Road buildings) shows greatly diminished available phosphorus and available nitrate (August, October, November), but a return to the same organic-to-inorganic nitrogen ratio present in the nutrient-laden headwaters (October) or to a ratio slightly less (September) than farther upstream. After passing through several hundred feet of emergent wetland, the stream's organic/inorganic ratio (at WM2) declines again, and available nitrogen and phosphorus increase (August, October, November, February).

The stream then winds through a large expanse of emergent wetland, and is joined by two tributaries, one from near a diked spoil disposal area and industrial Park to the east (station WC6), the other (WM1) from Pederson Ridge on the Peninsula. Compared to the middle (Cutoff Road) tributary, the eastern (WC6) tributary in September has greater reactive phosphorus, much less available nitrate, and a higher organic-to-inorganic ratio. Compared to the middle tributary, the western (WM1) tributary in July has about the same level of available nitrate, but less of it is in the form of ammonia. Available phosphorus is less at WM1, and WM1 is less exposed to tidal waters.

Tracing the WM1 tributary back into its headwaters in wetlands MW11 and MV20, note that as the tributary leaves muskeg MW11, passes under the peninsula road, and flows through MW20, it receives

runoff from unsewered residential areas and ditches on the peninsula road. Available nitrogen increases (except winter months) and available phosphorus decreases (all months). In February, turbidity increases (perhaps from road runoff). The ratio of organic-to-inorganic nitrogen decreases (October), as does the Ca-Mg ratio and aluminum (July).

Next, its gradient flattens as it leaves the forest and enters the tidal emergent wetlands. The ratio of organic-to-inorganic nitrogen increases (October), as does available nitrogen (in September, but not other months). Total phosphorus increases during all months, but in August it becomes relatively less available. Concentrations of available nitrogen and phosphorus in these tidal channels are exceptionally high (high enough to potentially stimulate a significant growth of algae) and turbidity is low (less than 10 NTU). These factors may help support the large numbers of summer-rearing salmonids found in this area.

Returning now to the middle tributary. Several samples were collected in the watershed of the eastern tributary near Industrial Park, but not from waters permanently connected to the tributary. Samples from the diked spoil area, compared to those from the flowing tributary, contained less available phosphorus, and more total phosphorus, iron, available nitrogen (in October but not in September), and a higher organic-to-inorganic nitrogen ratio. No lead or copper was detected in these surface water samples. Samples from two shrub wetlands in this watershed which were isolated by Industrial Park development were compared. The northern one (WC5) is completely isolated by roads and has more available nitrogen and total phosphorus, but less available phosphorus. Its Ca-Mg ratio is substantially greater than the southern one (WC4). Returning to the Cutoff Road tributary, by examining a stream which drains from wetland MW22, we can trace the effect of this muskeg on downstream water quality. As the stream exits MW22 and moves through forest toward the marsh, available nitrogen increases (all months). Iron increases in summer and total phosphorus in October, but available phosphorus and aluminum decline in July and September.

3.3.3 Salmonid Habitat

MENDENHALL RIVER

Anadromous Stream Catalog Number: 111-50-10500

Habitat:

The Mendenhall River originates in the glacier that feeds its headwater, Mendenhall Lake. It flows approximately 5 miles through the center of the Mendenhall Valley and enters saltwater in Fritz Cove.

The fish habitat of this river has never been inventoried due to the river's large size and glacial character. Montana Creek enters the Mendenhall River approximately 1 mile upstream from Glacier Highway, and Duck Creek enters the Mendenhall River near the Juneau Municipal Airport. The gradient is 0.0015 from the Loop Road down to the junction with Montana Creek, 0.0009 from there to Glacier Highway, and 0.0005 from there to the estuary.

No detailed habitat surveys or overwintering estimates were made for this study.

The mainstem is used by fish primarily as a migration route to the spawning areas of the upper watershed. Up to 15,000 salmon of all species and 30,000 Dolly Varden migrate up the Mendenhall River annually. Coho salmon are known to spawn in the Mendenhall River between the outlet of Mendenhall Lake and the Loop Road Bridge. There are no fish barriers. The extensive tidal wetlands located adjacent to the river's mouth are included in the Mendenhall Wetlands State Game Refuge.

The Mendenhall River flows through the most densely populated area in Juneau. Historically, gravel was mined from several gravel bars along the river. Many of the operations left depressions in which fish could become trapped and lost during low water levels.

The banks of the river have been stabilized with rip-rap in some sections to prevent erosion of private property. Drainage from residential areas and industrial sites adjacent to the river may degrade water quality. The old Red-Samm gravel pit located on the east bank upstream from Glacier Highway is suspected to be a source of chemical pollutants which drain into the river. Mendenhall Valley sewage treatment plant is located alongside the river near the municipal airport, and its outfall enters the river.

Fish Species Present:

The river has populations of coho, pink, chum, and sockeye salmon, cutthroat and steelhead/rainbow trout, and Dolly Varden. Eulachon (smelt) can be found in the lower Mendenhall River in the spring. The river has not been stocked. It is used as a migration route by Montana Creek and Steep Creek stocks of fish.

CASA DEL SOL CREEK (unofficial name) and ENGINEERS CUTOFF CREEK

Anadromous Stream Catalog Number: 111-50-10490-2013

Habitat:

This stream originates on the eastern slope of the Mendenhall Peninsula and drains an area of over 1,000 acres on the ridge and southwest corner of the Mendenhall Valley. Two of the largest tributaries run off Pederson Ridge and two smaller forks originate in the wetlands south of Glacier Highway. One of the larger tributaries runs under Engineers Cutoff Road near its intersection with Glacier Highway and the other at 0.3 mile Engineers Cutoff. This tributary is also crossed by Pederson Road. One of the smaller tributaries originates alongside of Glacier Highway west of Sherwood Lane and the other in the meadows east of Sherwood Lane. The stream enters saltwater in Fritz Cove, west of the mouth of the Mendenhall River. Both larger tributaries run directly off Pederson ridge and enter the grassy wetlands at the base of the ridge.

Both of the larger tributaries average 3 to 4 feet wide and up to 1 foot deep as they traverse forested areas. In the open wetlands the streams are 3 to 5 feet wide and 1 to 3 feet deep. The system has many meanders and wide floodplains. The water color is clear with a brownish tint. The intertidal section of this system is over 1 mile long. Chronic pollution from septic system leakage and sediment runoff may locally reduce habitat value.

The upper reaches of the system flow through forested areas and provide both rearing and spawning habitat. The lower sections of the tributaries and mainstem have a very low gradient and flow through grassy wetlands. Overhanging grass, numerous over hanging banks, and meanders provide rearing in this section of the stream. The only barrier on the drainages may be a dam on the west fork directly above Engineers Cutoff Road. However, some rearing coho reportedly occur above this dam. A detailed habitat inventory was conducted in November 1986, and winter populations were estimated in Engineers Cutoff Stream (Table 13).

Fish Species Present:

The Casa Del Sol system has populations of pink, chum, and coho salmon and Dolly Varden. The marine species rear in the lengthy intertidal area. The system has not been stocked. Trap data are available from ADFG, U.S. Fish and Wildlife Service, and National Marine Fisheries Service.

3.3.4 Wildlife

Freshwater wetlands either adjoin tidal wetlands (e.g., Brotherhood Park) or are mostly muskeg or forested. A noteworthy breeding season species in this subarea is Red-winged Blackbird. The emergent wetlands are dominated by Savannah and Lincoln's Sparrows. Forested wetland MV11 is dominated by Hermit Thrush, and the transitional wetland, MW22, has frequent Townsend's Warblers and Pine Siskins. Brotherhood Park is often used by Sharp-shinned Hawk, Northern Harrier, Kestrel, and other raptors. Red-breasted Nuthatch (a locally uncommon species) may nest along the meadow edge, as do Snipe.

The estuarine wetlands between the Mendenhall Peninsula and Industrial Park (wetland ES18) are the most heavily-used wetlands in the entire study area in winter for Canada Goose, Mallard and Bald Eagle as well as Bald Eagle adults in early summer. High numbers are partly but not entirely related to the fact this is the largest wetland (400+ acres). Northern Harrier, Short-eared Owl and other species frequent this area in migration.

The Mendenhall River near the municipal waste treatment plant (ESI) contains several backwater areas, channels, and flats used heavily by waterbirds. This is the most heavily used area in late fall and late winter for Bufflehead, Bald Eagle, and Goldeneye spp.; in spring for shorebirds, Common Merganser, and Goldeneye; and in early summer for Belted Kingfisher. Arctic Terns, notable in Southeast Alaska, forage heavily here.

Finally, the flats at the outer mouth of the Mendenhall (ES19), which comprise the second-largest tidal wetland (250+ acres), have the greatest number of individual birds in spring of all study area wetlands, as well as the most Bald Eagles in late winter.

3.3.5 Recreational Use

See section 3.5.6

3.4 Airport Jordan-Duck

3.4.1 Ground Water

Wetlands near the airport are either discharge areas where next to distributary channels, or zones of slow lateral flow. Wetlands on the alluvial fan east of Jordan Creek are probably groundwater discharge zones, although the volume of discharge water flowing through the surface wetland layer is small com pared to

that discharging directly to the creek from mineral soils and surface water runoff. The function in the Duck Creek watershed is variable, depending upon the position of the wetland relative to moraines, development and the creek. For example, ice-block wetlands in the moraine at the head of the watershed are probably recharge zones for flow systems that discharge to the creek. Along the creek in developed areas, the wetlands are either no-flow areas or zones of slow lateral flow or Limited discharge to the creek.

3.4.2 Surface Hydrologic Control

Jordan Creek

In the Jordan Creek part of this subarea, the HEC-1 computer model was used to analyze the ability of nine wetland storage areas to reduce peak flows and attenuate runoff. Readers should be aware of the limitations of this modeling approach, as stated in Section 2.1.2. Relationships described below are portrayed graphically in Appendix B, and Figure 6 shows locations of the reaches shown in that Appendix.

With regard to ability for reducing monthly flood peaks (i.e., maximum percent reduction) the following 3 wetlands at all seasons seemed most effective: FJ6 (from Hayes Way to Just below Nancy Street), and FJ11 and 12 (headwater alluvium). Although the reduction by headwaters was large when expressed as percent reduction, when expressed as absolute cubic feet/second flow reduction it was small relative to the effect of FJ6 and most other downstream areas. Peak flow reduction (as cfs) was greatest at FJ6 in September (peak reduced by 26 cfs and 65%). Average monthly maximum flows during the primary spawning season (August-October) were estimated to range from about 2 cfs in the headwaters to about 32 cfs Just below Jennifer Street (FJ8) and also near the mouth (FJ2). Flow near the mouth (actually, Just above the Airport Fire Station) was estimated to range from 4 cfs during average February and March storms to 27 cfs for September storms and 80 cfs for the maximum probable storm.

The effect on storm runoff timing was also examined. Peak flows near the mouth were predicted to occur from 13 (in June) to 24 hours (in several months) after the respective monthly storm peak. Flood peaks were delayed similarly at other stations.

During the flow recession period between 6 and 24 hours after a storm, the average flow in the headwaters receded 25% (in February) and 65% between Amalga and Jennifer Streets (in November). On most parts of Jordan during most months the flows receded 40-60% during this post-storm time period. The stream flow seemed to return most rapidly to its ambient condition (most months) in the Amalga-Jennifer, Nancy-Hayes, and the Hayes-Jennifer Street reaches. Biological “conditioning” of runoff might

therefore be least in such areas. However, the exceptional concentrations of wintering coho which we found in that area (see Section 2.1.4) might be related at least partly to the brief nature of extreme runoff events there. "Conditioning" of runoff by biological activity or sedimentation (i.e., longest detention times) is expected to be greatest in the headwater wetlands.

Storage of runoff at the time of peak flow in all Jordan wetlands was usually less than 10 acre-feet during monthly storms, but during the maximum probable storm could exceed 20 acre-feet at most wetlands, with the greatest storage (68 acre-feet) occurring in the Nancy-Hayes reach.

Duck Creek

In the Duck Creek part of this subarea, the HEC-1 model analyzed the ability of 21 wetland storage areas to reduce peak flows and attenuate runoff.

Using percent-reduction-of-peak as a criterion, the most effective wetland storage areas seemed again to be those near headwater areas (Taku Blvd. and Hayes Way pond). Using absolute reduction of peak flow (in cfs) as a criterion, these same areas plus the channel near the Airport were shown to be most effective. Peak flow reduction (in cfs) was greatest in the headwater reach just below Taku Blvd. in September (peak reduction by 4 cfs and 57%). During some months, most of the 21 Duck wetlands had no effect (or less than 0.1 cfs, difference) on peak flow. This situation happened particularly during winter and spring months. Flow near the mouth of Duck was projected to range from about 5 cfs during average February and March storms to nearly 18 cfs during average September and October storms, with an estimate of 48 cfs for the maximum probable storm.

The effect on storm runoff timing was also examined. Peak flows near the mouth were predicted to occur about 23 hours after the storm peak in all months. During the flow recession period between 6 and 24 hours following the maximum probable storm, the average flow receded 62% at the outlet of the wetland below Taku Blvd., but only 48% at the small wetland east of Cinema Drive. The time difference (desynchronization) between inlet and outlet peaks in all wetlands was usually small (less than 1 hour) but in a few cases was as great as 11 hours (e.g., wetland below McGinnis Drive in June).

3.4.3 Water Quality

Mendenhall River

(1) Overview

The Mendenhall River appears not to greatly subsidize the estuary with available phosphorus and nitrogen (i.e., estuarine concentrations are much higher), except possibly in winter. During months of greatest glacial meltwater input, available nitrogen levels and N:P ratios were highest, perhaps due to suppression of biological uptake caused by high turbidity. Maximum organic export to the estuary seems to occur in October, as suggested by high aluminum (corrected to DOC) and high organic-to-inorganic N ratio.

Nitrate concentrations moving downstream on the Mendenhall River show little change, remaining at relatively low concentrations throughout, while phosphorus levels are relatively high. A sharp temporary rise in nitrogen, phosphorus, and silica occurs in the reach containing the wastewater treatment plant (November). Levels of these nutrients are sufficient at this location to support substantial growths of algae, but light penetration is poor due to high turbidity associated with the river's glacial origin, thus limiting algal growth.

Turbidity ranges from about 25 NTU (August) to more than 180 NTU (October), with the poorest water clarity being at the Upper Loop Road sampling station, closest to the glacier.

(b) Role of Specific Areas

As this glacial river flows from the Loop Road bridge downstream to a point just above the mouth of Montana, water clarity remains constant (July, August, November) or improves slightly (October, February). Aluminum increases sharply (July) and the Ca-Mg ratio decreases (September). Organic nitrogen becomes more prevalent (relative to inorganic N) in August, but more typically shows a decline over this reach (July, September, October) and is always present in extremely small concentrations. Available nitrogen increases (July, November, February) but available phosphorus declines slightly some months (August, October) and increases during others (July, February). Iron increases in July and November, but drops in August.

As the river passes the mouth of Montana, samples from the mixing zone suggest Montana's possible influence on the Mendenhall's water quality. The ratio of organic to inorganic nitrogen increases sharply (September, October, February). The Ca-Mg ratio decreases (August, November), suggesting increased biological activity. Water clarity improves (October, February). Total phosphorus and available nitrogen change little.

Continuing downstream to the Egan Drive bridge, the ratio of organic to inorganic nitrogen continues to increase (October) as does nitrate (September, November). Iron and water clarity increase (October) but clarity in November is better closer to the mouth of .Montana. Total phosphorus increases toward Egan Drive (November) but the portion of reactive phosphorus declines (October, November).

Between Egan Drive and the mouth of Duck Creek, there is extensive urban runoff, the municipal wastewater treatment plant empties into the Mendenhall, and saltwater is encountered. Available nitrogen and phosphorus increase (September, November) and the expected drop in the ratio of organic to inorganic nitrogen occurs (November). The Ca-Mg ratio decreases (September) as a probable result of increased marine influence. Water clarity, perhaps surprisingly, improves. Concentrations, and ratios of major substances near this point (station WT9) are as follows (in micrograms per liter):

TABLE 28. Water quality in the Mendenhall River above saltwater influence (WT9), 1986.

	Mendenhall at Egan Drive			Mendenhall above Duck Cr. Mouth	
	16 July	**10 Sept**	**15 Oct**	**18 Nov (4)**	**18 Nov**
NO3+NO2	33.0	15.6	18.8	54.5	126.0
NH3+NO3	40.8	24.4	27.0	233.0	515.0
TKN	33.0	24.0	67.0	320.0	577.0
ON/IN (1)	0.62	0.65	2.18	0.61	0.36
N/P (2)	24.0	5.1	4.0	12.8	6.3
TP	78.0	77.0	210.0	212.0	215.0
FRP	1.7	4.8	6.7	18.2	82.4
TFP	2.9	5.7	6.5	18.1	83.9
Si	0.4	0.4	1.3	1.5	1.5
Fe (3)	0.0	0.04	0.40	0.53	0.24
Al	0.19	0.07	0.52	0.06	0.03
Chl-a	—	0.03	—	—	—
Conduct.	21.9	16.4	24.6	410.0	4530
pH	6.9	6.7	6.8	6.7	7.2

(1) organic/inorganic N
(2) (TKN+N03)/FRP)
(3) in mg/L
(4) actually located in mixing zone below Montana mouth; possible saltwater intrusion from tidal backwater effect (see conductivity).

Mendenhall River data from 14 years ago (Kirk 1973) shows higher nitrate levels (97 ug/L) in July, but exact sampling location and analytical procedures may be different.

As the Mendenhall passes the mouth of Duck Creek, outflow from Duck Creek at this point has greater concentrations of available nitrogen, silica, iron, and a higher N:P ratio, while the Mendenhall has greater total phosphorus, available phosphorus, total filterable phosphorus, (only slightly more) aluminum, and a higher organic-to-inorganic nitrogen ratio. However, in November the Mendenhall has the higher nitrogen concentrations (perhaps due to saltwater influx).

As the Mendenhall passes Duck Creek's mouth, concentrations of total phosphorus, available nitrogen, and the ratio of organic-to-inorganic nitrogen all plummet.

Overall, organic nitrogen-exporting conditions are found on the Mendenhall at the Egan Drive bridge in October, the Loop Road bridge in September (and secondarily, in October), and in the Montana Creek mixing zone in October.

Duck Creek

(a) Overview

Available nitrogen was generally higher than other streams excepting Vanderbilt Creek, and except in September and November, when Jordan also was greater. Nitrate concentrations moving downstream on Duck Creek generally rise from moderately low to high. Highest levels are at the Airport stations in August, but fall short of levels that normally trigger profuse growths of algae. However, when considered cumulatively with ammonia, such levels were reached in October in middle reaches of Duck (pond above Nancy Street) and at several locations in February-March.

As in Jordan Creek, the ammonia portion of nitrogen increases in winter, and both nitrate and ammonia are depleted somewhat in summer. An inexplicable, dramatic seasonal dip in nitrate occurs near the mouth in November. The ratio of organic to inorganic nitrogen is generally small (except in October) at the Nancy Street pond outlet, but at Duck Creek's mouth generally exceeds that at Jordan Creek's mouth (except in February). Organic forms seem more prevalent at higher seasonal flows. The N:P ratio at the mouth increases as winter approaches.

Total phosphorus concentrations are fairly stable moving downstream on Duck, and are moderately low. Highest levels were in October above the highest east branch pond and in November at the Nancy Street Pond outlet. Available phosphorus (as percent of total) is moderately high, with highest levels in November at the Nancy Street pond outlet. Only in Fall did it reach levels which might trigger profuse growths of algae in the ponds. Available phosphorus is generally less than in Jordan Creek.

Turbidity is generally high, with highest levels in September and October at the Nancy Street pond outlet and near the Airport, and in winter between Egan Drive and the mouth. These levels (exceeding 30 NTU) are sufficient to severely impair growth of algae and aquatic plants during the growing season.

(b) Role of Specific Areas

In the reach between WM7 and WM6 (an intermittent, urbanized headwater channel). In September, nitrate increases and available phosphorus decreases, as does iron. As Duck Creek passes through the first major gravel pit pond (wetland # D2) in September, the available nitrogen and phosphorus declined, as does the Ca-Mg ratio. This happens again in October, except available nitrogen increases, along with turbidity. Total phosphorus decreases.

Passing through the second gravel pit pond (wetland D4), turbidity continues to increase (in October and November). Available nitrogen, available phosphorus and total phosphorus increase in October and November, but in August the available phosphorus decreases here, perhaps due to biological uptake. The Ca-Mg ratio declines (August, November) as it passes through.

Passing through the third pond (wetland D5), available nitrogen decreases in August, as does the Ca-Mg ratio. Below Nancy Street (wetland D6) the available nitrogen trend reverses, showing an increase in the months August, September, October, and November. Both total and available phosphorus decline (August and October) as water clarity improves (September, October). Also in this reach below Nancy Street, iron increases (February) and aluminum decreases (July).

As Duck Creek passes under the Loop Road and flows downstream to the Super Bear drive (passing through wetland D7), water clarity continues to improve (September, October) but available nitrate again declines (August), as does the Ca-Mg ratio. In the wet land between the Super Bear drive and Egan Drive (D8), available phosphorus decreases in July but increases in August.

As Duck Creek parallels Glacier Highway below Egan Drive (wetland M19), available and total phosphorus decrease but available nitrogen increases (August). The Ca-Mg ratio decreases. In the reach above Berners Street (wetland M20), water clarity worsens (October). Available nitrogen increases in August but declines in September, October, and November. Available phosphorus increases in September. The Ca-Mg ratio again resumes its general downstream decrease (August, September, November data), and dissolved iron increases (September).

Between the power station near Berners Street and the mouth of Duck (i.e., the channelized reach next to the Airport), available nitrogen decreases (August, September, October) and water clarity improves, as dissolved iron and the Ca-Mg ratio decrease (October). Reactive phosphorus declines (November).

Finally, as Duck Creek enters the Mendenhall River, available nitrogen (October) and total phosphorus (August, September, October) increase, but the phosphorus increase is from mostly organic forms. Although in October the Mendenhall is more turbid than Duck, by November the clarity of the Mendenhall is actually greater than Duck's at this point.

Concentrations and ratios of major substances hear the mouth of Duck (station WDC2), before it enters the Mendenhall, were as follows (in micrograms/liter):

TABLE 29. Water quality in Duck Creek above mouth (WDC2), 1986-87.

	11 Aug.	**10 Sept.**	**14 Oct.**	**20 Nov.**	**3 Feb. (4)**	**26 Mar** (4)
NO3+NO2	225	110	158	3.0	285	255
NH3+NO3	259	139	252	138	641	676
TKN	—	97	242	182	612	1012
ON/IN (1)	—	0. 49	0.58	0.34	0. 40	0.92
N/P (2)		66	65	14	237	94
TP	—	2. 5	28.4	8.1	5. 1	57.7
FRP	4.4	2. 1	3.9	9.7	2. 7	7.2
TFP	5.8	2. 1	4.6	7.0	2. 7	9.1
Si	3.6	5. 2	—	8.6	—	—
Fe (3)	0.1	1. 4	—	16.8	—	—
Al	.01	.013	—	.012	—	—
Chl-a	1.05	—	—	—	—	—
Conduct.	130.5	175.1	173.2	165	163	42.1
pH	6.9	6.9	7.1	6.5	7.7	6.3

(1) organic/inorganic N
(2) (TKN+N03)/FRP)
(3) in mg/L
(4) slightly upstream at WD5

Returning to the headwaters, we consider now the west branch of Duck, originating above Taku Boulevard. Two culverts pass under the road, the eastern one (WM10) following with a very rusty color perhaps attributable indirectly to ground water discharge, and the western one (WM40) having surface runoff as its primary course. The rusty one, however, has a lower Ca-Mg ratio, as well as lower available nitrogen, reactive phosphorus, and total filterable phosphorus. Its concentrations of iron and silica are predictably higher.

Moving downstream toward Aspen Street, water clarity worsens (iron deposits are extensive) and dissolved iron increases. Total phosphorus increases (August, September, October). As Duck Creek flows

through the wetland just below Aspen Street, silica registers a curious increase (August, October, November), suggesting the possibility of some ground water influx. Dissolved iron, however, begins to disappear (all months) and water clarity improves (October). Total phosphorus decreases (August, September, October) while available nitrogen increases (September).

Continuing downstream to Just before the junction with the east branch, Duck-Creek flows intermittently through several very shallow, channelized, urban reaches. Water clarity actually improves somewhat (July, October, November) as dissolved iron diminishes. Available and total phosphorus decline (July, September, November), as does available nitrogen.

At this junction between the two branches (near Nancy Street), available nitrogen is greater in the vest branch (August, October), as is total phosphorus (September) and available phosphorus (August, October). However, total phosphorus is greater in the east branch in August and October. The west branch is clearer (July, October, November) and has less dissolved iron at this point (July).

Overall, the sampling locations on Duck most likely to be exporting organic nitrogen are (in rank order, from greatest to least): WT7 (November), WM12 (July), WM11 (July), WT7 (August), WT6 (July), WM12 (August). This suggests that wetlands D5, D7, D8, and the reach of the west branch above Nancy Street, support the greatest biological production on Duck Creek at these seasons, or experience the greatest denitrification or least ground water input.

Jordan Creek

(a) Overview

Nitrate concentrations on Jordan are relatively high and great enough to support profuse growths of algae, at least in the headwaters, but they decline or show little change moving downstream (in contrast to Duck Creek). During the growing season available nitrogen is generally less than in Duck Creek, suggesting greater biological activity (in Jordan). Higher aluminum levels in Jordan (correlated to DOC) also support this contention. Highest levels (0.5 mg/L) of nitrate occur in the headwaters (wetland J2) in July.

The N:P ratio and the ratio of organic to inorganic nitrogen are generally less than in Duck Creek. The latter tends to decrease with increasing flow. Export of organic forms to the estuary prevails in August and February. The ammonia portion of total nitrogen increases drastically in winter, becoming far more prevalent than the nitrate form. The N:P ratio at the mouth increases seasonally.

Total phosphorus concentrations are moderately low throughout, and over time seem positively correlated with flow. Highest levels (50 mg/L) are at the outlet of the Yandukin Drive-Airport ponds in August and March, and are capable of supporting a substantial growth of algae. Reactive phosphorus, relative to all dissolved phosphorus, shows a general downstream decline, but was very erratic in July. Available phosphorus is generally greater than in Duck Creek.

Turbidity is moderately low compared to other Juneau locations. The most turbid conditions are at the outlet of the Yandukin ponds in August, perhaps related to suspended algae. Even then, turbidity is less than 10 NTU.

(b) Role of Specific Areas

Headwaters consist of two major tributaries. One, which runs along Thunder Mountain trailer court, is man-made. The other originates in the ground water seepage area a few hundred feet to the east. The trailer Court ditch in July had higher levels of ammonia, total filterable phosphorus, organic nitrogen, total phosphorus, and turbidity. The "natural" tributary had higher levels of nitrate (slightly), reactive phosphorus, and iron.

In the reach between the natural headwaters and Amalga Street (Coho Park), Jordan Creek passes an area which was heavily disturbed by a dump and decomposing organic matter. In both July and February, available nitrogen, available phosphorus, and iron decreased in this reach, while the Ca-Mg ratio increased (suggesting increasing biological activity). Turbidity decreased (February). This is wetland number J3.

From Amalga Street to Jennifer Street (wetland J4), available nitrogen decreases (July, August, and October), but increases in September. Iron increases, as does the Ca-Mg ratio. From Jennifer down to Nancy Street (wetland J5), Jordan Creek passes through a series of beaver ponds. Available nitrogen continues to decline (July through October), but the ratio of organic to inorganic nitrogen also declines (July). Reactive phosphorus increases here in September, but decreases over this reach in July, August, and October. Iron increases in July and November (deposits are visible throughout) and the Ca-Mg ratio declines (November).

From Nancy Street to Egan Drive (wetland J6, mostly), reactive phosphorus continues to increase (July) but declines as Egan Drive is approached. A decrease in available nitrogen (August, September, February) logically coincides with an increase in the ratio of organic to inorganic nitrogen. The Ca-Mg ratio declines at first, but as Egan Drive is approached, it increases (July). Iron generally increases.

Between Egan Drive and the beginning of the Yandukin Drive- Airport ponds, Jordan Creek traverses a highly urbanized area and has been channelized in places. Available nitrogen and phosphorus decrease (all seasons) and the ratio of organic to inorganic nitrogen increases in summer-fall but decreases in winter. Passage through the Yandukin ponds (wetland M7) reduces the portion-of available phosphorus (September), increases the total phosphorus, and has a varying effect on available nitrogen (decrease in August, increase in September). Iron increases (November) and water clarity diminishes slightly (August). The Ca-Mg ratio increases (July, August), perhaps because of occasional marine influence or increased biological activity.

Next, the creek passes through a shrubby reach across from the fire station. Tidal influence grows stronger and some trends reverse. Water clarity improves slightly (August) and total phosphorus decreases (August). Available nitrogen also decreases (August, September, November) and perhaps consequently the portion of organic to inorganic nitrogen increases (August). Aluminum, iron and the Ca-Mg ratio decrease (August), but in September iron increases here. These trends mostly continue as Jordan Creek passes the Airport Pond (wetland M4) and turns southward.

Concentrations and ratios of major substances near the mouth of Jordan (station WA3) are as follows (in micrograms per liter):

TABLE 30. Water quality of Jordan Creek above mouth (WA3), 1986-87.

	11 Aug.	10 Sept.	14 Oct.	20 Nov.	3 Feb.	26 Mar
NO3+NO2	47	186	164	214	66	66
NH3+NO3	52	196	186	236	393	187
TKN	188	79	188	75	973	198
ON/IN (1)	3.45	0.35	0.89	0.22	2.09	0.41
N/P (2)	7	33	45	39	43.2	3.7
TP	34.7	5.8	13.9	6.3	9.8	64.0
FRP	6.7	5.8	4.2	6.0	9.1	50.5
TFP	8.3	7.5	5.3	7.1	9.8	50.0
Si	2.0	3.0	3.0	2.8	—	—
Fe (3)	.1	0.3	0.3	0.4	—	—
Al	.039	.018	.033	<.010	—	—
Chl-a	1.16	—	—	—	—	—
Conduct.	62	100	93	123	132	324
pH	6.8	7.4	7.2	7.4	7.3	6.8

(1) organic/inorganic N
(2) (TKN+N03)/FRP)
(3) in mg/L

Overall, the sampling locations on Jordan likely to be exporting organic nitrogen are (in rank order, from most to least): WA3, WA1, and WA4, all in August. These correspond with wetland numbers MS, M4, and M7 — essentially, the Airport ponds.

3.4.4 Salmonid Habitat

JORDAN CREEK

Anadromous Stream Catalog Number: 111-50-10620

Fish Habitat:

Jordan Creek flows through the eastern edge of the Mendenhall Valley. It drains an area of about 1,700 acres, is about 4 miles in length and enters Gastineau Channel through a culvert under the Juneau Municipal Airport runway. The stream's head waters are spring fed. Jordan Creek ranges from 5 to 20 feet in width, 4 inches to 8 feet in depth, and has a low gradient and mild meanders throughout its length.

Detailed habitat surveys and fish population estimates were completed for the entire stream as part of the present study. The amount of pools (deep slow) per reach was greater than for any other study area stream.

The entire Jordan Creek system consists of riffles and pools; spawning and rearing habitat is found throughout the system. Palustrine wetlands are most prevalent in the upper reaches. Most of the stream is bounded by overhanging vegetation. An active beaver colony that contains three dams and ponds is located approximately 1 mile upstream from Egan Drive.

Upstream from Egan Drive, Jordan Creek presently forms the eastern boundary of urban development, with the exception of the Coho Park housing project which is located on the east side of the stream. Near Nancy Street, the creek served as the boundary of a large timber clear cut which was harvested on the east side of the creek in the late 1960's. Slash and logging debris still remain in the stream in the section.

A gravel pit was excavated on the westernmost headwater tributary just downstream from Thunder Mountain Trailer Court in the 1960's. The abandoned pit has been used as a dump site for all types of refuse, including private household garbage. Water draining from the pit was determined by ADEC to be very high in iron sediment and low in dissolved oxygen. Other chemical properties of the drainage are suspected to have had detrimental effects on the production of upper Jordan Creek. Presently, drainage from the pit is being diverted to Duck Creek and the pit is being filled in with soil, woody debris, and a variety of other materials. A former channel adjacent to the pit has recently been filled.

Jordan Creek has been subjected to at least two unauthorized road crossings upstream from Egan Drive. The only authorized crossing currently existing above the Egan Drive is at Amalga Street. Downstream from Egan Drive, Jordan Creek has been subjected to many activities. There are at least six road crossings. Over 200 feet of fish habitat was replaced by a culvert in 1984 during reconstruction of old Glacier Highway. The culvert under the Juneau Municipal Airport is approximately 300 feet long. Bridges accessing the Jordan Creek Mall area were required to span the entire floodplain. From Egan Drive downstream to below old Glacier Highway, a 1,000-yard long section of the creek was channelized to provide for development of streamside property. Vegetation has grown back along the "channelized" section of lower Jordan Creek within the Jordan property. Culverts (e.g., adjacent to the Mendenhall fire station) are reportedly set too high in elevation (relative to the streambed) and caused sedimentation to fill in some of the pools. East of Dudley Street, construction of a water line and water tank has occurred.

Fish Species Present:

Jordan Creek has wild stocks of coho, chum, and pink salmon, and Dolly Varden char. Cutthroat trout were previously reported, but none were found during this study. The stream was stocked with 3,000 Eastern Brook trout (char) in 1953 and 4,800 coho in 1970. The fishery values of Jordan Creek have been documented many times in the past. Recent juvenile fish trap data and spawning escapement data are available from ADFG. Overwintering population estimates are shown in Table 13, Populations seem comparable to or higher than most other small streams in Southeast Alaska. The area near Amalga Street had exceptional numbers of juveniles, many of very good size.

DUCK CREEK

Anadromous Stream Catalog Number: 111-50-10500=2002

Habitat:

Duck Creek flows approximately 3 1/2 miles in a southerly direction through the middle of Mendenhall Valley and enters the Mendenhall River directly upstream from the Juneau municipal airport runway. The stream measures from 5 to 15 feet in width and from 6 inches to 2 feet in depth (the ponds being much deeper). The stream bed is essentially gravel and has been subjected to extensive gravel removal since historical times. Iron deposits often impart an orange color to the water.

Detailed habitat surveys and winter population estimates were completed for this study. Duck Creek has the most aquatic vegetation and the deepest soft sediment deposits per reach, as well as the least overhanging vegetation, shade, and undercut banks per reach of any study area stream.

Duck Creek has been subjected to more physical land use impacts than any other stream in the Juneau area. Natural pools in the upper reaches have filled in with sediment from polluted streamside drainage. Other larger ponds which were once gravel pits provide marginal rearing habitat. Some of these ponds have overhanging cover along shorelines. Emergent vegetation has encroached on mainstem channels. Several riffle areas located throughout the stream provide spawning habitat. In 1984, lower Duck Creek from Berners Avenue to Glacier Highway was channelized. This section of the creek often went dry during low flows, but newly created refuge pools should reduce loss of fish if the stability of pools can be maintained. CBJ water and sewer lines have crossed the creek in various places.

Fish Species Present:

Duck Creek has limited wild populations of pink, chum, and coho salmon, and Dolly Varden char. Historically, Duck Creek is reported to have had runs of up to 10,000 chum salmon and, as late as 1966, the coho escapement was estimated to be 500 fish. In recent years, the water has been too discolored from iron sediment to count spawners. Salmon escapement and rearing data is available from ADFG. The 1986 winter population survey found virtually no juvenile salmonids at any point on the stream. However, moderate numbers of Juvenile coho had been present a year earlier in wetland D8 (ADFG-NMFS-USFWS data).

FLOAT PLANE WETLANDS (Wetland # Ml, MIA, M1B, MIC)

Anadromous Stream Catalog Number: None

Habitat:

Float Plane Lake (Wetland # Ml) was the original source of material for construction of the Juneau Municipal Airport's runway. The lake is approximately 4,900 feet long, 400 feet wide, and averages 4 to 5 feet deep, with a 30-foot deep pocket in the south end. The water level of the lake is controlled by a culvert to the lower Mendenhall River. The culvert has flap gates which allow saltwater to enter the lake on high tides. The brackish waters, along with the wetlands adjoining the lake and good cover, provide a rich rearing environment for limited numbers of rearing salmonids. It is doubtful that the lake would support dense populations of rearing fish because of the unstable water levels, lack of overwintering areas, and potential for chronic oil pollution. Pink and chum salmon fry are commonly found in the lake during the spring fry outmigration. There are no known spawning areas.

Fish Species Present:

Float Plane Lake has contained populations of coho, pink, and chum salmon, cutthroat trout, Dolly Varden char, and various species important to food chains (e.g., flounder, stickleback, shrimp). However, limited trapping in late summer 1986 yielded no fish. The lake was reported to have been stocked with rainbow trout at one time, however, no documentation is available. In 1972, when the lake was drained for construction, fish from 4 to 10 inches were found in the lake. In 1984, 238,000 coho fry from Salmon Creek Hatchery were released in the lake when the hatchery ceased its operations.

SMITH-HONSINGER POND (Wetland # M2, M3)

Habitat:

The Smith-Honsinger pond is approximately 450 feet wide and 2500 feet long. It appears to have sufficient depth to preclude freeze-out mortality to fish. Several small tributaries originating on the southwesterly end of Thunder Mountain, with drainage area in the magnitude of 0.5 square miles flow into the vicinity of the pond. A tidal flapgate allows saltwater to enter.

The pond is presently privately owned.

Fish Species Present:

Limited trapping in late summer 1986 yielded no fish. Electroshocking in February 1987 was similarly unsuccessful, except for discovery of a single flounder. Fluctuating salinity and water levels, scarcity of cover, and partially restricted fish access all limit its present habitat value.

3.4.5 Wildlife

Tidal Wetlands (Airport Area)

Wetlands near the Airport support good numbers of waterbirds. The float plane pond itself (wetland Ml) supports the largest numbers (in the study area) of Scaup and Bufflehead in spring, Common Merganser in winter, and Arctic Tern (unusual in southeast Alaska) in late summer. More than 25 other water-dependent species occur here. The small excavated ponds within and along the Airport dike support the

largest numbers of shorebirds in early fall .and Greater Yellowlegs in particular in early summer. Regionally uncommon Killdeer and Arctic Tern feed in these ponds, as well as Canada Goose, Mallard, Teal, and other waterbirds. In 1987 an unprecedented flock of Black- crowned Night Herons used this area. The adjoining wetland shrubs and grasses, despite their relative isolation from upland habitat, support summering chestnut-backed Chickadee, Varied Thrush, Junco, Ruby-crowned Kinglet, Yellow Warbler, Rufous Hummingbird, Red-winged Blackbird, Song Sparrow, and other passerines.

The pond connected to Jordan Creek at the east end of the runway (M4) supports the largest (study area) concentrations of Scaup and Bufflehead in late winter-spring; Green-winged Teal and Mallard in late summer-early fall; and American Wigeon and Trumpeter Swan in early fall. The adjoining channel and banks of Jordan Creek, before it passes under the runway, receives occasional use by at least 22 species, the more noteworthy being Short-eared Owl, Kestrel, Bald Eagle, Song Sparrow, Canada Goose, and Mallard.

Neither Wetland ES11 (the Airport "crash-burn11 site) nor the high marsh surrounding Temsco helicopters represent the single moat important concentration area for any species at any season, but they are frequented by a good variety of species, the more noteworthy being Killdeer, Arctic Tern, Song Sparrow, Canada Goose, Red-winged Blackbird, Northern Harrier, Bald Eagle, Kestrel, and Violet-green Swallow.

Nearby, the Smith-Honsinger pond (M2) has the highest study area concentrations of Mallard and Trumpeter Swan in late summer; Scaup, Tundra Swan, Trumpeter Swan, and Pintail in spring; spring; Scaup in late winter; and immature Bald Eagle in late fall. Also notable are Arctic Tern, Canada Goose, Canvasback, and Whimbrel. Between the pond and Sunny Point, tidal wetland ES14 provides excellent habitat for several species. The largest study area concentrations of Mallard in winter, early summer, and late fall occur here. American Wigeon and Trumpeter Swan are also strongly dependent, and Canada Geese are exceptionally regular users of the small tidal ponds, as are shorebirds. The locally-restricted Red-winged Blackbird nests here in summer.

Returning to the Airport dike, the tidal wetlands adjoining to the south support numerous species easily visible to recreationists. The westernmost area here (ES2) near the Mendenhall River, has the highest study area concentrations in early summer of total waterbirds, as well as the highest concentrations of Canada Goose (spring-early summer, late fall-winter), Mallard (spring and winter), shorebirds (spring, late summer), Arctic tern and Bald Eagle (spring), and several others. Peregrine Falcons have also been sighted here.

The tidal wetlands abutting the eastern end of the Airport dike do not have exceptional concentrations of any species, but are regularly used by Canada Goose, Mallard, Arctic Tern, shorebirds and other species.

Continuing eastward, the tidal wetlands (ES7) abutting the south side of the runway's east end are a major concentration area for Canada Goose and Mallard, as well as being regularly used (most notably) by Short-eared Owl, Red-winged Blackbird, Bald Eagle, Arctic Tern, shorebirds, and other species.

Jordan-Duck Nontidal Wetlands

The forested wetland along Jordan Creek near the Thunder Mountain Trailer Court (J2) is mostly frequented in summer by Wilson's Warbler and Varied Thrush. Moving downstream, wetland J3 near Coho Park is mostly frequented by Townsend's Warbler and Varied Thrush. Noteworthy is the occasional presence of Killdeer, a regionally restricted species.

Species most frequently encountered in wetland J4 are Varied Thrush and Robin. Species here that are noteworthy because of their regional scarcity or localized distribution include Red- breasted Sapsucker, Hairy Woodpecker, and Northern Yellowthroat. In the wetland above Nancy Street (J5), Varied Thrush shares dominance with Wilson's and Townsend's Warblers. Noteworthy summering species are Mallard, Hairy Woodpecker, and Northern Yellowthroat. Continuing downstream to Egan Drive, wetland J6 primarily supports Varied Thrush and Townsend's Warbler; of exceptional interest is the reported presence of McGillvrey's Warbler nesting near the base of avalanche paths (R. Gordon, pers. comm.); this species is very rare in the study area.

South of Egan Drive and north of Yandukin, wetland M7 supports breeding Yellow Warbler, Savannah Sparrow, and Lincoln's Sparrow. River Otter have been reported from this area. Wetland M9, which has been physically isolated from Jordan Creek and subjected to some filling, has breeding Snipe, Lincoln's Sparrow, and Pine Siskin. Wetlands just east of Fred Meyers complex (M26 and M27) have locally uncommon Red-winged Blackbirds, and are basically dominated by Lincoln's and Savannah Sparrows.

On Duck Creek, the bird inventory was limited to areas between Egan and Berners Avenue (wetlands M19, M20, M21). Prevalent species were Ruby-crowned Kinglet, Pine Siskin, Robin, Orange-crowned Warbler, Steller's Jay, and Hermit Thrush.

Black bear, deer, mountain goats, beaver, and other mammals are found throughout the Jordan Creek and upper Duck Creek system.

3.4.6 Recreational Use

DUCK / JORDAN CREEKS

A major perceived function of these wetlands (based on the public survey) is as a buffer zone for avalanche hazard. Perceived hydrologic functions include: flood storage, clear drainage of the east Mendenhall Valley to the ocean, sediment trapping and ground water recharge. Perceived biological functions included fish spawning - this is known Coho salmon habitat, waterfowl habitat, productive headwaters for downstream game refuge, and certain unique plant species can be found in wooded sloughs.

Recreation experiences include hiking and horseback riding. Situational recreational uses include general play activities for children. Educational uses include nature interpretation for schools and public groups due to close proximity of urban wildlife and fish. Amenity/aesthetic values include vlsual quality, greenbelt potential, close access to creeks from homes. Problems with such uses and values include litter, vlsual eyesores, log jammed and polluted streams, little public access, and the general loss of open space. Harvest values include berry picking.

Jordan Creek (above the airport runway) has been closed to salmon fishing since 1962 and to all fishing since 1983. It was once a favorite location for cutthroat trout angling. The mouth of Jordan Creek, downstream from the runway, still receives moderate angling pressure from anglers targeting on coho salmon. The shores of upper Jordan Creek receive considerable use by neighborhood children.

Perceived consumptive non-renewable uses for Duck/Jordan Creeks include development for residential and/or commercial usage, for drainage containment or for a greenbelt to break up urban construction (but purchased by the government). Concern is expressed over flood prone housing close to the streams, encroachment of development and fill, and need for lateral drainage channels to alleviate severe erosion and localized flooding.

AIRPORT TIDAL WETLANDS

This includes the Float Plane pond as well as other ponds and estuarine wetlands near the airport. Perceived biological values include habitat for waterfowl and migrating birds (feeding and nesting) such as Canada geese, and a nursery area for juvenile marine fish, freshwater fish and crustaceans. Perceived hydrological functions include ground water supply, flood storage, and erosion control. Negative aspects associated with wetlands generally in this area include progressive habitat degradation and closing off of channels.

Recreational experiences include walking, jogging, bird watching, and kayaking. Educational uses include bird watching, nature walks, educational events during Sea Week and Christmas bird counts. Aesthetic functions include general scenic and open space accessible to the community. Harvest uses include hunting, fishing and spruce root gathering. Negative aspects include airport trash, difficulty of access to the open space due to airport security and safety requirements, and attendant noise from float planes and other aircraft.

The Float Plane Lake is reported to have historically provided a good sport fishery after it was stocked, Presently, the lake receives high use by private and commercial float equipped aircraft and the FAA discourages any "non-aircraft" activity in the area (for safety reasons). A public access corridor to the Mendenhall Wetlands State Game Refuge extends south of the airport from Radcliff Street and along a dike at the west end of Float Plane Lake. This area receives a high level of use by hikers, Joggers, bird watchers, and waterfowl hunters.

Consumptive uses include commercial and industrial land development, and airport development of runways which many feel is a top priority to the Juneau area. Some would like to see the marsh added to the airport land base, using the Justification that the estuary is already disrupted by Egan Drive. Others maintain the Borough should purchase the remaining area for parks and open space.

3.5 Montana Creek

3.5.1 Ground Water

The wetlands in this subarea are predominantly fens (reed-sedge wetlands), and have the most complicated recharge-discharge function. In the northern part of the region, the wetlands are probably discharge areas for local groundwater flow systems associated with the moraines that cross the valley. In at least the upper third of the fen between Mendenhall River and Montana Creek, the wetland is a recharge zone for local flow systems within the fen. Near the streams, the wetland discharges relatively small volumes of ground water. These functions may change seasonally with the rise and fall of the water table.

Muskeg wetlands on the slope above the creek are recharge zones coupled with lateral flow. Near "pipes" (underground channels) in the peat and near Montana Valley proper, there is a small discharge function at depth.

3.5.2 Surface Hydrologic Control

In this subarea, only the lower Montana fen (wetland #ML1) had sufficient topographic information to apply the HEC-1 model. We examined what effect this 268-acre wetland would have on runoff from the largest characteristic storm (or glacier-melt) occurring each month of the year, and for the maximum probable storm.

The Montana fen was found to reduce peak flows at its outlet during all months. The reduction ranged from 2 cfs (4%) in December to 187 cfs (43%) in July, when outlet peaks were 54 and 430 cfs, respectively, for average maximum storms during these months. During the critical fish spawning months of August-October, the runoff-buffering effect of the fen lowered the outlet peak by about 25% (normal peaks at this time are usually about 300 cfs).

Peak flow at the outlet occurs 10 hours after the storm peak in January) and 24 hours (in May) after the storm peak. In the flow recession period between 6 and 24 hours after a storm, there occurs an average flow drop of 18% (in May) to 55% (in November), i.e., the stream returns to ambient conditions more rapidly in November than in May. Maximum storage of runoff in the fen varies from about 5 acre-feet during winter months to 131 acre-feet in September, with 470 acre-feet theoretically being stored during the maximum storm of record. Thus, the greatest amount of runoff will be detained and thus exposed to biological activity in the fen during September, but the longest time of detention occurs in May.

3.5.3 Water Quality

(a) Overview

Available nitrogen is relatively low (Fall 1986) but generally greater than in the Mendenhall River, Lemon Creek, and Douglas Island streams. Maximum concentrations occur in November just downslope from the shooting range, and also near the mouth in February. Concentrations of both nitrate and ammonia are lowest, as expected, during the growing season. Maximum summer levels (130 ug/L) are

insufficient to sustain growths of algae at nuisance levels. At the 4 water quality stations directly on the stream, organic forms of nitrogen exceed inorganic forms only at the mouth and just below the shooting range (and only in October). The organic/inorganic N ratio is intermediate among Juneau streams, and la generally greater than in the Mendenhall River, as is the N:P ratio. Storm conditions (October) seemed to cause increased transport of organic N and available P, but decreased available nitrogen. Total phosphorus levels are moderately low and show little change downstream. Available phosphorus is lowest in summer, and generally intermediate among Juneau streams. It subsidizes the Mendenhall until October, Turbidity is low throughout, with a maximum on sampling dates of only 10 NTU. Two of the ponds along the Loop Road (WT26 and WT27) show signs of salt contamination (28 mg/L sodium).

(b) Role of Specific Areas

As Montana Creek passes from the Montana Creek Road bridge (WT21) downstream to just below the shooting range (WT20), it receives drainage from wetlands UM9, UM10, and UM11. Available phosphorus decreases here (July), but other constituents change little. As the creek passes through wetland UM1 (behind the golf driving range) (WT19), available phosphorus and available nitrogen both increase (July, Feb.). In November and February, however, available nitrogen declines. Iron increases in this reach (February), while total phosphorus (October) and the Ca-Mg ratio drop, suggesting intensified biological activity.

As the creek continues flowing through UM1 toward the Loop Road bridge, the increasing trend of available phosphorus and nitrogen reverses, and these nutrient forms diminish (July). The Ca- Mg ratio and iron also increase.

Between the Loop Road and the junction with the Mendenhall River, available nitrogen and phosphorus show a consistent increase as the Ca-Mg ratio drops (July, August, September, November).

The stream passes through wetland ML1 (the “Montana fen”, a ground water discharge wetland) which was sampled at two locations where standing water was present. Compared to the stream, these wetland ponds have less available nitrogen and a smaller portion of their phosphorus as available phosphorus, but they have higher absolute levels of available phosphorus (July) and iron. If these ponds are typical of wetland ML1, the wetland may enrich the stream with phosphorus (July, August, Sept., Oct.), and the stream, in turn, may enrich the wetland with available nitrogen when it floods.

Organic nitrogen predominates, whereas in the stream, inorganic nitrogen is prevalent (July, August, September). Chlorophyll-a (an indicator of primary production) is higher in the WT24 pond than anywhere else in the study area (8 ug/L in September), and is accompanied by low nutrient levels and an exceptionally high organic-to-inorganic N ratio.

Just before Montana enters the Mendenhall River (station WT17), its concentrations and ratios of major substances are as follows (in micrograms per liter):

TABLE 31. Water quality of Montana Creek above mouth (WT17), 1986-87.

	16 Jul	9 Aug	12 Sept	15 Oct	19 Nov *	5 Feb **
NO3+NO2	25.4	62.0	67.4	28.6	113.0	136.9
NH3+NO3	33.2	79.8	85.1	34.3	143.5	155.8
TKN	30.6	52.9	45.5	114.1	—	13.3
ON/IN (1)	0.69	0.44	0.33	3.16	—	0.42
N/P (2)	16.6	17.7	13.3	6.5	27.5	33.1
TP	14.3	17.4	7.7	26.1	—	4.9
FRP	2.0	4.5	6.4	5.3	5.2	4.7
TFP	2.3	4.3	7.8	5.7	4.3	3.3
Si	1.1	1.6	1.8	1.4	—	—
Fe (3) (4)	0	0.11	0.22	0.15	—	—
Al	0	0	0	0.11	—	—
Q (cfa)	88	158	64	—	—	—
Chl-a	0.06*	—	—	—	—	—
Conduct.	50.1	48.5	59.6	31.5	—	64.4
pH (5)	6.9	6.9	6.8	6.5	—	—

* actually, from WT18 (Loop Road bridge)
** actually, from WT19 (driving range area)
(1) organic/inorganic N ration
(2) (TKN+N03)/FRP)
(3) in mg/L
(4) in 1985, ranged from 0.02 to 0.11 at WT18 (W. Joiner, pers. comm..)
(5) in 1985, ranged from 7.0 to 7.8 at WT18 (W. Joiner, pers. comm..)

3.5.4 Salmonid Habitat

MONTANA CREEK

Anadromous Stream Catalog Number: 111-50-10500-2003

Habitat:

Montana Creek is the largest tributary to the Mendenhall River. It originates in a high mountain meadow and flows for approximately 8 miles before entering the Mendenhall River approximately 1 mile upstream

from Glacier Highway. The watershed drains an area of approximately 15 square miles. The gradient of the stream varies from steep in the upper drainage to low in the lower section. Within 2000 feet of the mouth the gradient is 0.0009, then increases to 0.0035 until reaching the Loop Road bridge, and increases still further beyond that point. The water color is clear with a brownish tint.

McGinnis Creek is the main tributary of Montana Creek and actually provides more water to the Montana Creek system than the headwaters of Montana Creek.

Detailed surveys were conducted from the mouth to the Montana Creek Bridge, and wintering population estimates were made at three locations within this reach (Table 13).

A gravel road runs adjacent to Montana Creek for approximately 2 miles. Sedimentation from the road currently poses a threat to Montana Creek fish habitat. Also, vehicles occasionally ford the stream (illegally).

The Montana Creek drainage provides a wide variety of fish habitat. In the upper reaches, the flow is fast and there are pools with overhead and instream woody cover. In the middle section, the gradient is lower and pools are larger. In the lower section, the gradient is low and the stream provides summer rearing conditions for coho salmon and cutthroat trout. The habitat survey showed Montana reaches having the most cobble-gravel, wood debris, maximum depth and velocity, and the least shade, of the study area reaches.

Fish Species Present:

Montana Creek has runs of coho, pink, chum, and sockeye salmon, cutthroat and rainbow/steelhead trout, and Dolly Varden. Chinook salmon adults straying from the Mendenhall Ponds salmon rearing facility spawned in Montana Creek from 1976 through 1978. However, Chinook (king) salmon have not been observed in Montana Creek since 1981. Montana Creek fish stocks have been documented through juvenile fish trap surveys and salmon escapement counts, available from ADFG.

Chum, coho, Dolly Varden, and cutthroat trout spawn in the middle and upper reaches, with the heaviest spawning occurring in the upper mainstem of Montana, Little McGinnis, and McGinnis Creeks. Numerous small inlets in the wetlands adjacent to the lower mainstem provide seasonal rearing habitat. Winter population estimates suggest low overwintering near the mouth and moderate overwintering densities in beaver sloughs (Table 133).

3.5.5 Wildlife

Wetland UM9, near the shooting range, features Red-breasted Sapsucker, Greater Yellowlegs, and a Townsend's Solitare of uncertain breeding status. Varied Thrush, Robin, and Rufous Hummingbird were the most frequently encountered species. Just across the Montana Creek Road (and formerly connected) are wetlands UM10 and UM11. Junco, Varied Thrush, and Robin predominate in these wetlands and Bald Eagles frequently visit.

Further downstream on Montana, the expansive wetland complex (UM1) behind the driving range features Great Blue Heron, Dipper, Greater Yellowlegs, Northern Waterthrush, Spotted Sandpiper, Red-breasted Sapsucker, Red-throated Loon, Bald eagle, Goshawk, Rufous Hummingbird, Northern Yellowthroat, Red- winged Blackbird, Song Sparrow, Yellow Warbler, Western Wood Peewee, to name Just a few of the more locally restricted species. Very likely, UM1 (on a per-unit-area basis) contributes the most to regional diversity of breeding birds.

The lower Montana wetland (ML1) is also quite diverse for its size, featuring Northern Waterthrush, Red-breasted Nuthatch, Red-throated Loon, Red-winged Blackbird, Northern Yellowthroat, Song Sparrow, and Western Wood Peewee— all rather uncommon elsewhere in the study area. Alder Flycatcher and Orange- crowned Warbler were encountered most frequently.

The Montana Creek subarea is probably the richest part of the study area for mammals. Deer, black and brown bears, mountain goat, river otter, beaver, and many other species occur here.

3.5.6 Recreational Use

Positive ecological values perceived by the workshop participants included hydrologic functions such as: drainage for adjacent lands and the watershed, flood storage, water supply, and water quality improvement through sediment trapping. Perceived biological values include: wet meadow wildflowers, diversity of plant communities, a unique spruce bog, fisheries spawning, waterfowl, bird and animal habitat. Negative hydrologic/ecological features include: bank erosion from placer mining, a poor coho salmon run, flooding danger to developed areas and rock erosion control along the east side of the Mendenhall River.

Recreational experiences along the Montana Creek/Mendenhall River include: rafting, skiing, boating, horseback riding, hiking and kayaking. Other recreational uses/functions include: camping, rafting, rifle range, golf activities. Educational uses include: bird watching, wildlife viewing, nature walks and field education. Aesthetic uses include: scenic enjoyment, photography and general open space uses. Problems noted with all recreational facilities are: the existence of garbage and trash dumps, lack of land stewardship, degradation of habitats and aesthetic values, shooting from the road and indiscriminate use of firearms, and little public access to the lower Mendenhall River and the need of a trail system. The CBJ intends to acquire land for a greenbelt which will include hiking trails along the Montana-Mendenhall corridor.

Harvest uses of the Montana Creek/Mendenhall River wetland areas include: subsistence and recreational fishing, hunting, firewood gathering, berry picking and gold panning.

Consumptive land uses advocated include property development for residential use, reclaiming land through channelization. Negative values associated with development include: gravel removal on the east bank of the Mendenhall River, residential encroachment and building in the flood plain, development along the Mendenhall River and loss of green belt/open space and river pollution. It is also perceived by some that a negative value is inhibition of land development.

3.6 Lemon - Switzer - Vanderbilt

3.6.1 Ground Water

The forested wetlands in the headwater reaches of these streams are predominantly groundwater discharge zones where they are located next to the stream channels. The hydraulic head which drives the discharge function probably originates at higher levels in groundwater flow systems in the alluvial deposits mantling the lower mountain slopes.

3.6.2 Water Quality

Lemon Creek

Lemon Creek, like the Mendenhall, receives substantial amounts of glacial meltwater runoff. As it enters the estuary, avail- able nitrogen increases (August), as does the very low ratio of organic-to-inorganic nitrogen (September, October). In comparison to other study area streams, levels of available nitrogen are moderate-low, and reactive phosphorus is very low. Available phosphorus increases at the estuarine interface in September, but declines here in November. Both iron and aluminum increase (September, November). In August, water clarity is actually poorer in the estuary than in the creek near its mouth. Water quality data (26 observations) are available from USGS sporadically for the period 1948-1972.

Two small creeks enter the estuary east of Sunny Point. The westernmost of these has a higher Ca-Mg ratio, more aluminum, and more iron. The eastern one, which drains from an area near Switzer Village, has moderately low available nitrogen levels (September, November) and moderately high available phosphorus levels (October, November).

Switzer Creek

The eastern, forested branch of Switzer Creek travels a considerable distance along the edge of an urbanized area before reaching the open emergent wetland along Glacier Highway (WS3). Moving downstream from its headwaters (WS5), water clarity worsens slightly (November), iron and aluminum decline, and available nitrogen increases. Continuing toward the highway, this branch merges with the north branch, which has the lowest nutrient levels of the tributaries in July, but the highest in February (nitrate). Available nitrogen organic/inorganic ratio, iron, and total phosphorus increase while water clarity improves (July) as both branches near the highway. Two branches from the west, near Switzer Village, also join in (WS1 and WS2). In contrast to the north branch, their Ca-Mg ratio is smaller relative to the station near the highway, and total phosphorus decreases. Levels of available nitrogen and phosphorus are low despite the proximity to sewered residences, but upon joining the other tributaries and nearing the highway, nutrients are sufficient to support substantial growths of algae. Organic nitrogen-exporting conditions were documented in the eastern tributary in September and October, as well as in the western tributary (WS2) in July.

Vanderbilt Creek

Vanderbilt Creek has the highest concentrations of available nitrogen of the study area streams (exceeded only by Duck Creek in August). The ratio of organic to inorganic forms of N is consequently low relative to other streams. Available phosphorus is also the highest of the study streams (July through October).

As Vanderbilt Creek flows through the center of wetlands L12 and L14, nitrate and iron increase, while total phosphorus and the organic-inorganic iron ratio decrease (stations V3 and V4, July). In contrast, a parallel branch (stations V6 and V2) consisting of a ditch along Glacier Highway shows a slight downstream loss of nitrate and increasing organic-to-inorganic ratio. A third branch (VV1) is fed from the slopes of the adjoining mountain. Nutrient concentrations are relatively high where the three branches join.

Available nitrogen is greatest above the wetlands, where gravel mining has considerably altered the landscape. When the IRE; branches join, the ditched branch has the highest nitrate concentrations (July).

3.6.3 Salmonid Habitat

LEMON CREEK

Anadromous Stream Catalog Number: 111-40-10100

Habitat:

Lemon Creek drains an area of approximately 25 square miles and runs for about 6 miles in a southerly direction before draining into Gastineau Channel. In the lower sections, Lemon Creek has a gradient of 0.006, is 30 to 50 feet wide, and is 1 to 3 feet deep during low flows. The stream is fed by several large glaciers; they cover nearly 30% of the watershed.

Habitat:

No habitat surveys were conducted during this study. Rearing habitat in the study area seems generally poor due to lack of undercut banks, little overhead cover, seasonally high turbidity, fluctuating water levels, and scarcity of rearing pools. Better rearing areas may be present on tributaries upstream, outside the study area. No barriers are present on Lemon Creek. Lemon Creek has been used as a source of gravel since historic times. Gravel is removed occasionally from Lemon Creek upstream from Glacier Highway. When removal occurs in the fall, it potentially limits spawning. This section of the streambed is approximately 15 feet lower than it was historically.

A commercial sanitary landfill is located adjacent to lower Lemon Creek. The refuse is surrounded by a large berm, but it is not known if this barrier is effective, especially during spring tide storms, in preventing pollutants from leaking into Lemon Creek. Within this berm are several artificial ponds/ash pits which are mapped as wetlands (L 5, 7, 7AV 20, 22, 23). However, they are either inaccessible to fish or cannot sustain anadromous fish populations due to tide-gated culverts and severe chemical and thermal conditions.

Fish Species Present:

Lemon Creek has Dolly Varden and coho, chum, and pink salmon. Salmon spawning escapement data are available from ADFG.

Chum and coho salmon have been observed spawning in Lemon Creek's mainstem during August. Brief checks for overwintering fish at the Glacier Highway bridge and in the ditch east of the landfill berm (L 18) indicated none to be present in winter, 1 DC although at the latter locality Juvenile coho, starry flounder, and cottids have been reported by ADF6 personnel.

SWITZER CREEK

Anadromous Stream Catalog Number: 111-40-10070

Habitat:

Switzer Creek is a relatively small stream which flows approximately 1 mile before entering Gastineau Channel east of Sunny Point. The stream ranges from 2 feet in width in the upper reaches to 15 feet in the intertidal area. The depth ranges to 2 1/2 feet deep. Switzer Creek has a moderate to low gradient and the water is usually clear. The stream is spring-fed at least in part and has one major pool approximately 50 feet wide by 100 feet long. The streambed substrate is primarily gravel, with some pools having sediment deposits. The intertidal section of the stream (ES 42) is at least 1/2 mile in length. Detailed habitat surveys and winter fish population estimates were undertaken for this study. The Creek had one of the highest amounts of overhanging vegetation per reach, and also had large (for Juneau) amounts of woody debris.

Switzer Creek has at least four tributaries which enter upstream from Old Glacier Highway. Two of Switzer Creek's tributaries enter the mainstem in the meadows directly upstream from the Highway and the other two tributaries enter the mainstem further upstream in the forested area. Host of Switzer's productive fishery areas are included in wetland L 16.

Most of Switzer Creek drainage has overhead, streamside, and instream cover and provides rearing habitat. The spring-fed water flowing into Switzer Creek adds significantly to its fish habitat values. The stream flows all winter, while other non- spring-fed systems sometimes freeze dry or experience extremely low flows.

A large 1960's clearcut in the headwater of Switzer Creek is believed to have been a major source of sediment which has been deposited in the downstream pools and the low gradient reaches of the stream. In 1970, Spring Pond was reported to be over 8 feet deep, however, at present, the pool is less than one half that depth.

There has been some bank erosion in more frequently visited areas. Several surface water drainage systems from adjacent residences drain into the stream. A faulty fuel oil tank in an adjacent housing development was responsible for an oil slick on the lower part of Switzer Creek in the early 1980's. A pile of corroded automobile batteries adjoins the easternmost tributary. The tidal portion between Egan and Old Glacier Highway has been channelized. A large wetland complex was destroyed by construction of the trailer park.

Fish Species Present:

Switzer Creek has populations of coho pink, and chum salmon, Dolly Varden, and cutthroat trout. The long intertidal area has populations of numerous marine species. Coho salmon spawn throughout the tributaries and mainstem upstream from Old Glacier Highway. Pink and chum salmon spawn throughout the intertidal area upstream to the Spring Pond (off Lund Street).

As many as 1,000 Dolly Varden, of which an estimated 10% were spawners, have been counted in Switzer Creek at one time during salmon escapement surveys (ADFG data).

Overwintering coho and Dolly Varden Juveniles were numerous in the upper tidal meadow tributaries in February 1987, but were rare or absent above the forested pond. Population estimates are given in Table 13.

In April 1982 some 320 coho smolt were tagged in Switzer Creek, and in 1983, 6 tagged fish were recovered in the fisheries and 2 were recovered in the escapement. During the trapping period, a mark: recapture population estimate indicated that a total population of 1,697 coho smolt (at the 95% confidence level) were in the stream. Undoubtedly, some smolt has already outmigrated from the stream. Of the coho smolt tagged, 51% were 1-year olds and 106.4 am fork length. Two year-old coho smolt comprised 49% of the population and average 120.9 mm fork length.

Based on the estimated marked/unmarked ratio of smolt leaving the system and commercial port sampling factors, Switzer Creek probably contributed 69 coho salmon to the various fisheries in 1983. Sixty-six fish would amount to a 45% harvest rate for Switzer Creek coho. This is similar to the harvest rates calculated for Auke Creek, where much more data on tagged fish are available. Switzer Creek has not been stocked.

VANDERBILT CREEK

Anadromous Stream Catalog Number: 111-40-10125

Habitat:

Vanderbilt Creek drains the eastern side of the Lemon Creek Valley and western slope of Blackerby Ridge. The stream flows for approximately 1 mile and enters saltwater in the Mendenhall State Game Refuge near the intersection of Egan Drive and Vanderbilt Hill Road. Vanderbilt Creek has three tributaries; one draining a small pond system. The upper reaches of the tributaries have a steep gradient, however, the gradient of the mainstem is quite low. The stream has an intertidal section of approximately 1/2 mile. The mainstem of Vanderbilt Creek ranges from 4 to 8 feet in width and depths are from 6 inches to 4 feet. Detailed habitat surveys and overwintering population estimates were conducted in the fall-winter 1986. Vanderbilt had the most undercut bank area per reach, and tied Switzer Creek for most overhanging vegetation per reach.

Vanderbilt Creek originally provided an excellent combination of pools and riffles with good streamside and instream cover. Some of the spawning habitat and rearing pools may have been impacted by large quantities of sediment washed into the stream from a large gravel pit in the stream's headwaters. Streamside and instream woody cover is excellent. There are no barriers on Vanderbilt Creek.

The fish habitat values of Vanderbilt Creek potentially may be degraded through increased turbidity and the deposition of sediment from a large gravel pit in the stream's headwaters. Drainage from the pit originally drained directly into the mainstem, however, the polluted drainage was subsequently directed into a ditch alongside Jenkins Street and usually by passes the most productive section of the stream, entering Vanderbilt Creek directly below Lemon Road. The intertidal spawning area still receives much sediment and possibly leachates from the garbage dump. A section of the stream downstream from Glacier Highway was re-established in the 1970's after being impacted by a streamside commercial development.

Fish Species Present:

Vanderbilt continues to provide outstanding rearing habitat. Winter surveys in one of its lower channels yielded the highest population densities of any study area stream (Table 13) and perhaps one of the highest densities for a stream of each snail size for all of Southeast Alaska. Large, older-year-class individuals comprised a majority of the fish sampled. While other streams in Southeast Alaska provide larger total escapements of salmon, their habitat productive capacity (per unit area) has not been shown to be as great as here.

Summer trapping data are available from ADF6.

Also, pink and chum salmon spawn in the intertidal area and upstream to just above Glacier Highway. In contrast, Coho spawn somewhat further upstream. The stream has not been stocked.

WEST CREEK (UNOFFICIAL NAME)

Anadromous Stream Catalog Number: 111-40-10050

Fish Habitat:

This small stream flows in a southerly direction off the south side of Thunder Mountain for approximately 1 mile before 1AQ entering Gastineau Channel just east of Sunny Point. It is the

westernmost of two small streams flowing through Switzer Creek trailer court. The stream drains a watershed of approximately 1 square mile, averages about 4 feet in width and 6 inches in depth. Wetland # L 1 adjoins near Glacier Highway.

Habitat was not mapped by this study. The stream flows quite fast, with few protected areas above Glacier Highway. However, the long intertidal area provides excellent nursery habitat for juveniles. A 5-foot high falls at 3/4 mile upstream is probably a barrier. Private developments and streets in the adjoining trailer court could be impacting the water quality and fish habitat values.

Fish Species Present:

West Creek has populations of pink and coho salmon and Dolly Varden. In August 1985, 30 adult pink salmon were observed in the stream directly downstream from Glacier Highway, and are known to spawn here. In the past, adult coho have been observed in the stream during the fall, however, escapement data are not available. Juvenile coho and Dolly Varden were trapped above Lemon Road in late summer 1986, and overwintering coho were present in February 1987. West Creek has not been stocked.

3.6.4 Wildlife

The tidal wetland south of Egan Drive and west of Lemon Creek's mouth (ES16) has some of the study area's highest late-summer concentrations of Bald Eagle, as well as exceptional use by Green-winged Teal and Trumpeter Swan. Red-winged Blackbirds breed here, and the wetland is used by shorebirds, Canada Geese, Arctic Terns, and many other species. Switzer Creek flows into the estuary here.

To the east, where Vanderbilt Creek passes under Egan Drive and enters the estuary, there are exceptional concentrations of Bufflehead (early fall), Goldeneye spp. (late winter). Surf Scoter (spring), and adult Bald Eagle (early summer and early fall). This wetland hosts the greatest numbers of individual waterbirds in late summer and early fall.

The gravel pit/ash pit ponds north of Egan Drive are not as heavily used. Wetland L5 sometimes has Scaup, Bufflehead, Goldeneye, and Mallard. Wetland L6 (at the junction of Egan and Glacier Drives) has Northern Harrier, Great Blue Heron, and shorebirds. Killdeer (a locally restricted species) uses several artificial ponds, and Bald Eagles congregate at the municipal dump (wetland L18 adjoins).

During the breeding season, the prevalent species in the Vanderbilt freshwater wetlands (L12, L13, L14) are Lincoln's Sparrow, Orange-crowned Warbler, Townsend's Warbler and Ruby- crowned Kinglet.

Least Sandpiper may nest in the lower Vanderbilt meadows. In the Switzer Creek fresh wetlands (L6) Lincoln's and Savannah Sparrows prevail in open areas, and Varied Thrush, Winter Wren, and Orange-crowned Warbler further upstream.

Black bear make frequent use of the subarea, particularly along Vanderbilt Creek, and deer near Switzer are common relative to other parts of the study area.

3.6.5 Recreational Use

Lemon Creek: Hydrologic values of Lemon Creek wetlands are perceived as flood/water storage, erosion control, water quality maintenance and flood control. Perceived biological functions include habitat for fish, eagles, seabirds, ducks and Canada geese. Negative aspects include little erosion control, floods, poor drainage of developed areas, loss of fishery and pollution from industrial activities and toxic wastes.

Recreational experiences include hiking. Educational values include bird watching, nature study with easy access to bogs, fens, and tidal beaches and muskeg plant identification as well as scientific research. Aesthetic values include open space values of Switzer meadow, scenic attributes, and close proximity to the city. Harvest uses include plant collecting. Negative attributes include vlsual blight from the landfill and industrial uses, smoke, smell and loss of aesthetic values.

Table 32. Distribution of Juneau Freshwater Wetlands by Size Class: Wetland Acreage Subtotals.

Figures are total acres in that size class. Parenthesized numbers are counts of individual wetlands. Wetlands smaller than 1 acre or narrower than 100 feet are not tallied.

	Size (Acres)				
	1-2	2-4	4-16	>16	TOTAL
Unconsolidated bottom, saturated	.27(3)				.27(3)
Unconsolidated bottom, seasonally flooded	.61(1)				.61(1)
Unconsolidated bottom, semipermanently flooded	.61(1)				.61(1)
Unconsolidated bottom, permanently flooded	6.02(9)	3.57(1)	4.6(1)		14.19(11)
TOTAL	7.50(14)	3.57(1)	4.6(1)		15.68(16)
Unconsolidated, excavated, seasonally flooded	.12(1)	6.83(2)			6.83(3)
Unconsolidated, excavated, permanently flooded	4.92(6)	14.61(5)	50.87(8)	43.58(2)	113.98(21)
TOTAL	4.92(7)	21.44(7)	50.87(8)	43.58(2)	120.81(24)
Scrub-shrub (broad-leaved deciduous), saturated	42.83(22)	38.46(13)	102.95(13)	917.53(14)	1,082.74(62)
Scrub-shrub (broad-leaved deciduous), seasonally flooded	1.99(1)		5.9(1)	173.41(2)	185.80(4)
Scrub-shrub (broad-leaved deciduous)		2.24(1)			2.24(1)
Scrub-shrub (broad-leaved deciduous, seasonally flooded saturated		3.44(1)	5.75(1)		9.19)1)
Scrub-shrub (broad-leaved deciduous), permanently flooded	0.7(1)		4.6(1)		5.30(2)
Scrub-shrub (needle-leaved evergreen) saturated	14.07(10)	125.48(8)	101.47(11)	537.15(10)	778.17(39)
Scrub-shrub (needle-leaved evergreen) seasonally flooded		2.99(1)			2.99(1)
Scrub-shrub (needle-leaved evergreen) semipermanently flooded		3.6(1)			3.60(1)
TOTAL	14.07(34)	132.07(12)	101.47(14)	537.15(12)	784.76(70)

192

Table 32. **Distribution of Juneau Freshwater Wetlands by Size Class: Wetland Acreage Subtotals.**

Figures are total acres in that size class. Parenthesized numbers are counts of individual wetlands. Wetlands smaller than 1 acre or narrower than 100 feet are not tallied.

	Size (Acres)				
	1-2	2-4	4-16	>16	TOTAL
Forested (needle-leaved evergreen) saturated	8.04(8)	37.16(13)	91.19(21)	1,382.02(20)	1,518.41(62)
Forested (needle-leaved evergreen) seasonally flooded		3.2(1)			3.20(1)
Forested (needle-leaved evergreen) seasonally flooded saturated	1.26(1)		15.4(2)		16.66
TOTAL	9.30(9)	40.36(14)	106.59(23)	1,382.02(20)	1,538.27(66)
Persistent emergent, saturated	44.80(25)	43.19(14)	266.42(16)	403.98(11)	758.30(66)
Persistent emergent, seasonally flooded	6.36(6)	6.83(2)	32.09(4)	190.88(3)	236.16(15)
Persistent emergent, seasonally flooded saturated	2.23(2)	3.44(1)	28.74(1)		34.41(4)
Persistent emergent, semipermanently flooded	3.25(5)		13.6(1)		16.8(6)
Persistent emergent, permanently flooded	1.88(4)		218.3(1)		220.18(5)
TOTAL	58.52(42)	53.46(17)	559.15(23)	594.86(14)	1,265.90(96)
Floating vascular aquatic bed			6.89(1)		6.89(1)
Unconsolidated shore		6.98(2)	15.05(2)		22.03(4)
Lacustrine				208.26(2)	208.26(2)
TOTAL (Freshwater excluding stream channels)	139.01 (107)	301.24 (54)	963.82 (72)	3,843.09 (50)	5,147.16* (283)

*This is NOT the total study acreage or number of wetlands, as some composite types have been double-counted and several mapping units within a single wetland are tallied individually.

Table 33. Distribution of Juneau Freshwater Wetlands by Size Class: Wetland Code Numbers

Refer to Map Appendix for locations.

	Acreage Category 1-2	2-4	4-16	16-256
Unconsolidated bottom, saturated	DW3 M1B DW2			
Unconsolidated bottom, seasonally flooded	M51			
Unconsolidated bottom, semipermanently flooded	M1B			
Unconsolidated bottom, permanently flooded	J7 A5 J3 ML19 M1B ML1 MW4 DE10 ML16	M1C	DE2	
Unconsolidated, excavated, seasonally flooded	MW22	M51 M1B		
Unconsolidated, excavated, permanently flooded	L1B M1B M7 L22 D4 D7	UM1 MW17 D5 M1A D11	M1C DW18 D6 L7 DW17 D2 L19 M4	L5 M3
Scrub-shrub (broad-leaved deciduous), saturated	A5 A5 ML2 M19 MW18 A5 M20 J3 M17 A12 A1 J7 DE4 MW23 J3 MW25 A15 M13 DW2 M50 L27	ML1 DE5 MW5 L12 M21 A7 D3 MW30 M16 D8 A14 A9 A13	ML16 J5 A10 DW7 UM11 UM1 UM8 MW11 DW3 UM7 L12 A11 MW1	DW2 J4 DE2 DE2 J1 UM1 J5 UM1 UM9 M1B J2 DE2 A1 ML1 DW7 A7 DW2
Scrub-shrub (broad-leaved deciduous), seasonally flooded	L6		UM6	UM1 ML1
Scrub-shrub (broad-leaved deciduous)		M15		
Scrub-shrub (broad-leaved deciduous), seasonally flooded saturated		M14	M7	
Scrub-shrub (broad-leaved deciduous), permanently flooded	ML1		DE2	
Scrub-shrub (needle-leaved evergreen), saturated	DE10 D9 A17 DW7 DW6 ML16 L90 MW9 MW20 L15	M16 UM9 L91 MW11 J5 A19 DE7 UM10	L6 DE2 J5 DE9 MW60 L6 DE3 DW3 MW5 DE4 A8	DW2 DW9 UM9 DE2 J4 DE4 DW2 ML1 DE3 DW2
Scrub-shrub (needle-leaved evergreen) seasonally flooded		M5		
Scrub-shrub (needle-leaved evergreen) semipermanently flooded		UM1		

Table 33. **Distribution of Juneau Freshwater Wetlands by Size Class: Wetland Code Numbers**

Refer to Map Appendix for locations.

	Acreage Category 1-2	2-4	4-16	16-256
Forested (needle-leaved evergreen) saturated	DW2 A5 MW18 J3 MW12 MW14 UM1 MW22	D8 A5A A14 DE8 A9 A7 A13 L14 DW13 MW16 ML17 MW15 MW5	ML16 MW30 M1B A10 MW6 UM11 DW12 UM8 DE1 MW11 A5B DE3 MW13 UM7 DW11 DW5 L12 UM9 A11 MW22 DE2	J1 J6 J5 DW4 UM9 DW2 J2 A1 MW11 DW7 A5 A7 A7 DW2 DW5 J4 DW2 DE4 DE4 UM1
Forested (needle-leaved evergreen) seasonally flooded		UM6		
Forested (needle-leaved evergreen) seasonally flooded saturated	MW21		A6 J7	
Persistent emergent, saturated	A1 M17 MW22 MW23 J7 M1B MW25 D9 ML1 M13 DW6 ML16 M50 MW9 UM11 L17 MW20 M1B ML2 L15 M1 A5 A17 MW21 MW2	DE5 L14 L12 M7 A17 UM1 MW3a L18 MW11 UM10 A19 UM10 MW19 A7	MW1 L6 J5 MW5 DW7 M1B UM1 L14 MW60 L14 L4 DW3 M11 DW15 UM9 A8 J5	ML1 MW6 DW2 J4 UM9 MW2 DE4 M1B DE3 DE2 MW1 ML1 MW3 MW21
Persistent emergent, seasonally flooded	M51 M10 A5 MW11 L14 UM7	M51 M1B		UM1 ML1 L6
Persistent emergent, seasonally flooded saturated	UM9 M1B	M14	M26 M9 M27 M3	
Persistent emergent, semipermanently flooded	A2 ML1 M1 M1B ML16		UM1 UM9	
Persistent emergent, permanently flooded	M51 ML1 M1B DE10		DW16 L8	
Floating vascular aquatic bed			A2	
Unconsolidated shore		L23 M8	M6 DW8	
Lacustrine				M1 A2

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1029/18-24

EPILOGUE

As this report was going to press, it was discovered that the study area's most outstanding stream reach — a portion of wetland L12 in Vanderbilt Creek — had just been altered by a private landowner. This stream reach had been found to contain some of the highest densities of overwintering salmon ever recorded in Southeast Alaska. Such callous destruction underlines further the need for sound planning, heightened public awareness, and steep, certain penalties for wetland violations. Otherwise, we will lose the resources valued by all Alaskans.

APPENDIX A

Explanation of Appendix A.

- In the Cumulative Surface Area graph, a sudden rise means a sudden widening of the stream. For Cumulative Deep Slow Area (same graph), a long flat curve section may mean few pools.

- In the Cumulative AV and Cumulative 0V graph a paucity of adequate fish cover may be indicated where both curves are simultaneously flat, particularly if the Cumulative Debris and UC curves are also flat.

- In the Cumulative Shade graph, a sharp rise indicates movement of the stream into a more densely wooded area. In the Cumulative Bank graph (same graph), a flattening may indicate locally deteriorated bank stability.

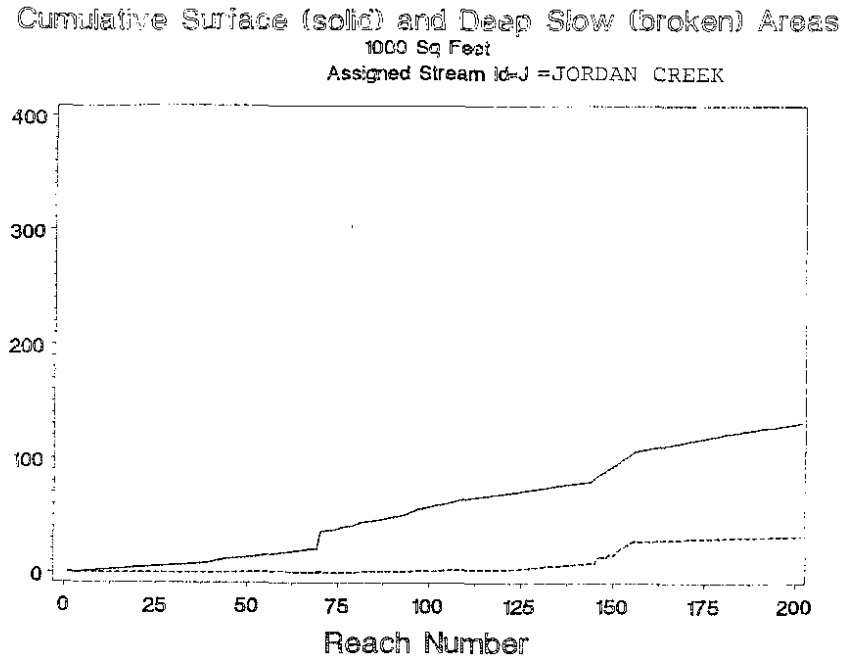
- In the Cumulative CG graph, a flattening indicates depositional conditions (fine sediment). In the Cumulative Fe graph, a sharp rise indicates locally increased iron- staining.

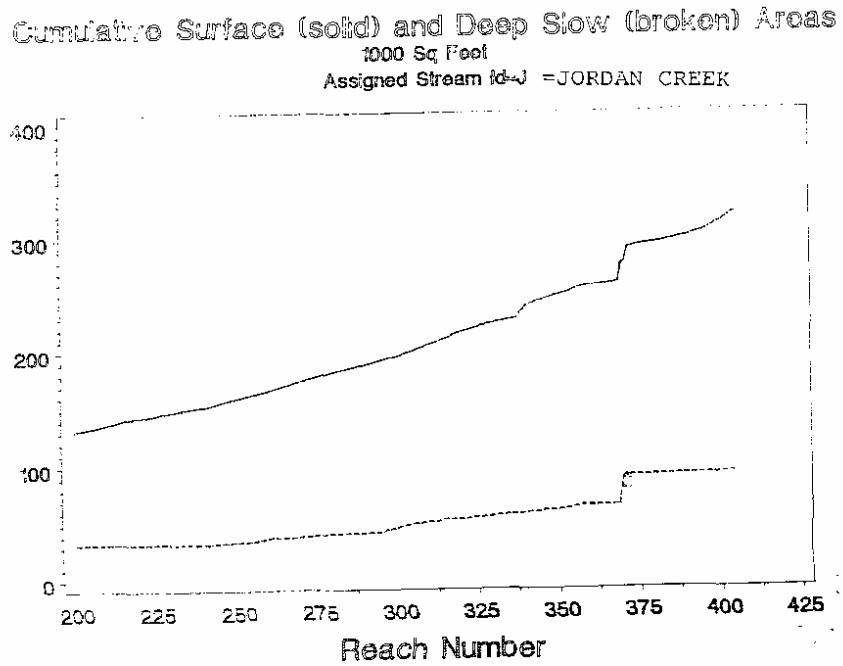
- In the Cumulative UC graph, a sharp inflection indicates an abundance of undercut banks where few were present in adjoining reaches

- In the Cumulative S6TF graph, a flat area documents a long segment of stream with fast-flowing water prevailing over slow-flowing water (i.e., slow greater than fast—SGTF—was rated 0). In the cumulative SGTD graph, an inflection indicates a segment where pools are suddenly prevalent after a relative absence (i.e., shallow greater than deeper—SGTD—was rated 0).

The reach number on each x-axis refers to assigned reach numbers shown in Table 11 and in Appendix A. Reaches are generally 50 feet in length (except for Montana Creek and a few reaches on other streams, which are 100 feet long). The scale on the y- axis is the cumulative total; where this total is very large it is divided by 1000 throughout as shown in the graph heading.

Figure A


Cumulative Surface (solid) and Deep Slow (broken) Areas
1000 Sq Feet
Assigned Stream Id=J =JORDAN CREEK
400
300
200
100
0
0
25
50
75
100
125
150
175
200
Reach Number


Cumulative Surface (solid) and Deep Slow (broken) Areas
1000 Sq Feet
Assigned Stream Id=J =JORDAN CREEK
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300
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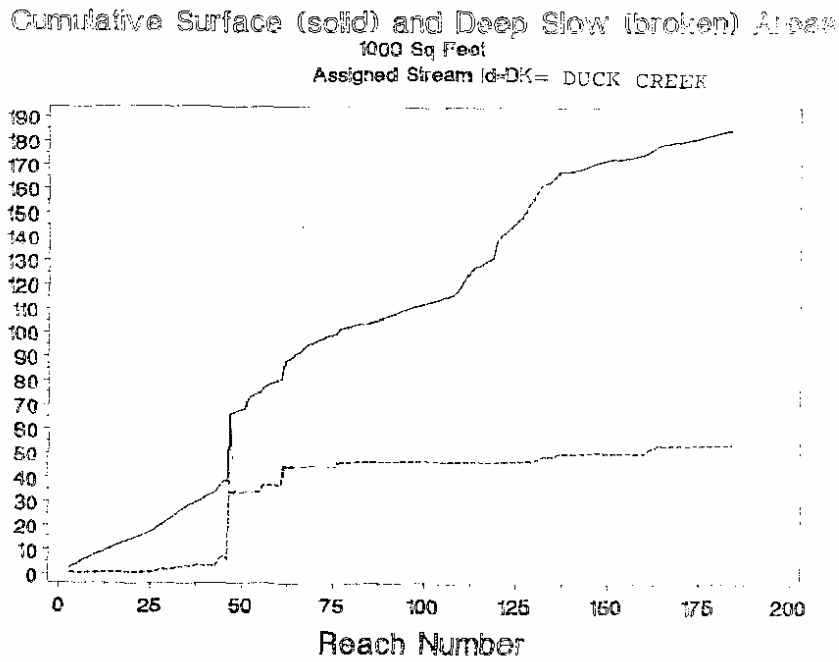
100
0
200
225
250
275
300
325
350
375
400
425
Reach Number

Figure A (cont'd)



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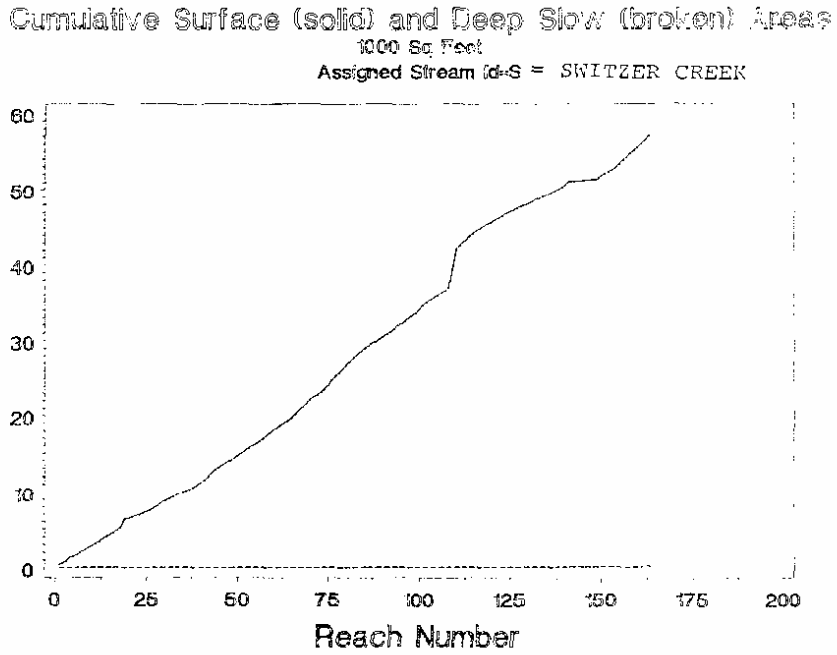

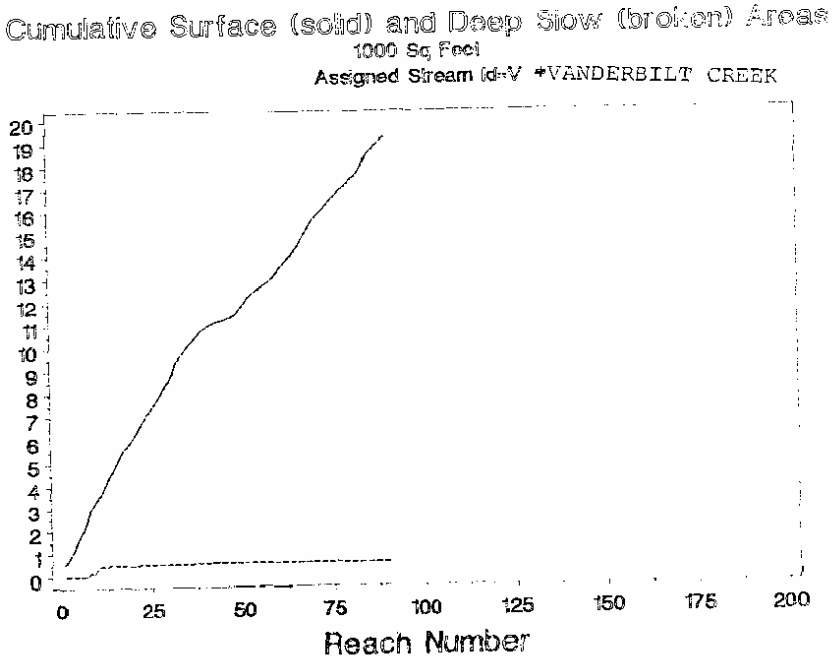

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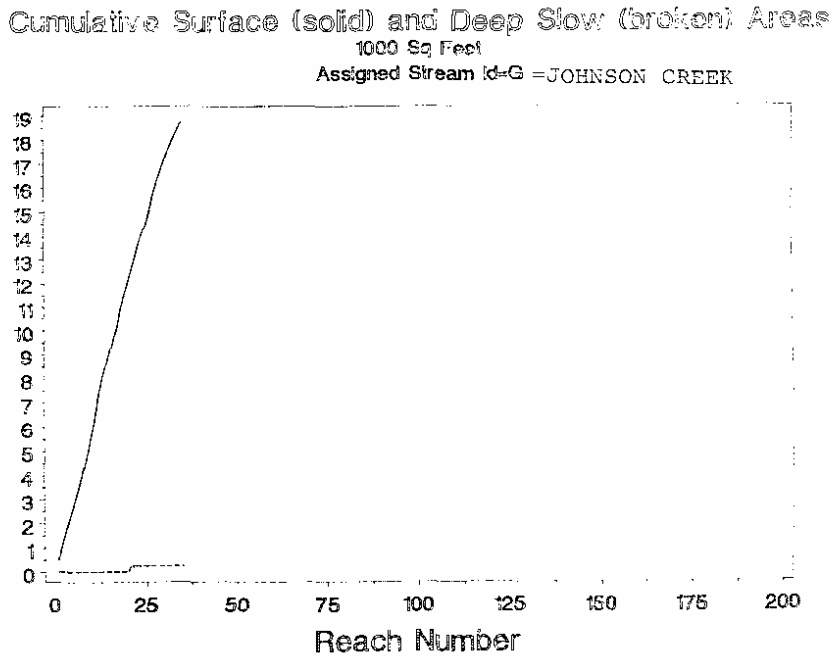


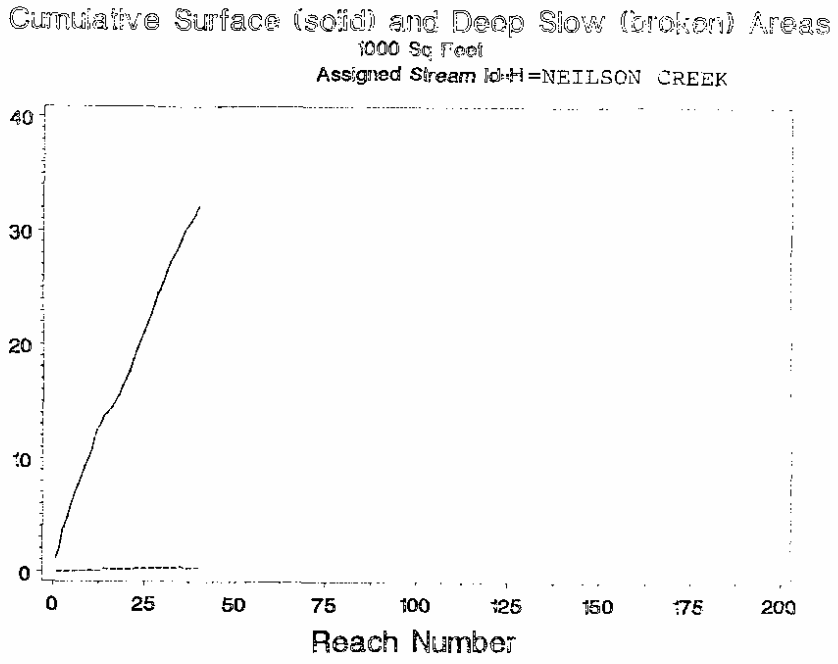
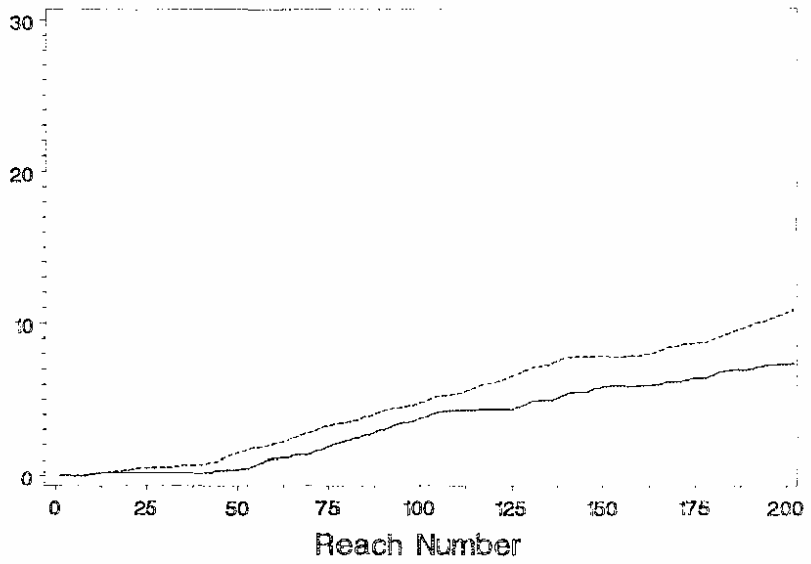


Figure B

Cumulative AV (solid) and Cumulative OV (broken)

1000 Feet

Assigned Stream Id-J =JORDAN CREEK



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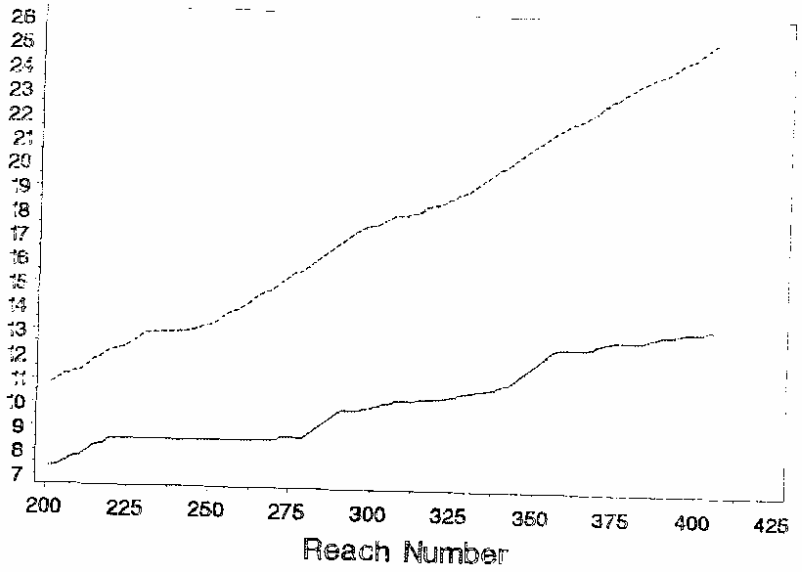

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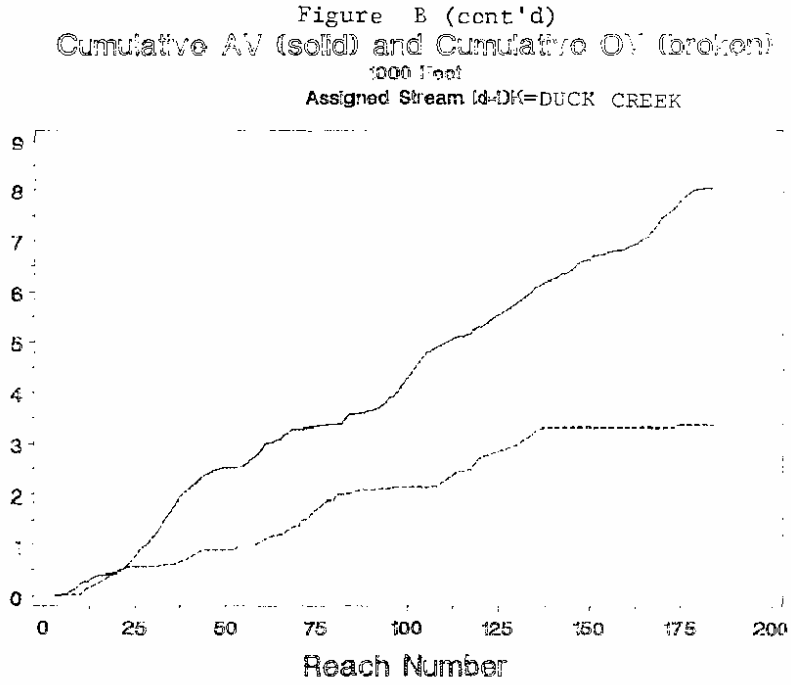


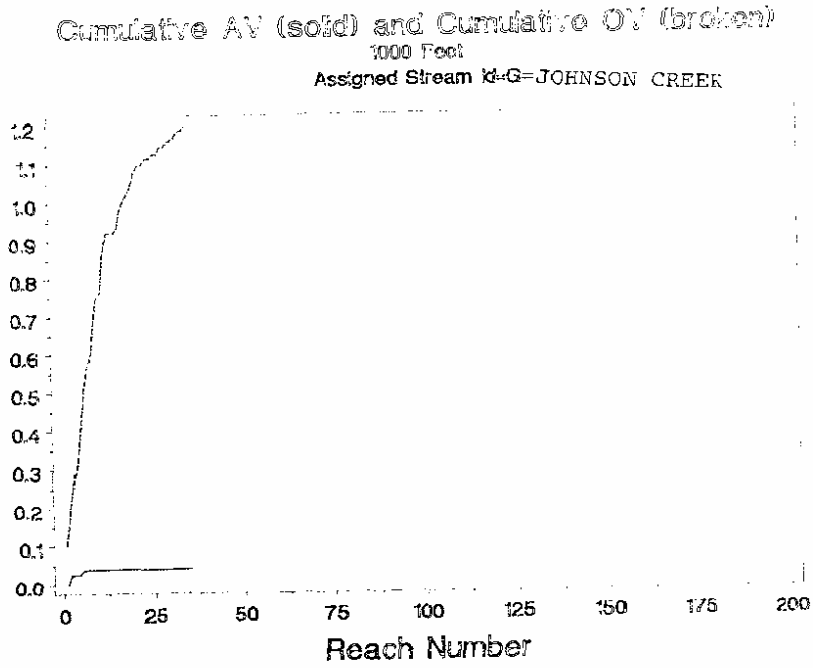
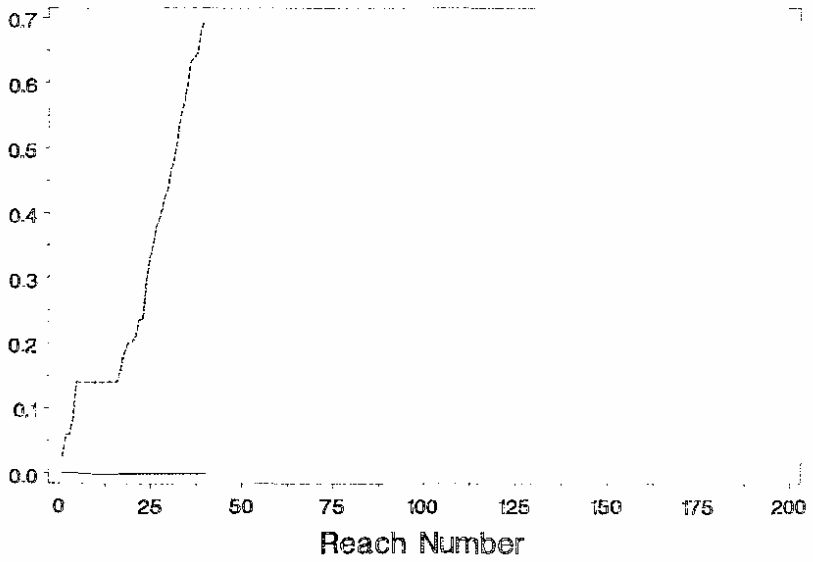


Figure B (cont'd)

Cumulative AV (solid) and Cumulative OV (broken)

1000 Feet

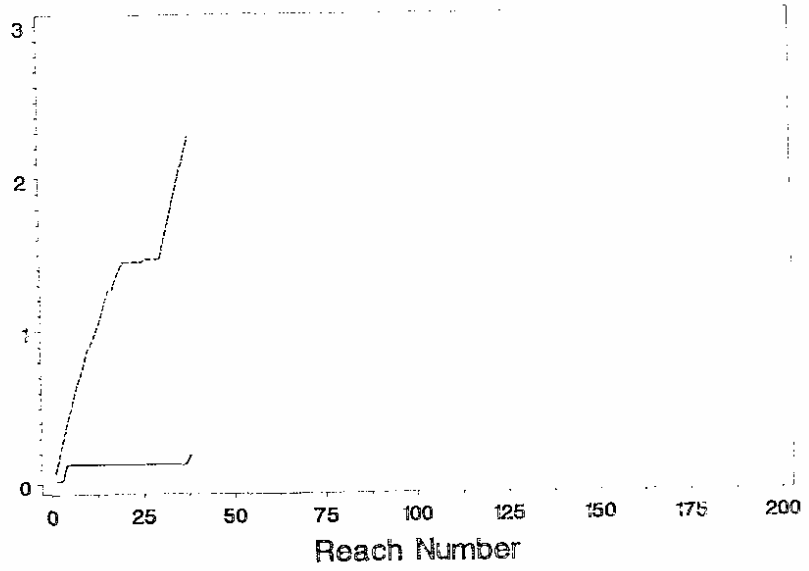
Assigned Stream Id-H =NEILSON CREEK



Cumulative AV (solid) and Cumulative OV (broken)

1000 Feet

Assigned Stream Id-KK="CASADELSOL" CREEK



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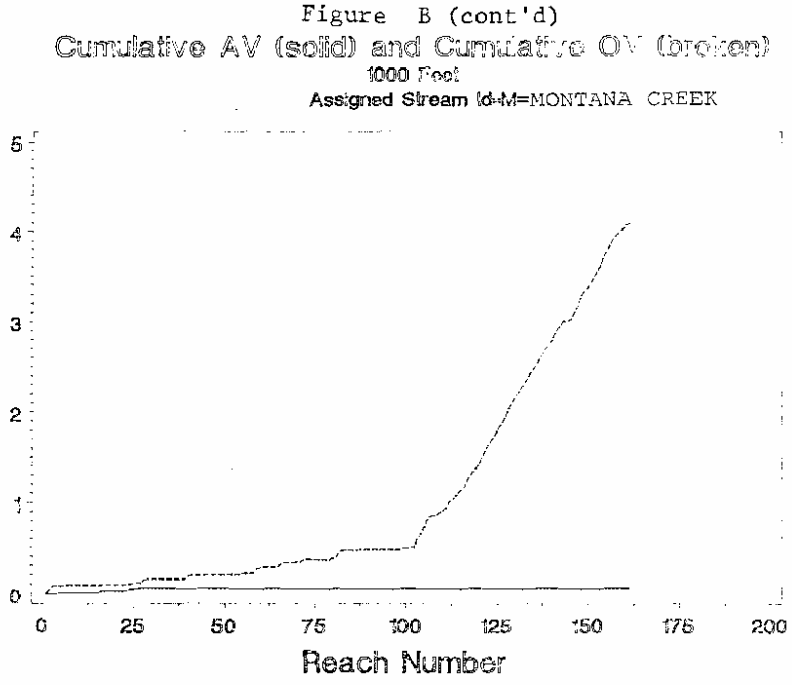


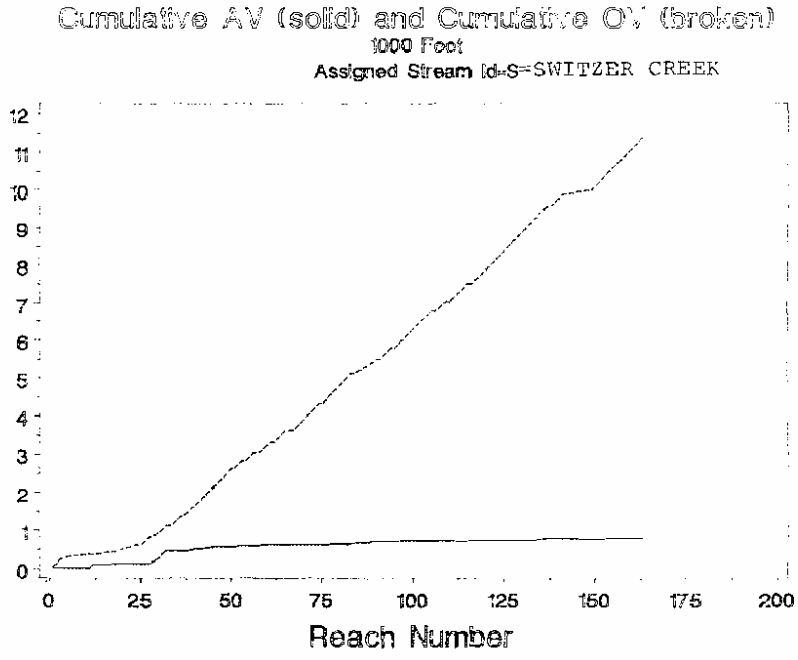


Figure B (cont'd)

Cumulative AV (solid) and Cumulative O' (broken)

1000 Feet

Assigned Stream Id-V =VANDERBILT CREEK

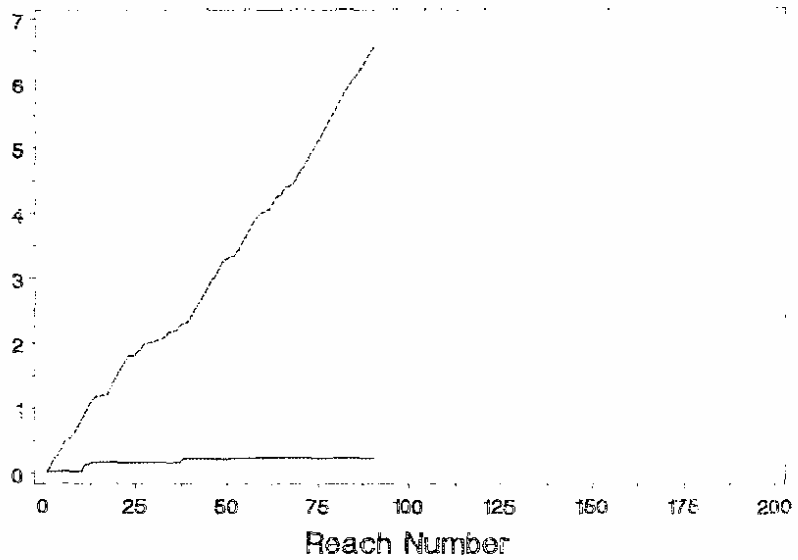
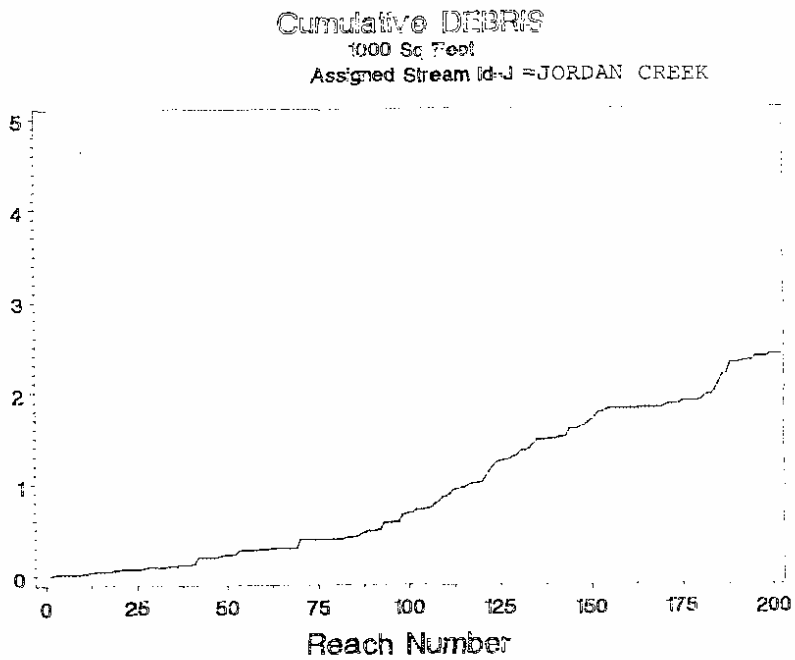


Figure C


Cumulative DEBRIS
1000 Sq Feet
Assigned Stream Id-J =JORDAN CREEK
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2
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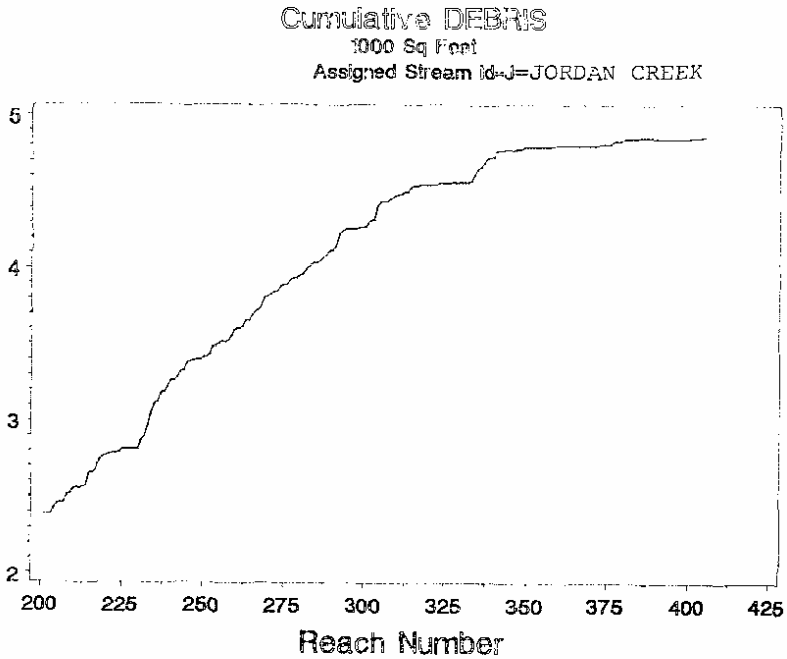
125
150
175
200
Reach Number


Cumulative DEBRIS
1000 Sq Feet
Assigned Stream Id-J=JORDAN CREEK
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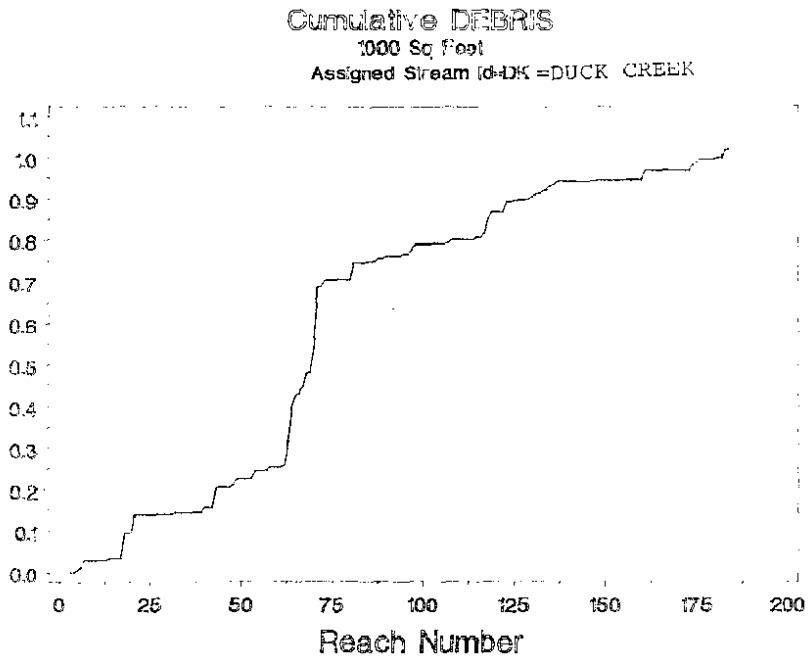
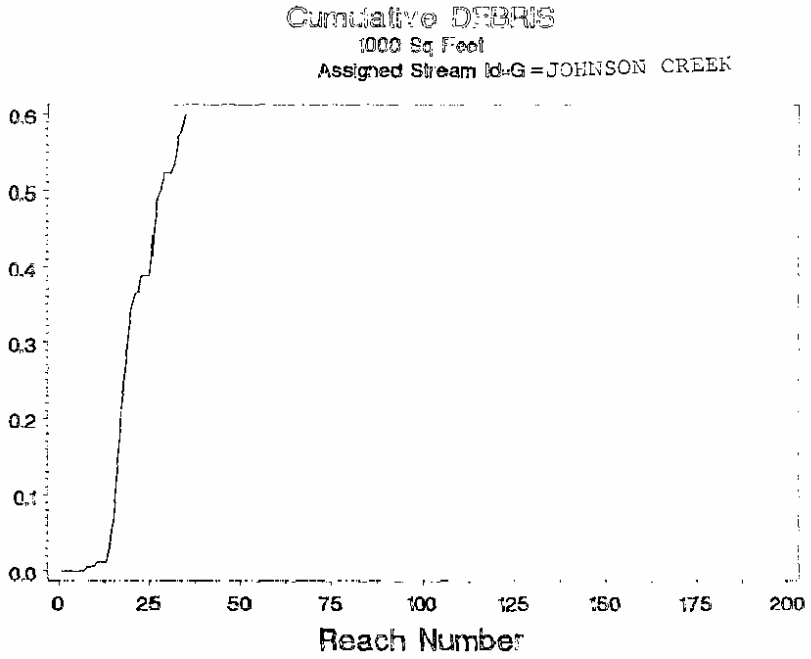
425
Reach Number

Figure C (cont'd)





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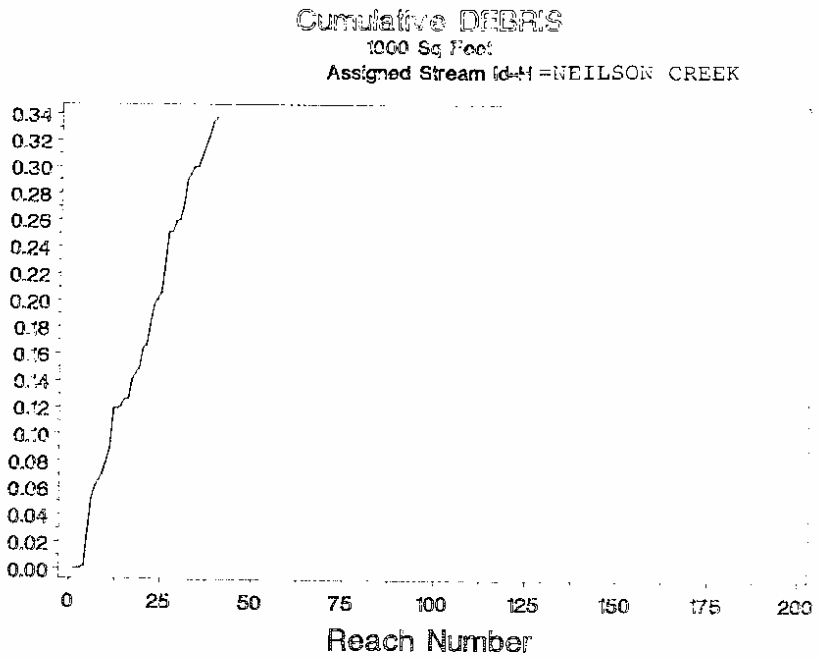
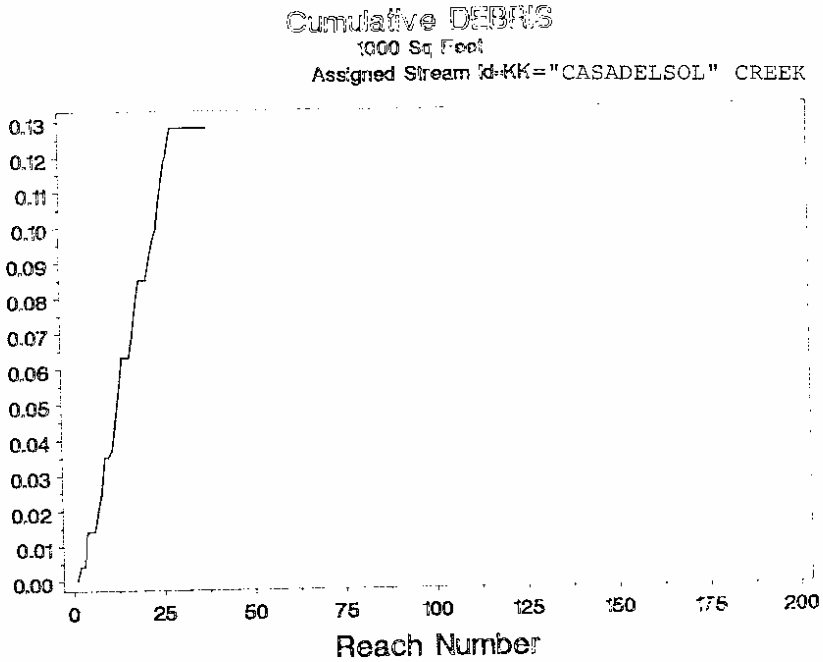
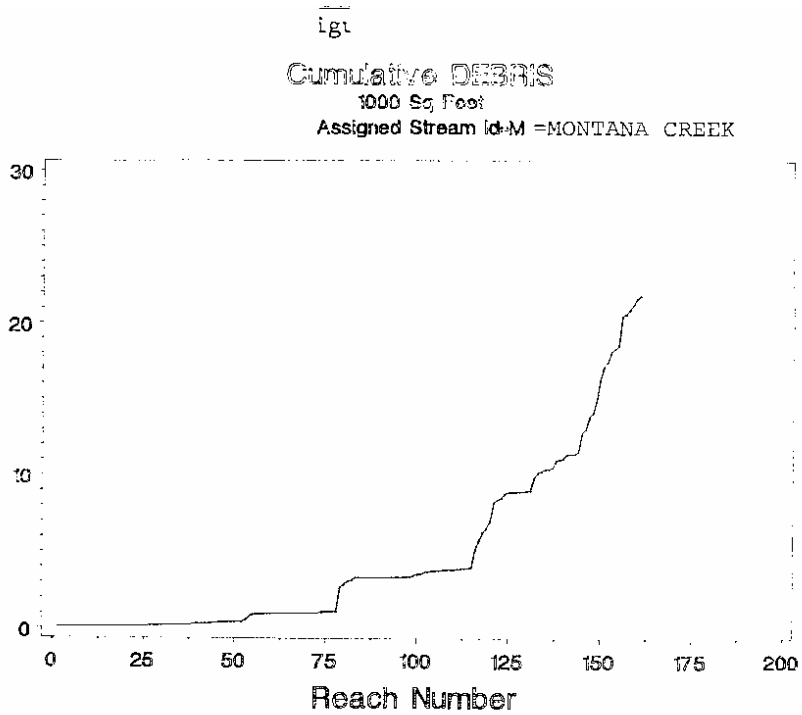





Cumulative DEBRIS
1000 Sq Feet
Assigned Stream Id=M =MONTANA CREEK
30
20
10
0
0
25
50
75
100
125
150
175
200
Reach Number

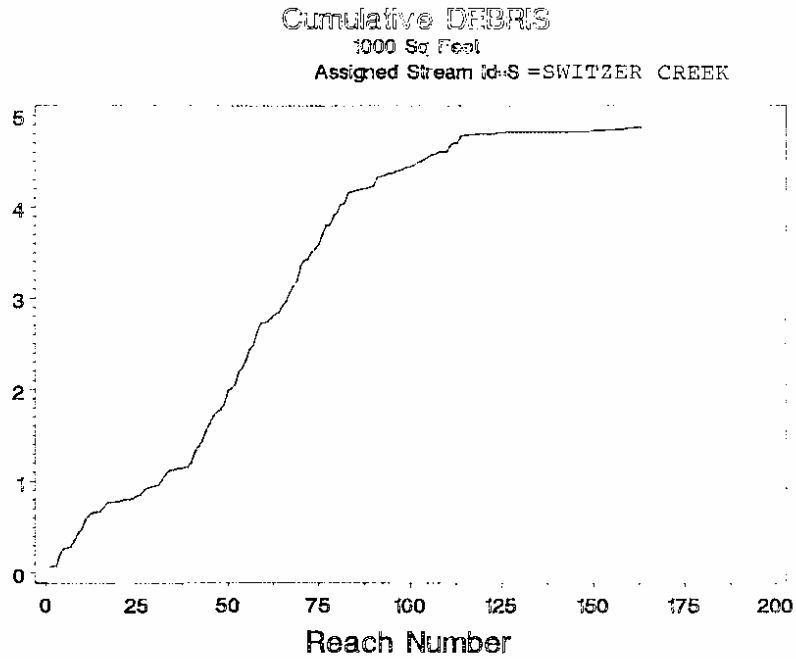

Cumulative DEBRIS
1000 Sq Feet
Assigned Stream Id=S =SWITZER CREEK
5
4
3
2
1
0
0
25
50
75
100
125
150
175
200
Reach Number

Figure C (cont'd)

A-16

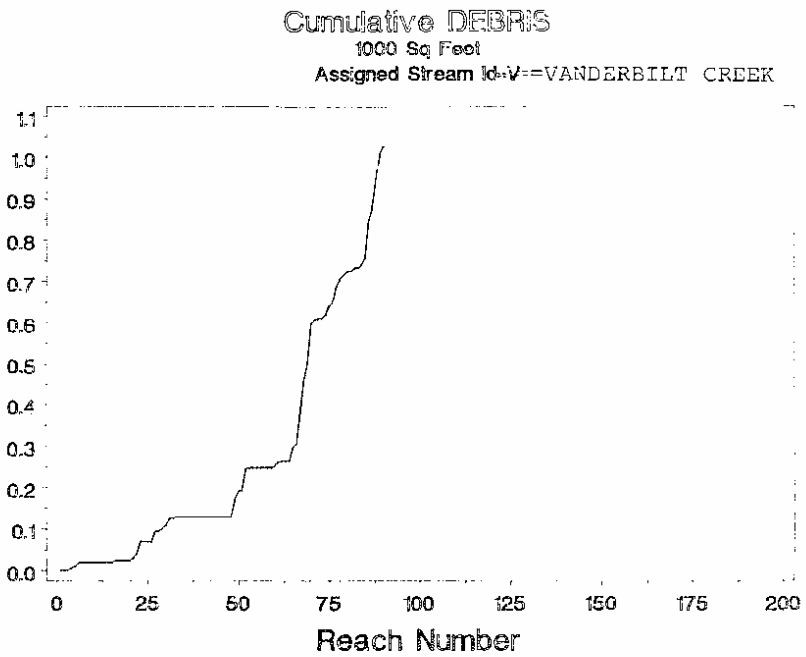
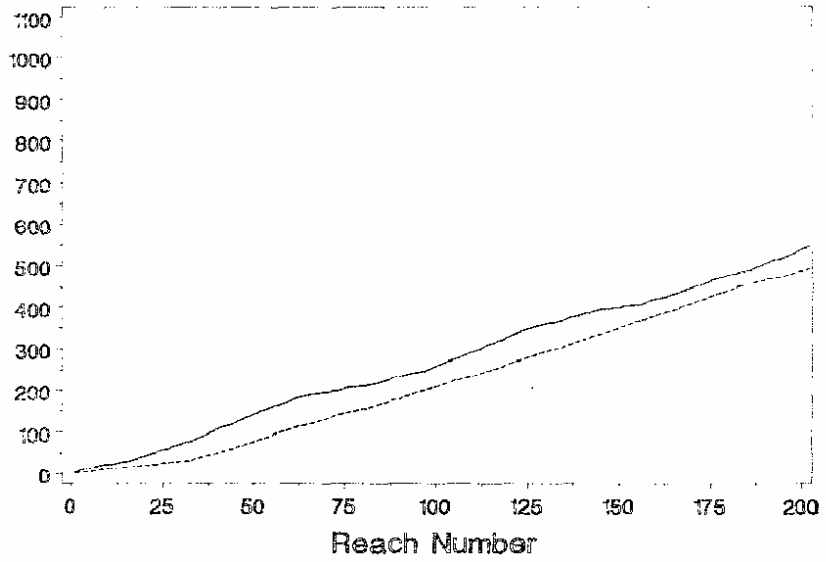


Figure D

Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=J=JORDAN CREEK



Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=J=JORDAN CREEK

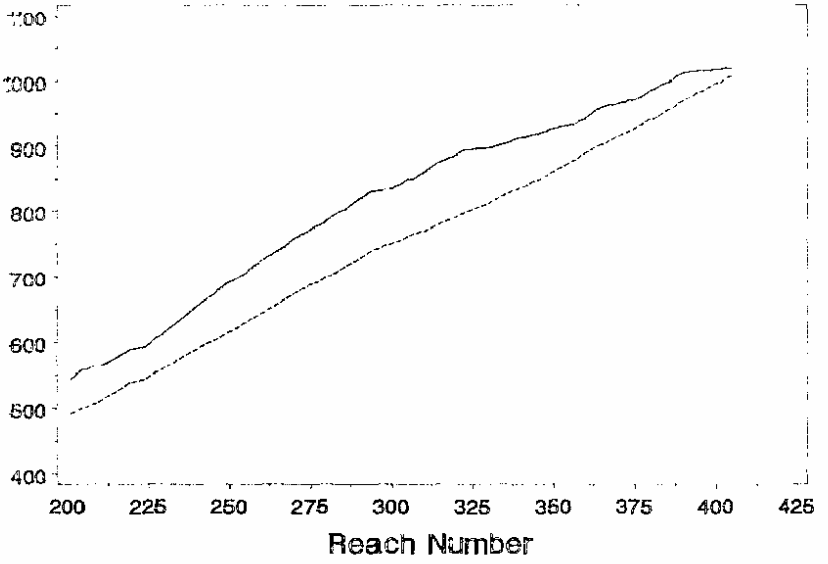
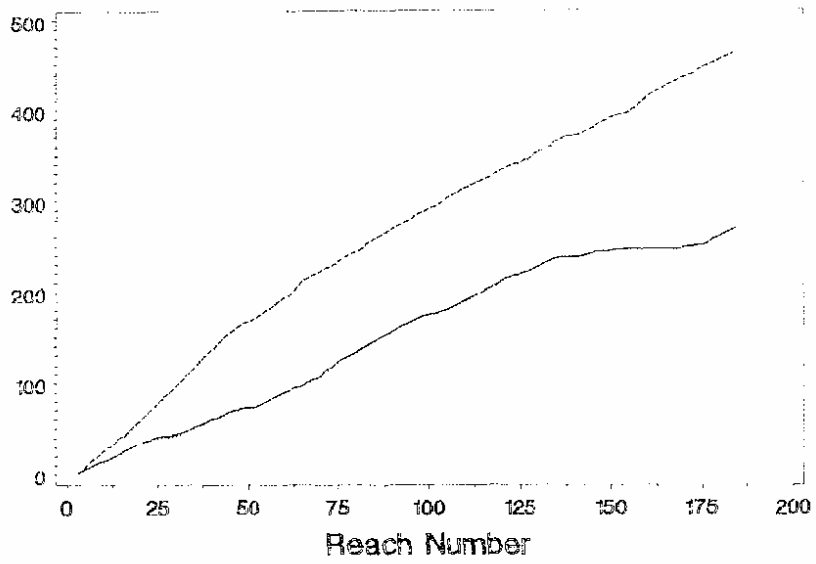


Figure D (cont'd)

Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=DK=DUCK CREEK



Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=G =JOHNSON CREEK

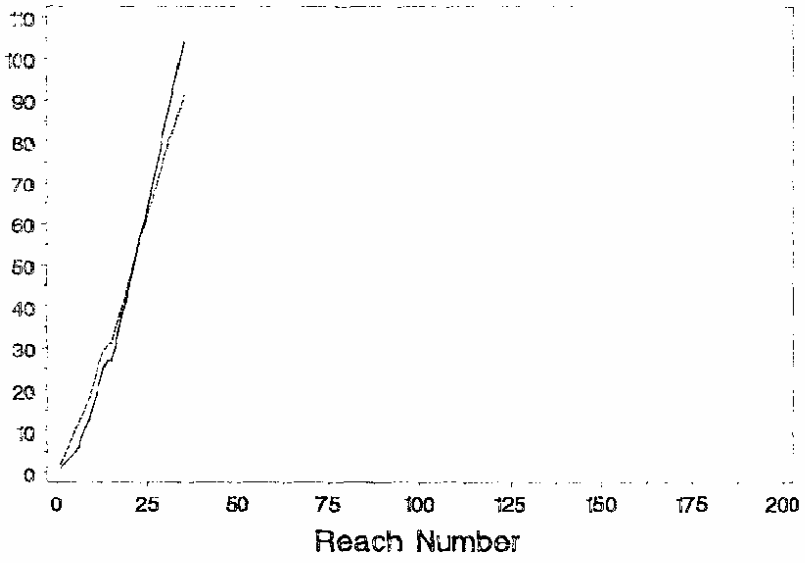
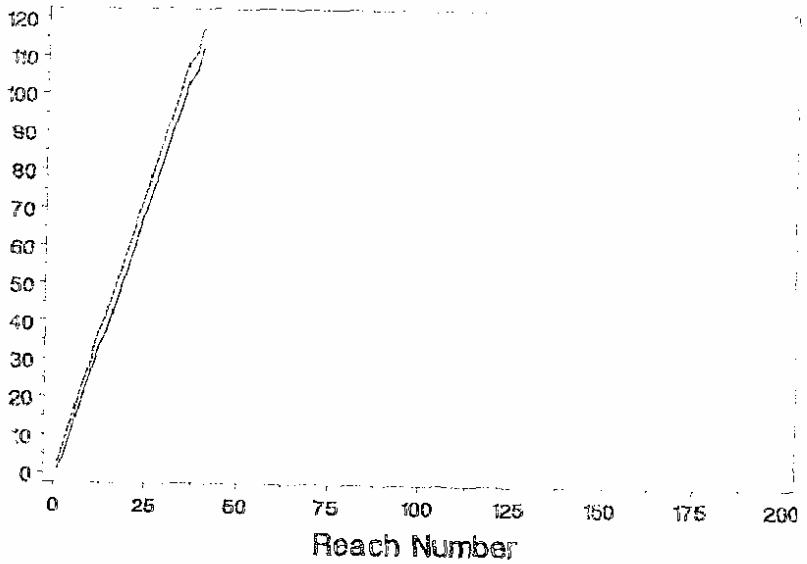


Figure D (cont'd)

A-1

Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id-HH=NEILSON CREEK



Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id-KK="CASADELSOL" CREEK

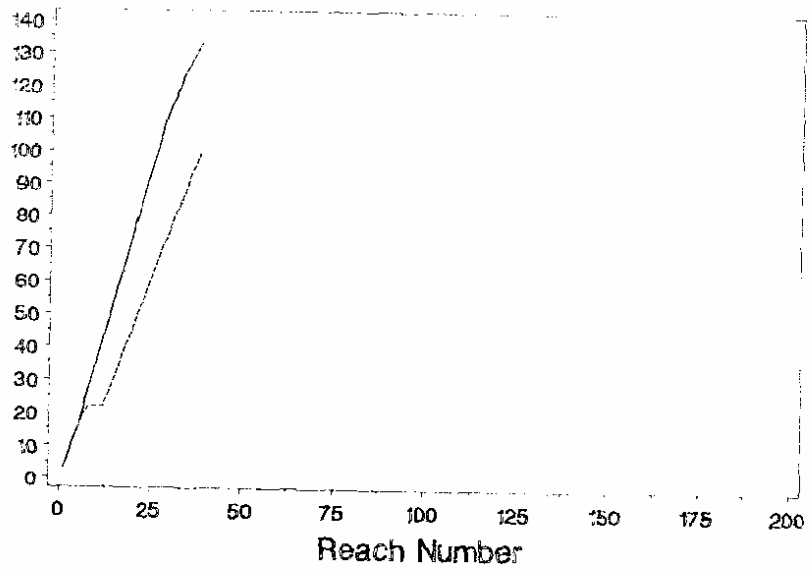
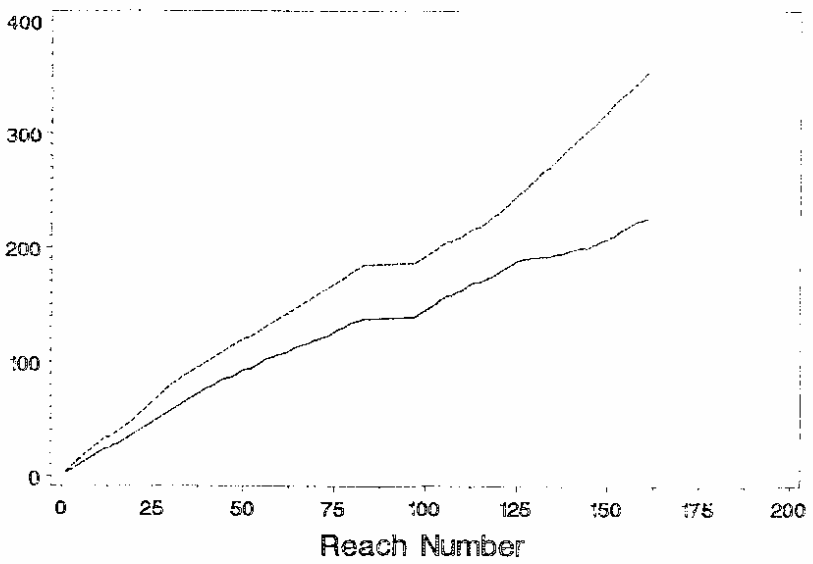


Figure D (cont'd)

Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=M =MONTANA CREEK



Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=S =SWITZER CREEK

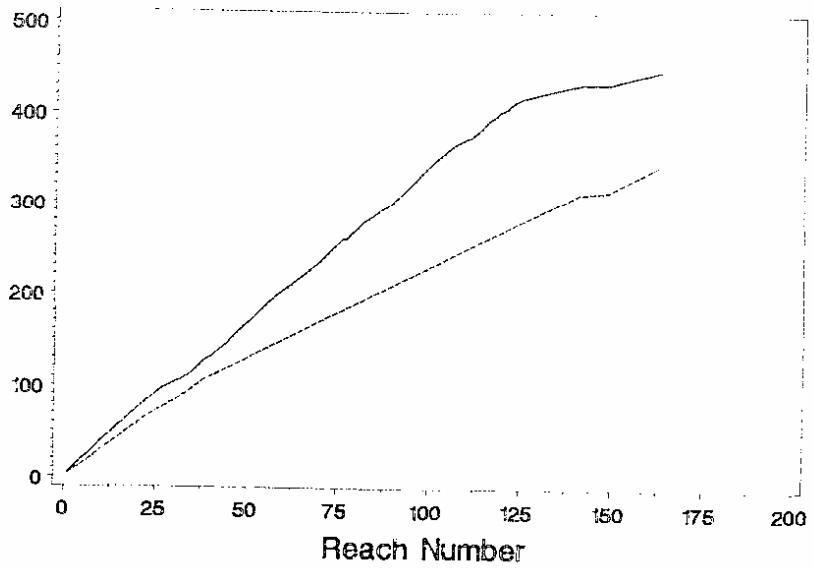


Figure D (cont'd)

Cumulative SHADE (solid) and Cumulative BANK (broken)

Assigned Stream Id=V =VANDERBILT CREEK

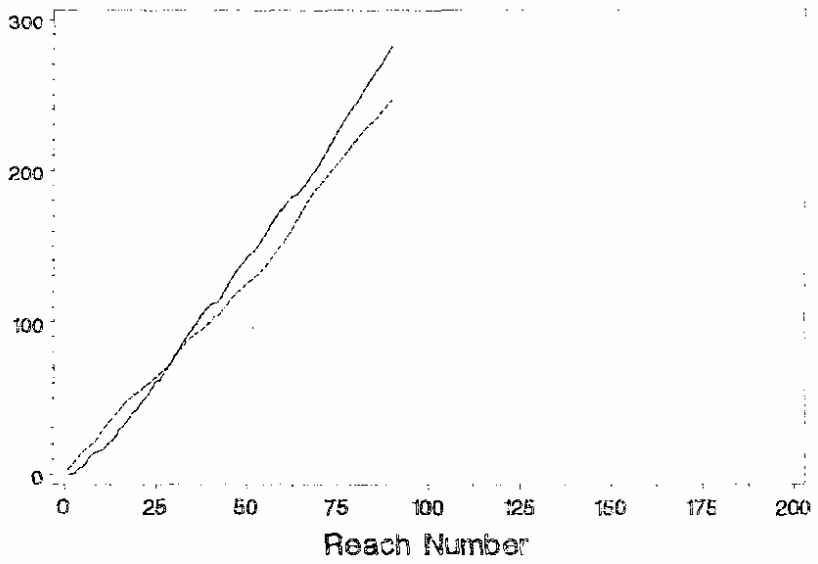
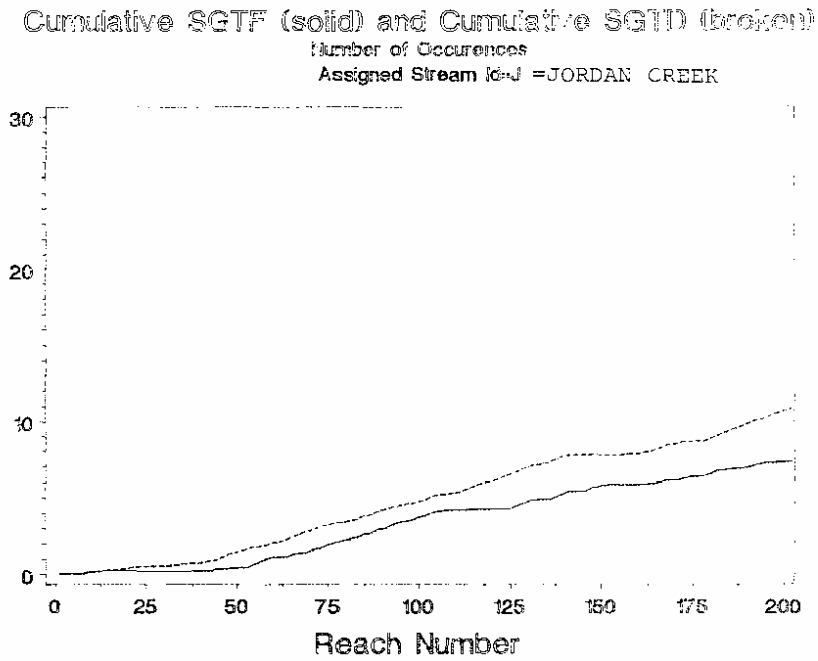


Figure E


Cumulative SGTF (solid) and Cumulative SGTD (broken)
Number of Occurences
Assigned Stream Id=J =JORDAN CREEK
30
20
10
0
0
25
50
75
100
125
150
175
200
Reach Number

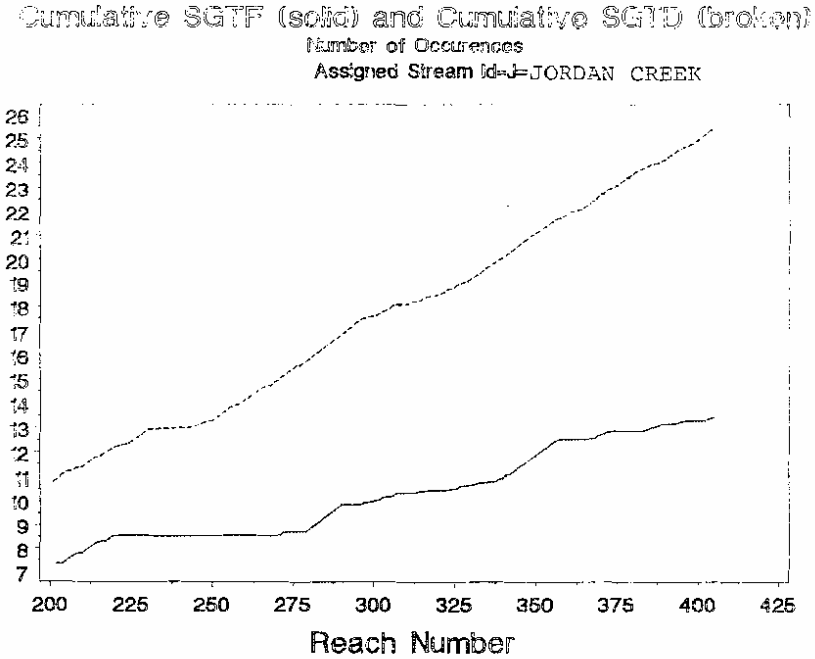
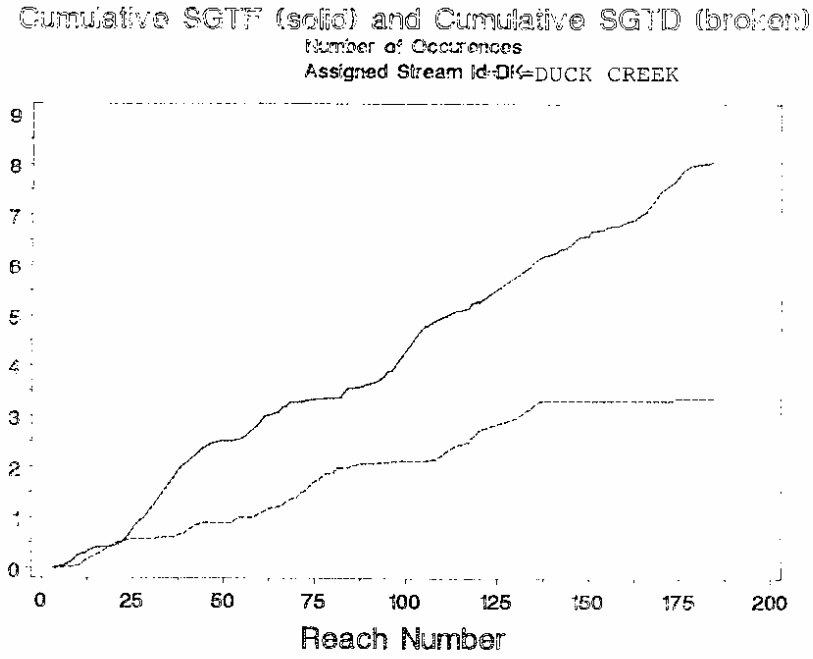

Cumulative SGTF (solid) and Cumulative SGTD (broken)
Number of Occurences
Assigned Stream Id=J=JORDAN CREEK
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
200
225
250
275
300
325
350
375
400
425
Reach Number

Figure E (cont'd)



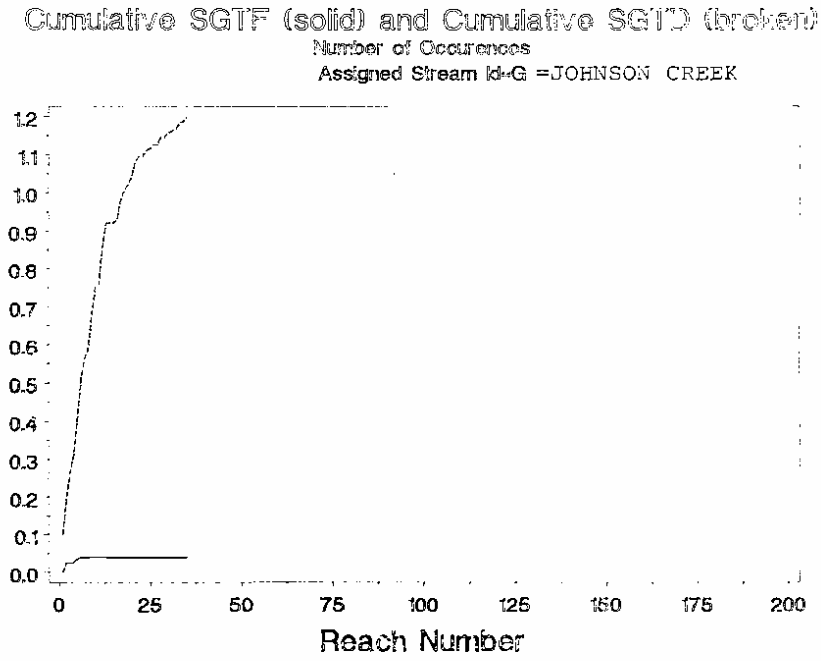
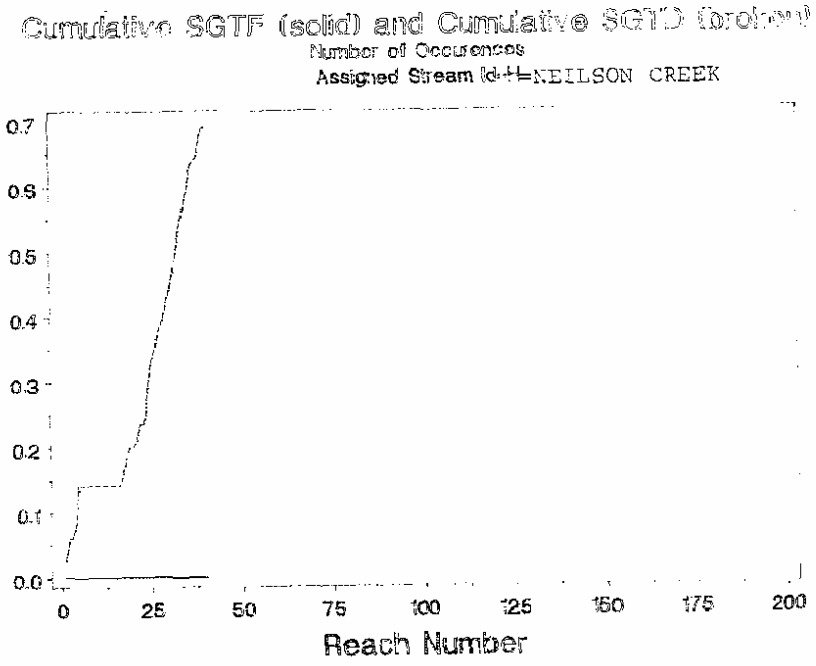
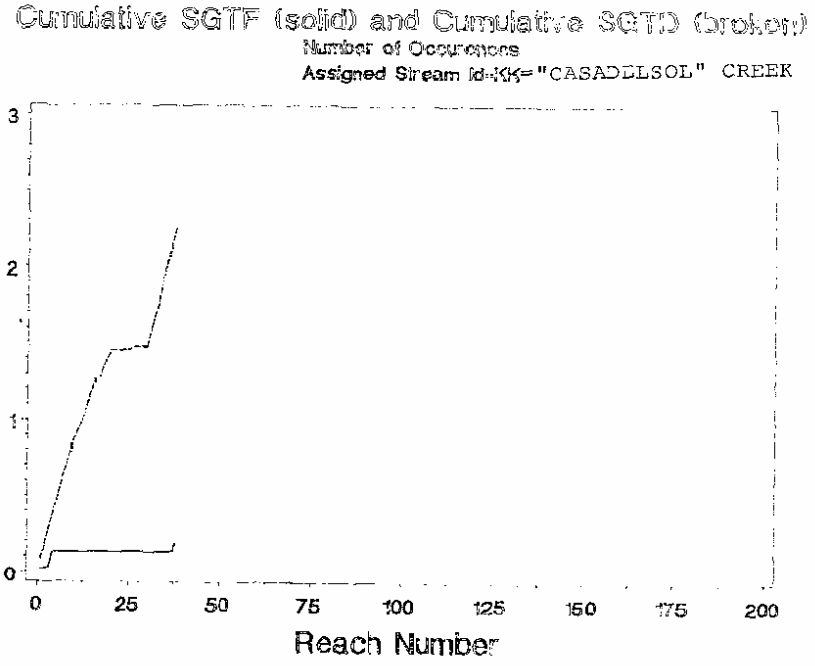


Figure E (cont'd)





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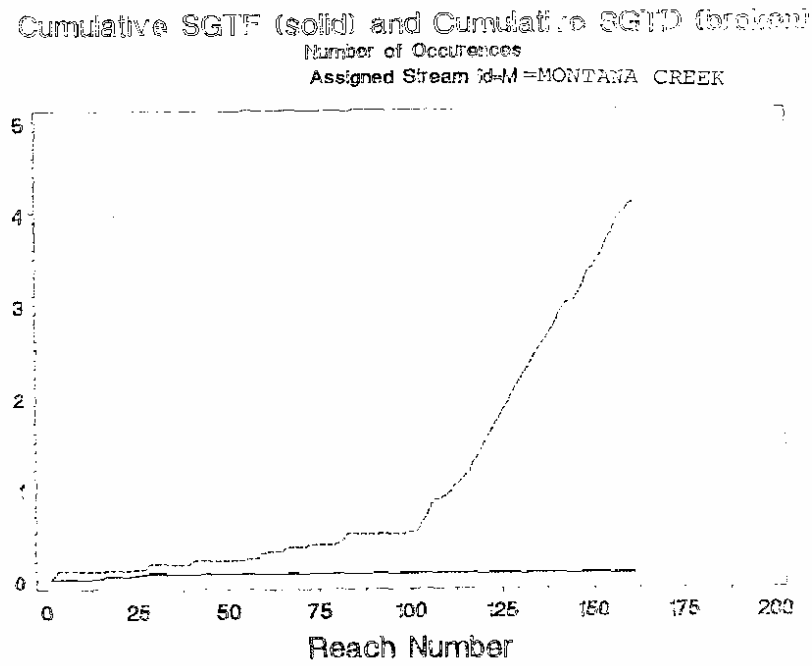


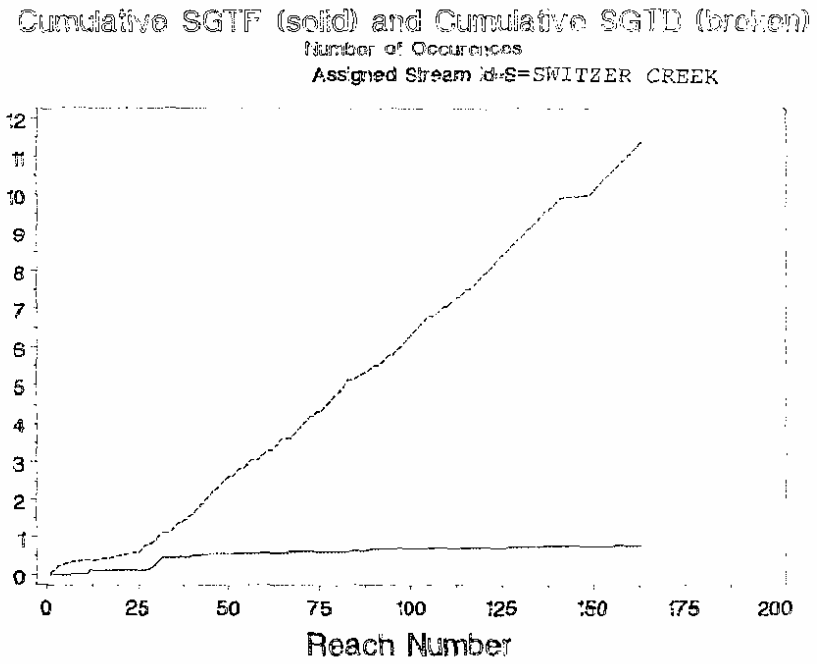


Figure E (cont'd)

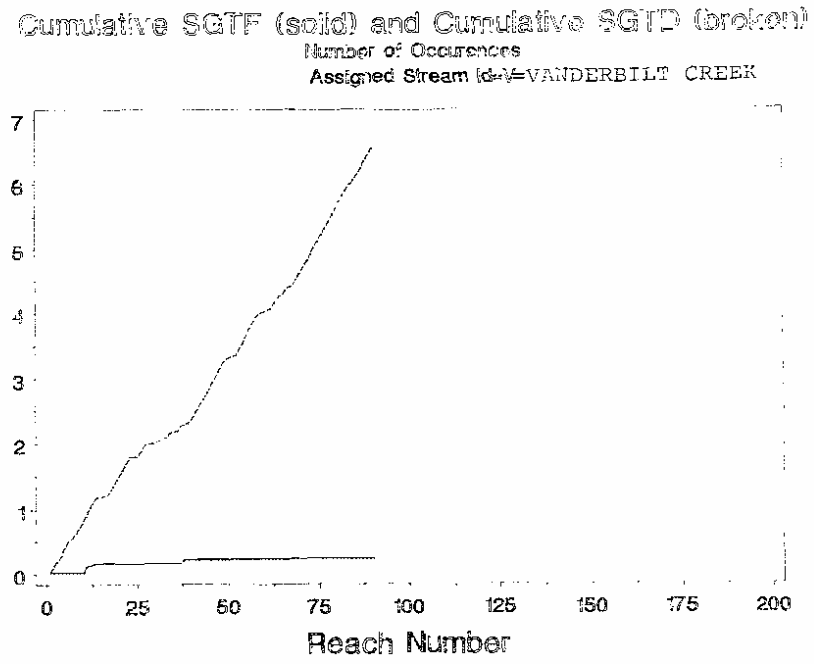
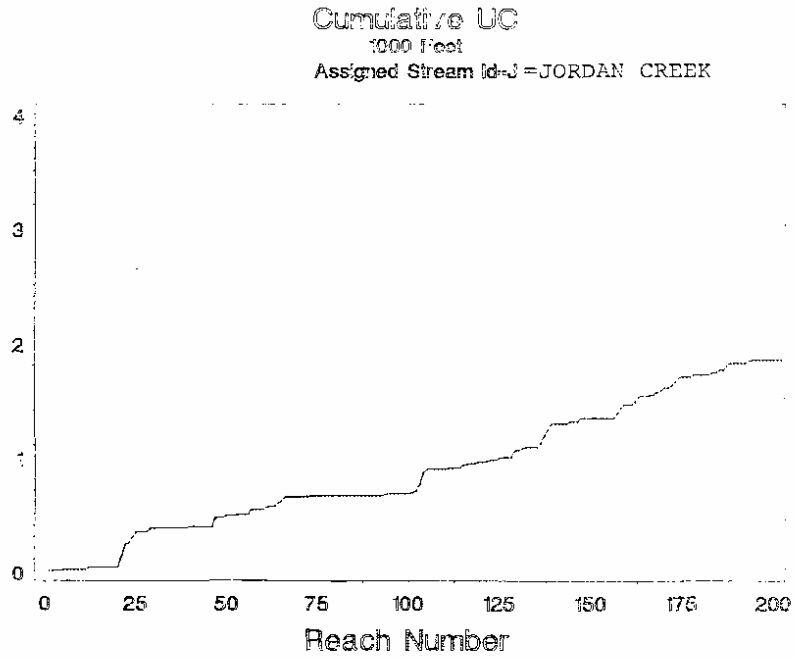


Figure F

A-2


Cumulative UC
1000 Feet
Assigned Stream Id-J =JORDAN CREEK
4
3
2
1
0
0
25
50
75
100
125
150
175
200
Reach Number

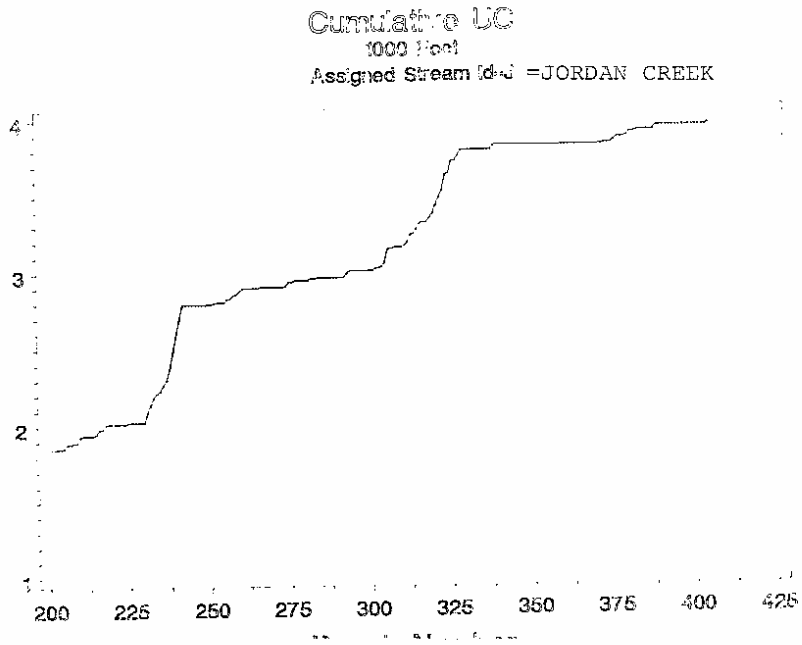
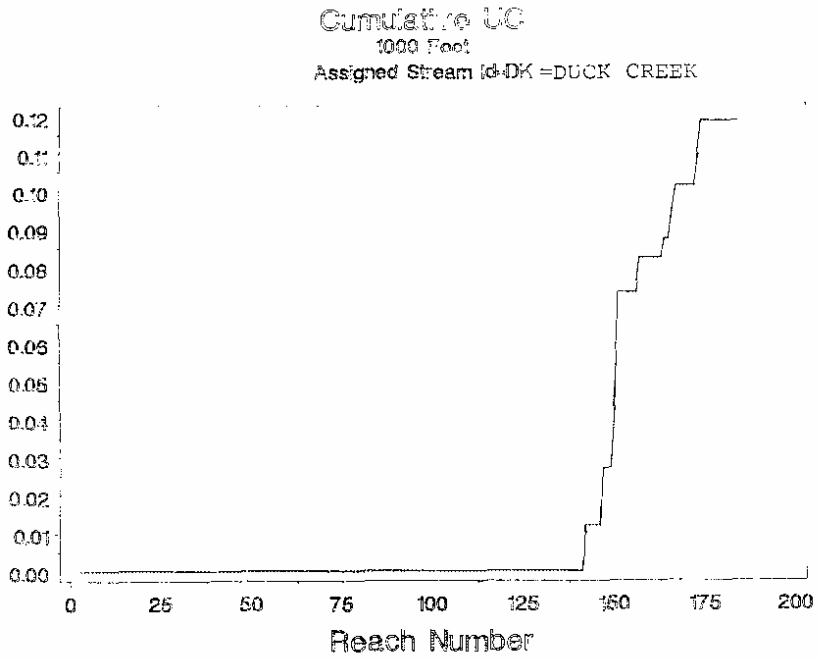

Cumulative UC
1000 Feet
Assigned Stream Id-J =JORDAN CREEK
4
3
2
1
200
225
250
275
300
325
350
375
400
425

Figure F (cont'd)



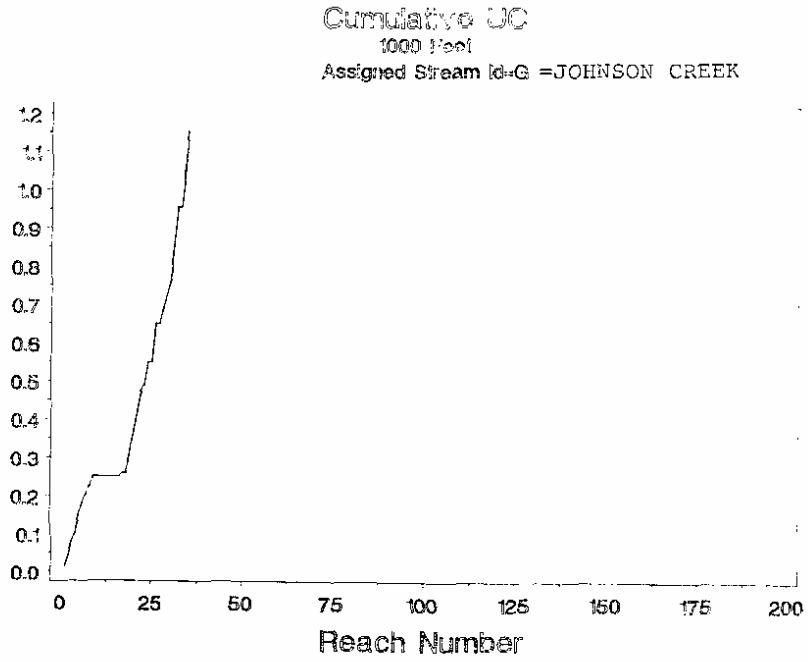
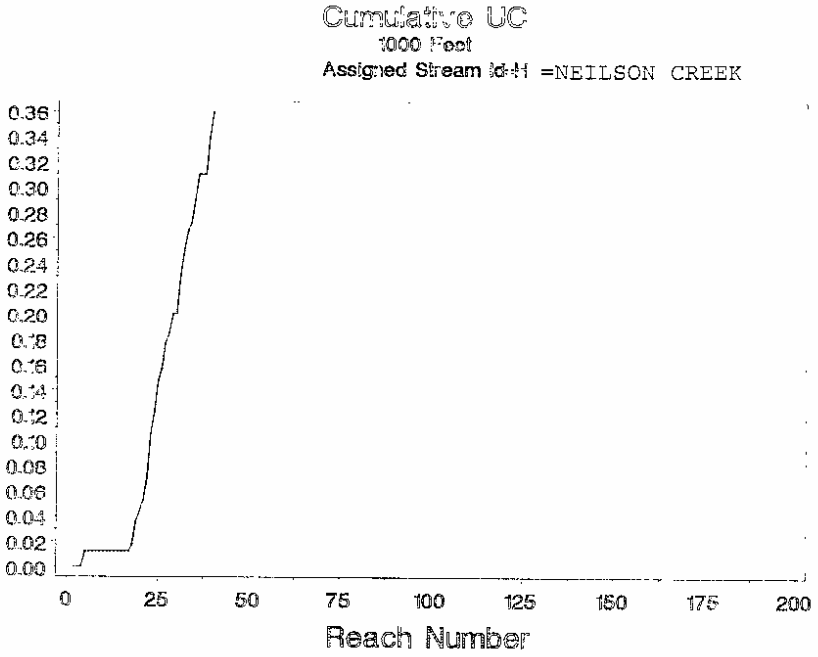


Figure F (cont'd)

A-29



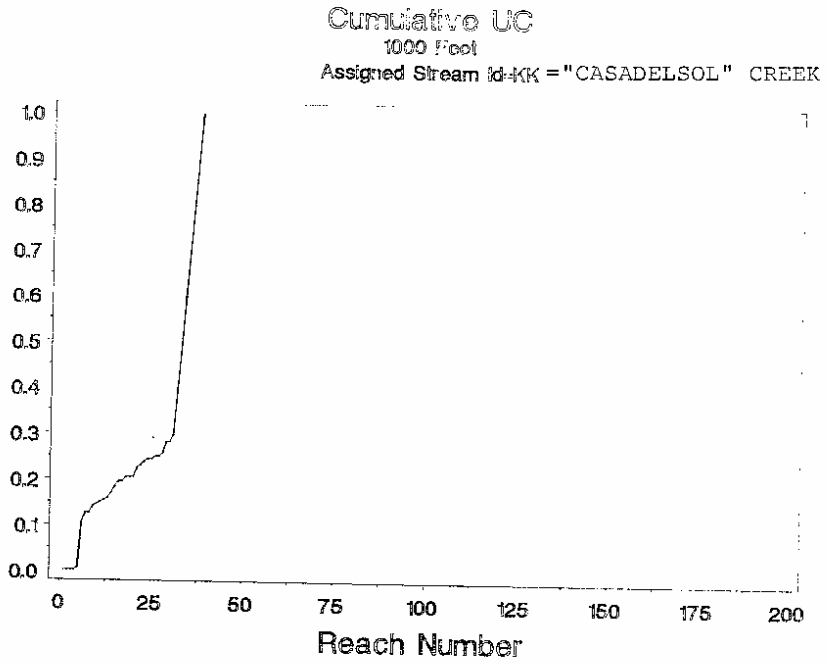
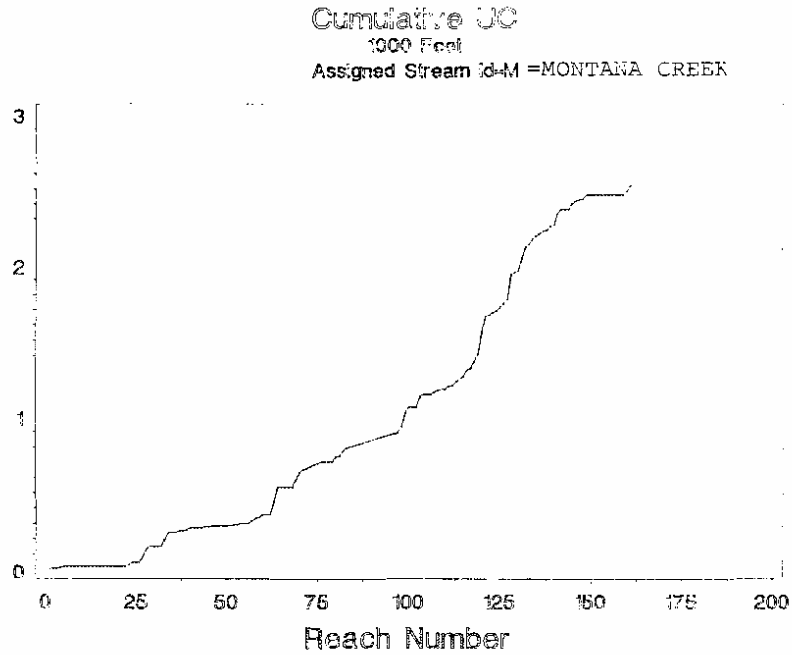


Figure F (cont'd)



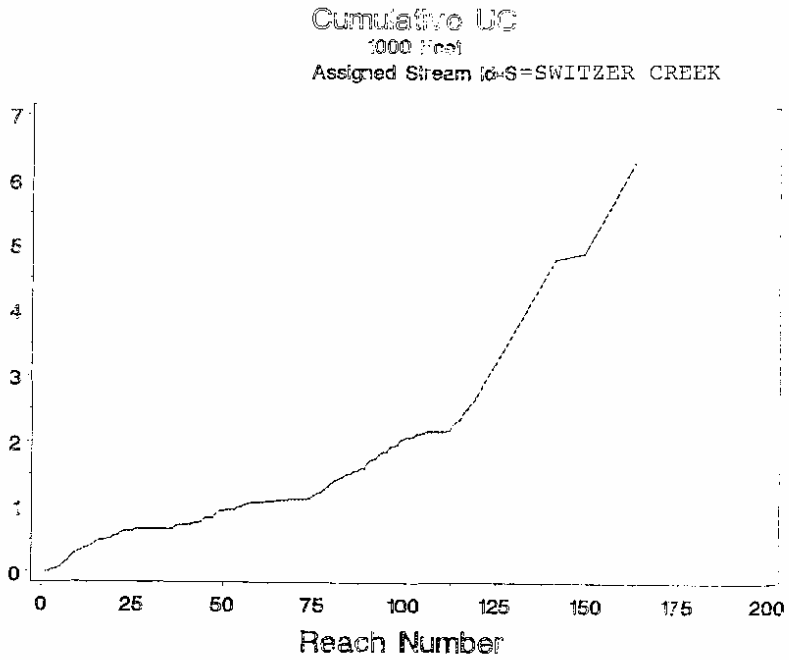


Figure F (cont'd)

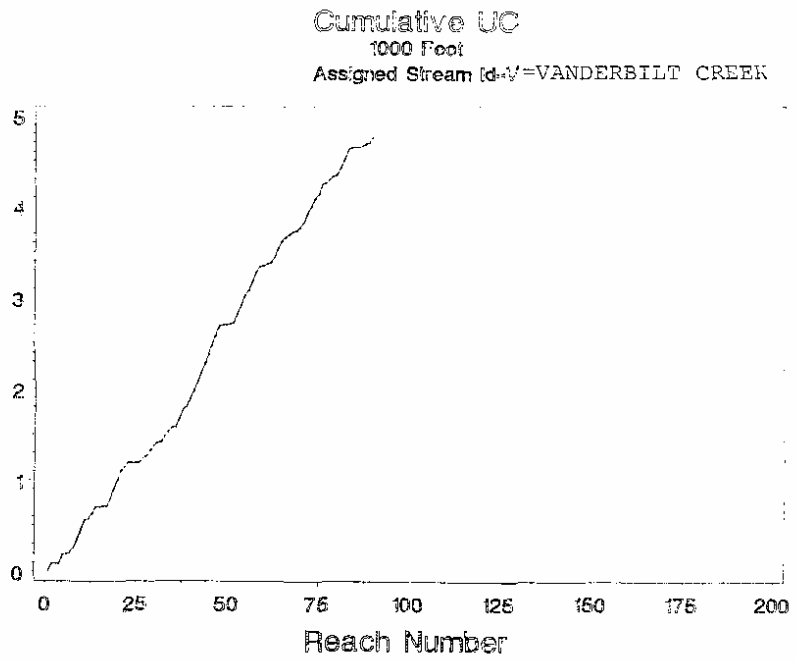


Figure F (cont'd)

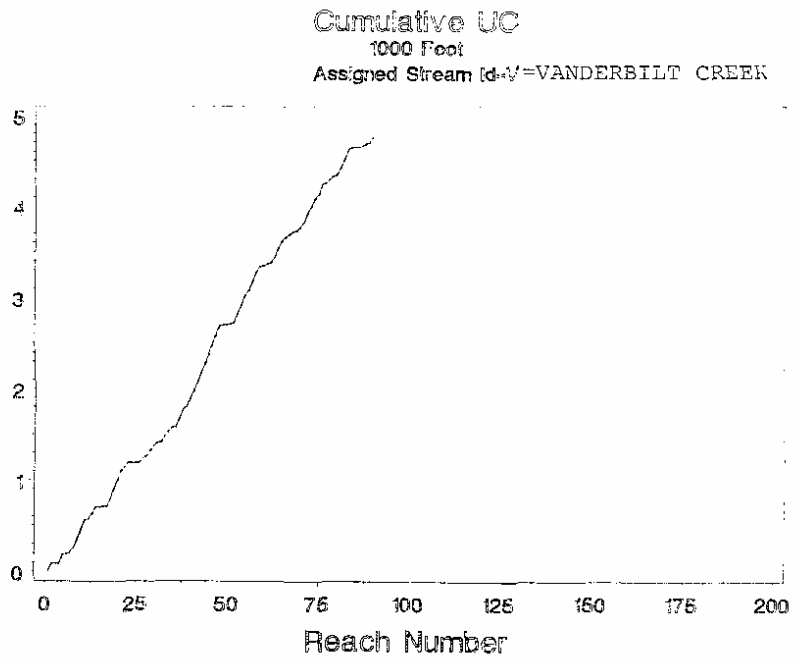
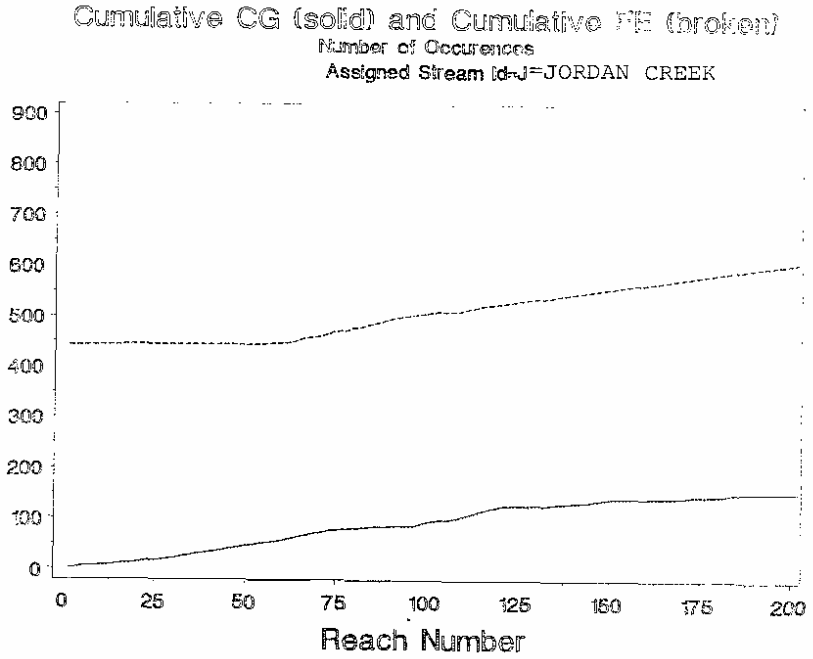


Figure G


Cumulative CG (solid) and Cumulative FE (broken)
Number of Occurences
Assigned Stream Id-J=JORDAN CREEK
900
800
700
600
500
400
300
200
100
0
0
25
50
75
100
125
150
175
200
Reach Number

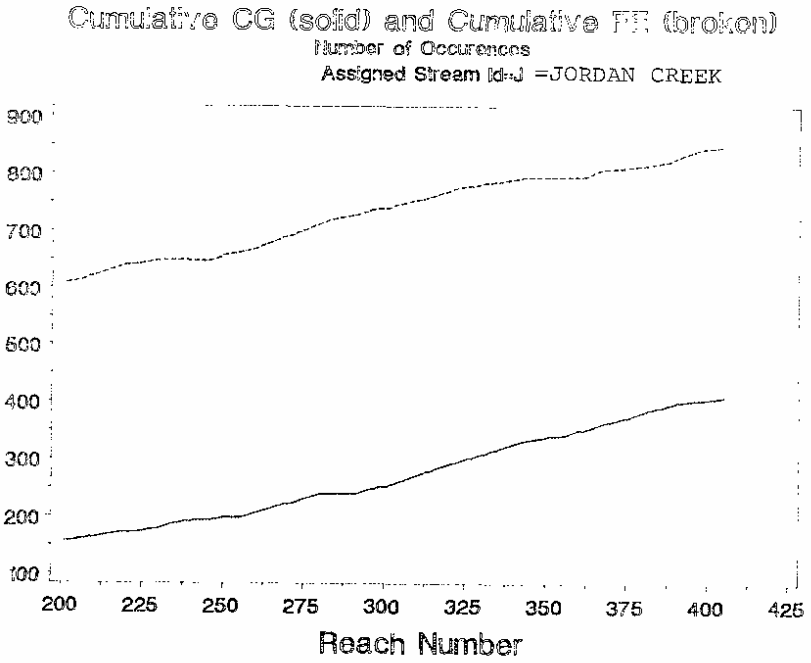
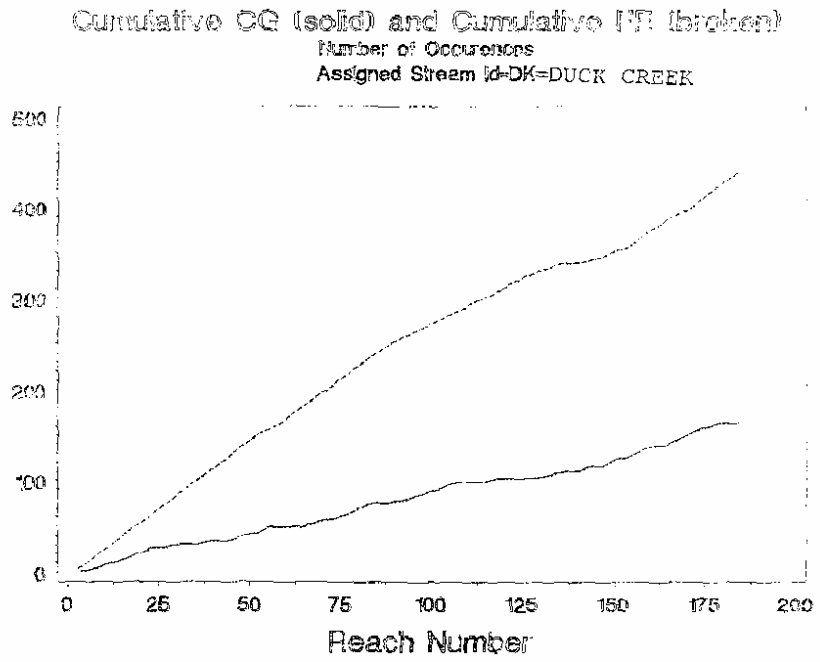

Cumulative CG (solid) and Cumulative FE (broken)
Number of Occurences
Assigned Stream Id-J =JORDAN CREEK
900
800
700
600
500
400
300
200
100
200
225
250
275
300
325
350
375
400
425
Reach Number

Figure G (cont'd)



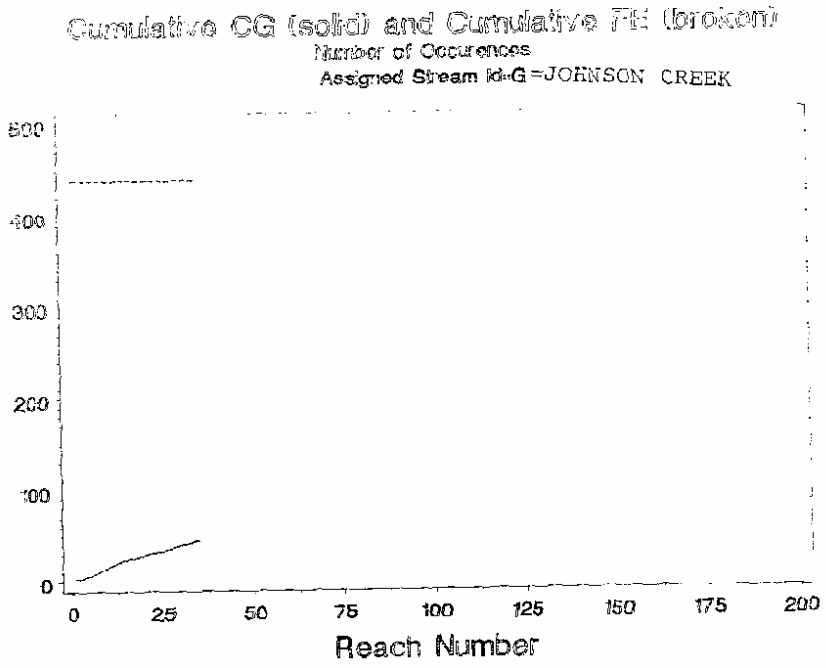
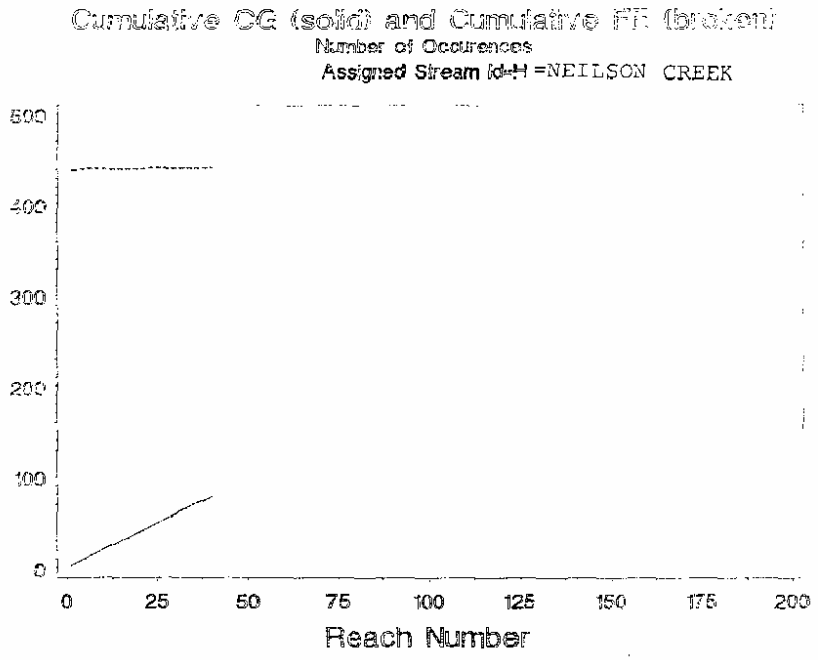


Figure G (cont'd)



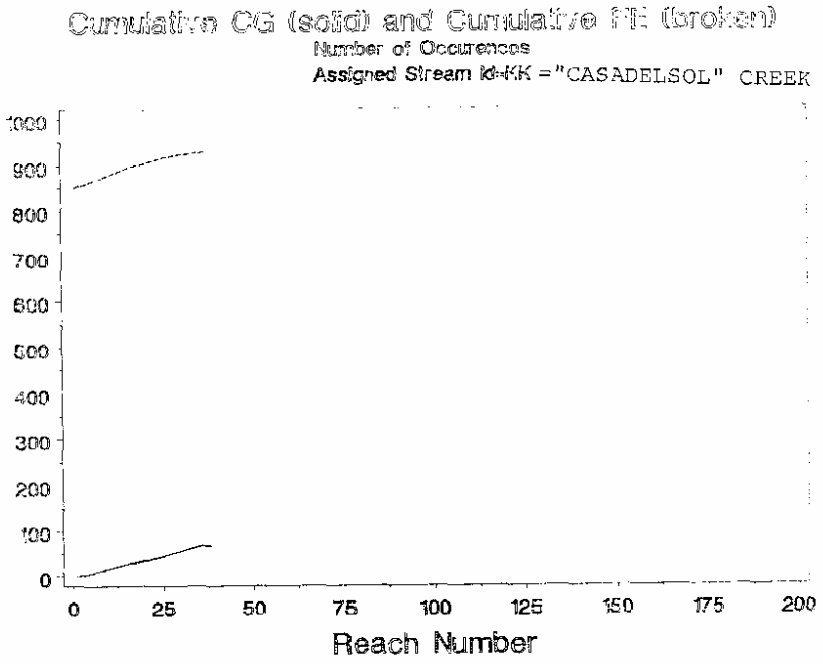
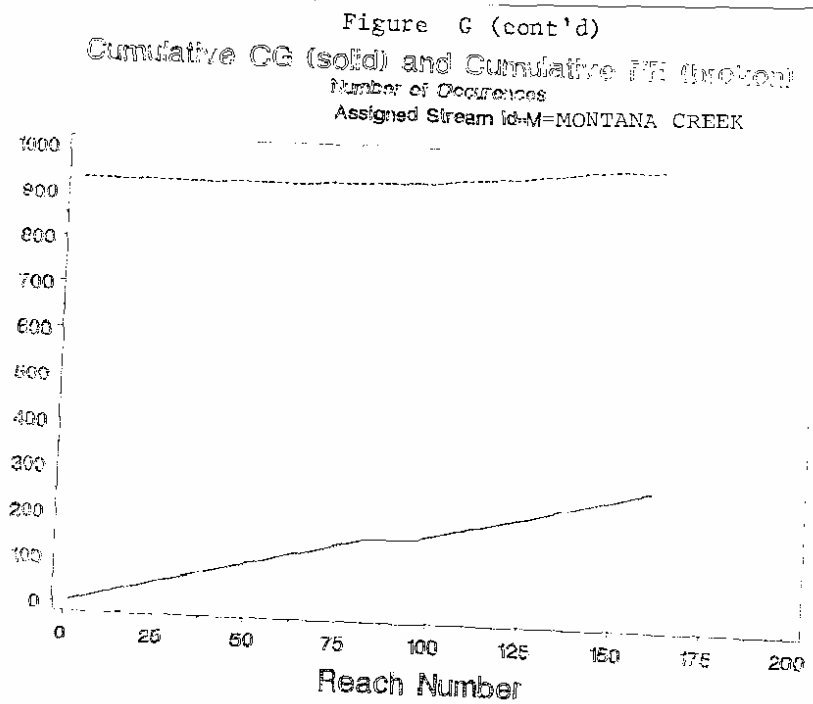


Figure G (cont'd)



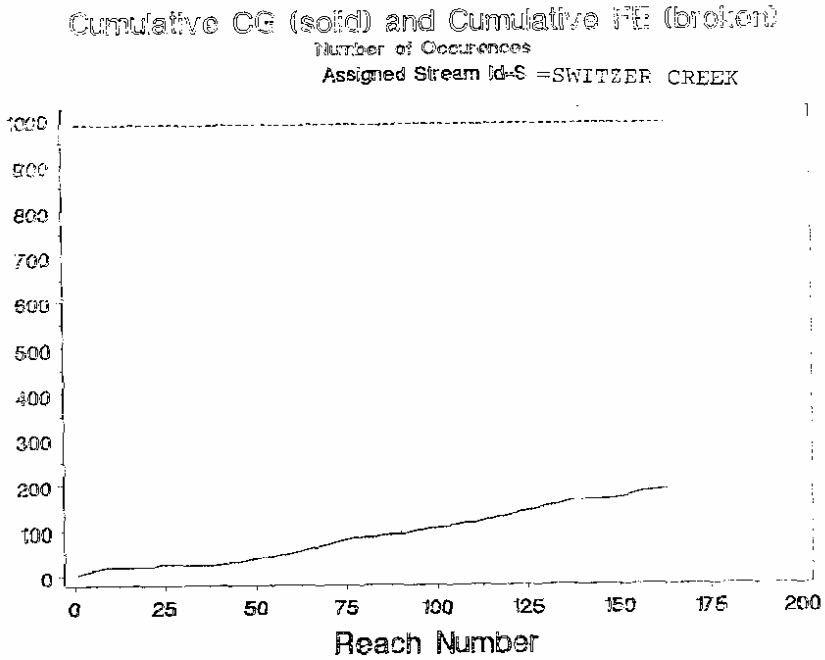
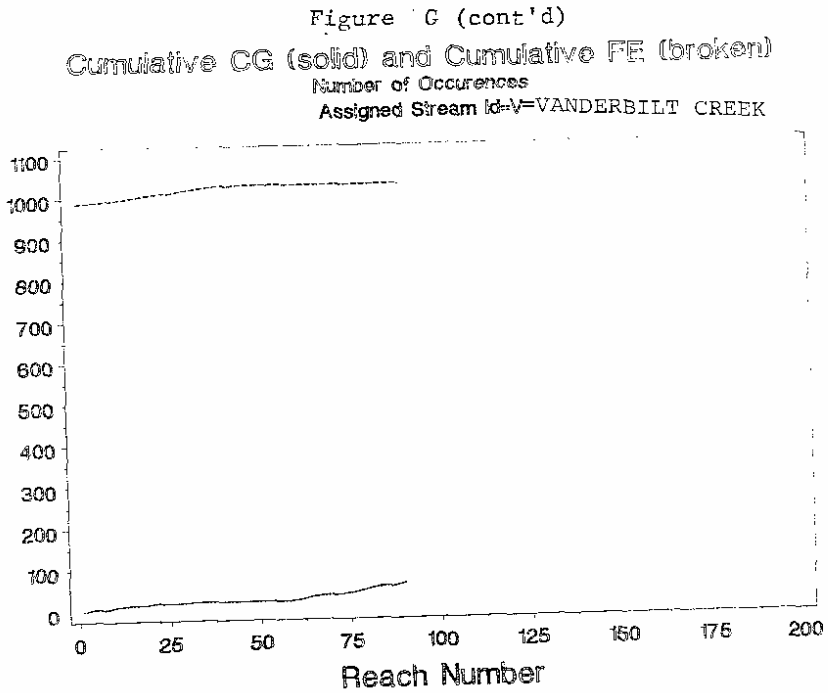


Figure G (cont'd)



APPENDIX B

Appendix B. Estuarine and Airport Wetlands: Bird Species Lists and Dependency.

The following pages contain species lists for each estuarine/airport wetland. Each wetland number (locations are shown in map appendix) is followed by two lists. The "Most Dependent Species" list contains species which were more numerous (per visit) at the noted wetland than at any other study area estuarine wetland during any or all seasons during the 12-month US Fish and Wildlife Service survey in 1986-87 (See Section 2.1.6, Methods). Species present at no wetland more than once in 1986 were excluded. The second list ("Other Waterbird Species") contains all species seen at least once. Songbirds were excluded unless they occurred in the wetland between June 6 - July 7, indicating probable breeding. Data from ARA, Inc. and ADFG surveys was included in the second list.

Next to each entry is the percentage of all observer visits to the wetland at which any number of individuals of the species was noted. This, also, is an indication of dependency on the particular area. For dependent species, the season(s) of greatest (relative to other wetlands) dependence are abbreviated as follows:

w = winter (Jan. 8 - Feb. 10, 1987)
lw = late winter (Feb. 19- Apr. 8, 1986)
s = spring (Apr. 14 - Jun. 11, 1986)
esu = early summer (June 15 - July 7, 1986)
lsu = late summer (July 15 - Aug. 27, 1986)
ef = early fall (Sept. 9 - Nov. 20, 1986)
lf = late fall (Nov. 28, 1986 - Jan. 2t 1987)

Also note that three species (Canada Goose, Mallard, Bald Eagle) have an asterisk. This is intended to highlight their importance as described in Section 2.2.7.

The concept of dependency, as used here as a rating criterion, must be qualified. A few species (e.g., Belted Kingfisher) have less tendency to congregate than others, and may feed opportunistically over a wide area, making them particularly vulnerable to cumulative impacts. Most-dependent-use areas for such species were often difficult to identify. Moreover, even species which occur predictably in a few areas may be sensitive to water quality or disturbing activities which originate in adjoining wetlands, as well as adjoining upland.

ES1: Most Dependent Species: Bufflehead-40.5% - lw, lf, v; Bald Eagle immatures**-8.3% - lw; Bald Eagle adults**- 26.2% - lw, esu, lf; Barrow's Goldeneye-4.8% - s; Goldeneye sp.-29.8% - lw, s, lf; Common Merganser-6% - s; Shorebird sp.-3.6% - s; Trumpeter Svan-2.0% - lw; Belted Kingfisher-3.6% - esu.

Other Waterbird Species: Canada Goose**- 15.5; Green-Winged Teal - 8.3%; Mallard** - 35.7%; Pintail - 2.0%; American Wigeon - 2.0%; Scaup - 9.5%; Surf Scoter - 2.3%; White-Winged Scoter - 2.0%; Common Goldeneye r - 13.1%; Barrow's Goldeneye - 11.9%; Bufflehead-13.1 %; Greater Yellowlegs - 8.3%; 'Lesser Yellowlegs - 2.4%; Western Sandpiper - 2.4%; Pectoral Sandpiper - 2.0%; Dowitcher 2.4%; Bonaparte's Gull - 3.6%; Mew Gull - 22.6%; Herring/ Thayer's Gull - 2.0%; Glaucous-Winged Gull - 3.0%; Arctic Tern - 11.9%; Belted Kingfisher - 17.1%; Water Pipit - 2.0%; Northwestern Crow 3.1%; Common Raven - 25.0%; Song Sparrow - 3.6%; Violet-Green Swallow - 6.0%; Cinnamon Teal - 2.%; Robin - 2.0%; Savannah Sparrow - 2.4%; Rufous Hummingbird - 2.%; Red-Winged Blackbird* - 2.0%.

ES2: Most Dependent Species: Canada Goose** - 42.2% - s, esu, lf, w; Green-Winged Teal - 3.6% - s; Mallard** - 30.1% - s, w; Pintail - 4.8% - s; Scaup - 15.7% — S.W; Bufflehead - 39.7% - s; Bald Eagle adults** - 30.1% - s; Greater Yellowlegs - 12.0% - s, lsu; Shorebird sp. - 6.0% - s, lsu; Arctic Tern - 6.0%, s; Dowitcher 3.6% - lsu; Bonaparte's Gull - 10.8% - lsu, ef; Trumpeter Swan - 1.2% - s.

Other Waterbird Species: Common Snipe - 1.2%; Blue-winged Teal - 2.1%; Northern Shoveler - 4.8%; Red-Winged Blackbird* - 1.2%; Mew Gull - 15.6%; Glaucous-Winged Gull - 37.3%; Arctic Tern - 9.6%; Belted Kingfisher - 2.4%; Barn Swallow - 1.2%; Northwestern Crow - 28.9%; Song Sparrow - 14.5%; Common Raven - 26.5%; Violet-Green Swallow - 2.4%; Savannah Sparrow - 6.0%; N.Phalarope - 1.2%; Junco - 1.2%; Rufous Hummingbird - 3.6%; Robin - 3.6%; American Wigeon - 1.2%; Scaup - 10.8%; Surf Scoter - 1.2%; Common Goldeneye - 4.8%; Barrow's Goldeneye - 8.4%; Common Merganser - 4.8%; Bald Eagle immatures** - 6.0%; Northern Harrier - 3.6%; Semipalmated Plover - 1.2%; Lesser Yellowlegs - 1.2%; Least Sandpiper - 1.2%; Peregrine Falcon - 1.2%.

ES3 (M1B): Most Dependent Species: Bald Eagle adults** - s, w - 19.7%; Bald Eagle immatures** - 17.0% - w.

Other Waterbird Species: Canada Goose** - 7.0%; Green-Winged Teal - 4.2%; Mallard** - 18.3%; Pintail - 2.8%; Oldsquaw - 1.4%; Greater Yellowlegs - 5.6%; Pectoral Sandpiper - 5.5%; Goldeneye sp. - 4.2%; Common Snipe - 1.4%; Glaucous-Winged Gull - 18.3%; Arctic Tern - 7.0%; Belted Kingfisher - 2.8%; Barn Swallow - 1.4%; Northwestern Crow - 42.3%; Song Sparrow - 28.2%; Raven - 28.2%; Canvasback - 1.4%; Violet-Green Swallow - 1.4%; Savannah

Sparrow - 8.5%; Chestnut-Backed Chickadee - 1.4%; Ruby-crowned Kinglet - 2.8%; Yellow Warbler - 1.4%; Robin - 2.8%; Rufous Hummingbird - 5.6%. Northern Harrier - 4.2%; Red-Winged Blackbird* - 2.8%; Pine Siskin - 2.8

ES4 (MlC): Most Dependent Species: Shorebird 8p. - 3.3% - ef. Other Waterbird Species: Killdeer* - 1.6%. Dowitcher - 1.6%; Mew Gull - 1.6%; Glaucous-Winged Gull - 1.6%; Belted Kingfisher - 13,1%; Tundra Swan - 1.6%; Northwestern Crow - 18.0%; Dipper - 1.6%; Junco - 1.6%; Mallard**; Savannah Sparrow - 1.6%; Common Raven - 6.6%; Song Sparrow - 1.6%; Canada Goose** - 9.8%.

ES5: Most Dependent Species: None. Other Waterbird Species: Killdeer* - 1.1%; Northern Harrier - 3.4%. Dowitcher - 5.7%; Common Snipe - 2.3%; Bonaparte's Gull - 6.8%; Mew Gull - 3.4%; Glaucous-Winged Gull - 18.2%; Arctic Tern - 13.6%; Belted Kingfisher - 4.9%; Barn Swallow - 1.1%; Northwestern Crow - 27.3%; Merganser Sp. - 1*1%; Song Sparrow - 27.3%; Raven - 14.8%; Shorebird spp. - 1.1%; Savannah Sparrow - 6,8%; Robin - 5.7%; Violet-Green Swallow - 1.1%; Rufous Hummingbird - 1.1%; Trumpeter Swan - 1.1%; Canada Goose** - 44.3%; Mallard, Green-Winged Teal, American Wigeon.

ES6 (MIA): Most Dependent Species: Greater Yellowlegs - 4.8% - esu.

Other Waterbird Species: Common Raven - 7.1%; Dowitcher 2.4%: Tundra Swan - 2.4%; Northwestern Crow - 16.7%; Song Sparrow - 23.8%; Violet-Green Swallow - 2.4%; Dipper - 2.4%; Arctic Tern - 7.1%; Bank Swallow - 2.4%; Ruby-Crowned Kinglet - 4.8%; Varied Thrush - 4.8%; Robin - 2.4%; Savannah Sparrow - 4.8%; Belted Kingfisher - 9.5%; Rufous Hummingbird - 2.4%; Glaucous- winged Gull - 2.4%; Mew Gull - 2.4%; Bufflehead - 4.8%.

ES7: Most Dependent Species: Canada Goose** - 11.5%; Mallard** - 35.9%.

Other Waterbird Species: Red-Winged Blackbird* - 2.6%; Short-Eared Owl* - 1.3%. Green-Winged Teal - 2.6%; Pintail - 5.1%; American Wigeon - 3.8%; Scaup - 10.3%; Common Goldeneye - 1.3%; Goldeneye sp. - 11.7%; Bufflehead - 28.2%; Bald Eagle adults** - 19.2%; Bald Eagle immatures** - 3.8%; Greater Yellowlegs - 12.8%; Shorebird sp. – 3.8%; Western Sandpiper - 1.3%; Glaucous-Winged Gull - 28.2%; Northwestern Crow - 21.8%; Raven - 10.3%; Dowitcher 3.8%; Mew Gull – 6.4%; Arctic Tern - 10.3%; Barn Swallow - 2.6%; Savannah Sparrow - 3.8%; Belted Kingfisher - 2.6%; Fox Sparrow - 1.3%; European Starling - 2.6%; Robin - 1.3%; Song Sparrow - 6.4; Bonaparte's Gull - 5.1%; Rufous Hummingbird - 1.3%.

ES8 (M1): Most Dependent Species: Trumpeter Swan - 1.4% - lw; Scaup - 5.5% - s; Bufflehead - 12.3% - s; Arctic Tern - 11.0% - lsu; Common Merganser - 8.2% - w.

Other Waterbird Species: Canada Goose** - 17.8%; Great Blue Heron - 1.4%; Mallard** - 15.0%; Barrow's Goldeneye - 5.5%; Bald Eagle adults** - 6.8%; Bald Eagle immatures** - 1.4%; Goldeneye sp. - 13.7%; Common Goldeneye - 13.7%; Pintail - 4.1%; Surf Scoter - 1.4%; Greater Yellowlegs - 2.7%; Shorebird sp. - 1.4%; Green-Winged Teal - 1.4%; American Wigeon - 9.6%; Glaucous-Winged Gull - 18.2%; Crow - 4.1%; Raven - 4.1%; Mew Gull - 4.1%; Arctic Tern - 8.2%; Belted Kingfisher - 6.8%; 7%; Violet-green Swallow - 1.4%; Savannah Sparrow - 1.4%; Robin - 1.4%; Bonaparte's Gull - 4.1%; Tree Swallow - 1.4%.

ES9 (M4): Most Dependent Species: Scaup - 6.9% - lw; Bufflehead - 20.8% - lw, s; Green-Winged Teal - 8.3% - lsu; Mallard** - 25.0% - lsu, ef; American Wigeon - 8.3% - ef; Trumpeter Swan - 5.5% - ef.

Other Waterbird Species: Northwestern Crow - 12.5%; Arctic Tern - 8.3%; Tree Swallow - 2.8%; Northern Shoveler - 1.4%; Blue-winged Teal - 1.4%; Violet-green Swallow - 1.4%; Savannah Sparrow - 1.4%; Belted Kingfisher - 5.5%; Bank Swallow - 1.4%; Song Sparrow - 1.4%; Bonaparte's Gull - 1.4%; Canada Goose** - 12.5%.

ES10: Most Dependent Species: None.

Other Waterbird Species: Short-Eared Owl* - 1.8%; Canada Goose** - 10.5%; Bufflehead - 10.5%; Goldeneye sp. - 1.8%; Mallard** - 40.4%; Greater Yellowlegs - 7.0%; Scaup - 1.8%; Green-Winged Teal - 5.3%; Western Sandpiper - 1.8%; Pintail - 3.8%; American Wigeon - 7.0%; Bald Eagle adults** - !.8%; Kestrel - 1.8%; Common Merganser - 3.5%; Belted Kingfisher - 10.5%; Northwestern Crow - 22.8%; Song Sparrow - 7.0%; Savannah Sparrow - 1.8%; Barn Swallow - 1.8%; Rufous Hummingbird - 1.8%; Common Snipe - 3.5%; Trumpeter Swan - 1.8%.

ES11: Host Dependent Species: None.

Other Waterbird Species: Killdeer* - 1.9%; Northwestern Crow - 27.4%; Glaucous-Winged Gull - 3.9%; Arctic Tern - 5.8%; Belted Kingfisher - 3.9%; Tree Swallow - 1.9%; Song Sparrow - 9.8%; Savannah Sparrow - 5.8%; Common Snipe - 3.9%; European Starling - 1.9%; Bonaparte's Gull - 1.9%; Barn Swallow - 1.9%; Rufous Hummingbird – l.9%; Raven - 11.7%; Canada Goose**.

ESI2: Most Dependent Species: None.

Other Waterbird Species: Red-Winged Blackbird* - 1.6%; Canada Goose** - 8.1%; Northern Harrier - 1.6%; Tree Swallow - 3.2%; Bald Eagle adults** - 3.2%; Kestrel - 1.6%; Bald Eagle immatures** - 1.6%; Crow - 27.8%; Raven - 19.6%; Song Sparrow - 16.3%; Savannah Sparrow - 21.3%; Pine Siskin 1.6%; Junco - 1.6%; Robin - 3.2%; Belted Kingfisher - 3.2%; Barn Swallow - 4.9%; Violet-green Swallow - 1.6%; Common Snipe - 3.2%; Glaucous-Winged Gull - 4.9%.

ES13 (M2): Most Dependent Species: Scaup - 7.1% - lw,s; Tundra Swan - 2.8% - s; Pintail - 2.8% - s; Trumpeter Swan - 4.2% - 8, lsu, w; Mallard** - 45.7% - lsu; Bald Eagle immatures** - 5.7% - lf.

Other Waterbird Species: Glaucous-Winged Gull - 8.5%; Common Merganser - 1.4%; Red-Breasted Merganser - 2.8%; Arctic Tern - 5.72; Belted Kingfisher - 4.2%; Barn Swallow - 1.4%; Crow - 8.5%; Song Sparrow - 2,8%; Raven - 7.1%; Canvasback - 1.4%; Savannah Sparrow - 1.4%; Bonaparte's Gull - 1,4%; Rufous Hummingbird - 1.4%; Mew Gull - 5.7%; Canada Goose** - 61.4%; Green-Winged Teal - 1.4%; Common Goldeneye - 4.2%; Bufflehead - 12.8%; Bald Eagle adults** - 4.2%; Goldeneye sp. - 10.0%; Barrow's Goldeneye - 2.8%; Northern Harrier - 1.4%; Scaup - 5.1%; Lesser Yellowlegs - 1.4%; American Wigeon - 4.2%; Semipalmated Plover - 1.4%; Greater Yellowlegs - 1.4%; Whimbrel - 1.4%; White-Winged Scoter - 1.4%; Common Loon - 1.4%.

ES14: Most Dependent Species: Mallard** - 41.1% - lw, wt esu, lf; Trumpeter Swan - 10.2% - s, lsu, w; American Wigeon - 2.92 - 1su.

Other Waterbird Species: Red-Winged Blackbird* - 2.9%; Glaucous-Winged Gull - 32.3%; Raven - 11,7%; Mew Gull - 2.9%; Arctic Tern - 2.9%; Water Pipit - 1.4%; Northwestern Crow - 10.2%; Song Sparrow - 8.S%; Savannah Sparrow - 2.9%; Dowitcher 1.4%; Bonaparte's Gull - 5.8%; Herring/Thayer's Gull - 1.4%; Belted Kingfisher - 2.9%; Rufous Hummingbird - 1.4%; Great Blue Heron - 7.3%; Pintail - 8,8%; Bufflehead - 13.2%; Bald Eagle immatures** - 7.3%; Bald Eagle adults** - 17.6%; Northern Harrier - 2.9%; Western Sandpiper 2.9%; Shorebird sp. - 7.3%; Greater Yellowlegs - 10.2%; Green-Winged Teal - 2.9%; Common Merganser - 2.9%; Barrow's Goldeneye 1.4%; Goldeneye sp. - 4.4%; Canada Goose** - 60.2; Scaup.

ES15: Most Dependent Species: None.

Other Waterbird Species: Red-Winged Blackbird* - 5.2%; Bald Eagle adults** - 63.1%; Canada Goose** - 10.5%; Mallard** - 21.0%; Northwestern Crow - 21.0%; Savannah Sparrow - 10.5%; Greater Yellowlegs - 5.2%; Glaucous-Winged Gul1 - 5.1%; Arctic Tern - 5.2%; Raven - 26.3%.

ES16: Most Dependent Species: Green-Winged Teal - 3.6% - s, ef; Bald Eagle immatures** - 7.2% - lsu; Bald Eagle adults** - 19.2% - lsu; Trumpeter Swan - 2.4%.

Other Waterbird Species: Red-Winged Blackbird* - 1.2%; Mallard** - 34.9%; Bufflehead - 13.2%; Goldeneye sp. - 6.0%; Glaucous-Winged Gull - 31.3%; Northwestern Crow - 16.8%; Raven - 10.8%; Canada Goose** - 20.4%; Greater Yellowlegs - 1.2%; Shorebird sp. - 2.4%; Bonaparte's Gull - 3*6%; Mew Gull - Scaup - 1.2%; Savannah Sparrow - 2.4%; Bank Swallow - 1.2%; European Starling - 1.2%; Western Sandpiper 1.2%; Common Snipe - 2.4%;

Herring/Thayer's Gull - 3.6%; Barn Swallow - 1.2%; Song Sparrow - 2.4%; Common Goldeneye - 1.2%; Dowitcher 1.2%; Canada Goose** - 24.1%; American Wigeon.

ES17: Most Dependent Species: Goldeneye sp. - 12.5% - lw; Surf Scoter - 8.3% - s, Bald Eagle adults** - 20.8% - esu, ef Bufflehead - 33.3% - ef(Trumpeter Swan - 4.1% - w.

Other Waterbird Species: Mallard** - 29.1%; Common Merganser - 8.3%; Pintail - 4.1%; Scaup - 12.5%; Greater Yellowlegs - 8.3%; Barrow's Goldeneye - 8.2%; Bald Eagle immatures** - 8.3%; Green-Winged Teal - 8.3%; American Wigeon - 4.1%; Mew Gull - 45.8%; Glaucous-Winged Gull - 62.5%; Belted Kingfisher - 4.1%; Crow - 20.8%; Bonaparte's Gull - 16.6%; Herring/Thayer's Gull - 12.5%; Arctic Tern - 4.1%; Violet- green Swallow - 4.lt.

ES18: Most Dependent Species: Canada Goose** - 33.3% - lw; Mallard** - 40.0% - lw; Bald Eagle adults** - 40.0% - esu, w; Bald Eagle immatures** - 6.6% - w.

Other Waterbird Species: Pintail - 6.6%; Song Sparrow - 6.6%; 75.0%; Crow - 6.6%; Raven - 46.6%; Mew Gull - 6.6%; Glaucous- Winged Gull - 13.3%; Arctic Tern - 6.6%; Green - Winged Teal; Scaup, Surf Scoter.

ES19: Most Dependent Species: Bald Eagle immatures** - 7.1% - lw; Bald Eagle adults - 57.1% - lw.

Other Waterbird Species: Mallard** - 35.7%; Pintail - 14.2%; Bufflehead - 21.4%; Common Merganser - 21.4%; Goldeneye sp. - 35.7%; Green-Winged Teal - 21.4%; American Wigeon - 21.4%; Greater Yellowlegs - 7.1%; Oldsquaw - 7.1%; Surf Scoter - 21.4%; Mew Gull - 28.5%; Glaucous-Winged Gull 71.4%; Belted Kingfisher - 7.1%; Crow - 42.8%; Raven - 35.7%; Merganser - 14.2%; Bonaparte's Gull - 42.8%; Song Sparrow - 7.l%; Canada Goose***

ES21: Most Dependent Species: None.

Other Waterbird Species: Horned Grebe - 5.2%; Mallard** - 26.3%; Barrow's Goldeneye - 10.5%; Bufflehead - 15.7%; Common Merganser - 10.5%; Red-breasted Merganser - 5.2%; Belted Kingfisher - 31.5%; Bald Eagle adults** - 21.0%; Greater Yellowlegs - 5.2%; Crow - 26.3%; Raven - 10.5%; Song Sparrow - 5.2%; Barn Swallow - 5.2%; Great Blue Heron - 10.5%; Bald Eagle immatures** - 10.5%; Violet-green Swallow - 5.2%; American Wigeon - 10.5%.

Other Waterbird Species: Common Loon - 14.2%; Horned Grebe - 38.0%; Mallard** - l4.2%; Surf Scoter - 9.5%; Bufflehead - 42.87; Bald Eagle adults** - 47.6%; White-Winged Scoter - 4.7%; Common Goldeneye - 9.5%; Barrow's Goldeneye - 14,2%; Red-Breasted Merganser - 4.7%; Common Merganser - 9.5%; Bald Eagle immatures** - 4.7%; Mew Gull - 28.5%; Glaucous-Winged Gull - 52.3%; Crow - 23.8%; Violet Green Swallow - 4.7%; Arctic Tern - 4.7%; Barn Swallow - 4.7%; Bonaparte's Gull - 4.7%; Herring/Thayer's Gull - 4.7%; Raven - 4.7%.

ES23: Most Dependent Species: Bald Eagle adults** - 5.2% - lsu; Bald Eagle immatures** - 10.5% - lsu.

Other Waterbird Species: Canada Goose** - 10.5%; Mallard** - 26.3%; Scaup - 5.2%; Barrow's Goldeneye - 10.5%; Bufflehead - 21.0%; Goldeneye sp. - 31.5%; Common Merganser - 5.2%; Belted Kingfisher - 5.2%; Crow - 31.5%; Song Sparrow - 10.5%; Raven - 15.7%; Greater Yellowlegs - 5.2%; Western Sandpiper 5.2%; Robin - 5.2%; Violet-green Swallow 10.5%; Winter Wren - 5.2%; Barn Swallow - 5.2%; Great Blue Heron - 5.2%; Dowitcher 5.2%; Bonaparte's Gull - 5.2%; Mew Gull - 21.0%; Glaucous-Winged Gull - 84.2%; Herring/Thayer's Gull - 5.2%.

ES24: Most Dependent Species: Surf Scoter - 14.2% - s, w; Bald Eagle adults** - 19.0% - s, esu; Bald Eagle immatures** - 4.7% - esu; Common Merganser - 4.7% - ef; Goldeneye sp. - 9.5% - ef; Common Goldeneye - 9.5% - lf.

Other Waterbird Species: Great Blue Heron - 9.5%; Mallard** - 9.5%; White-Winged Scoter - 14.2%; Barrow's Goldeneye - 23.8%; Bufflehead - 33.3%; Shorebird sp. - 4.7%; Mew Gul1 - 38.0%; Glaucous-Winged Gull - 66.6%; Northwestern Crow - 33.3%; Red- breasted Merganser - 4.7%; Scaup - 4.7%; Bonaparte's Gull 4.7%; Violet-green Swallow - 4.7%; American Wigeon - 4,7%; Song Sparrow - 4.7%.

ES25: Most Dependent Species: Merganser spp. - 10.0% - lw; Surf Scoter - 10.0% - s; Bald Eagle immatures** - 5.0% - esu; Bald Eagle adults** - 35.0% - esu; Mallard** - 15.0% - w.

Other Waterbird Species: Common Goldeneye - 10.0%; Barrow's Goldeneye - 10.0%; Great Blue Heron - 10.0%; Northern Harrier - 5.0%; Common Merganser - 15.0%; Canada Goose** - 5.0%; Oldsquaw - 5.0%; Mew Gull - 30.0%; Glaucous-Winged Gull - 60%; Crow - 25.0%; Bonaparte's Gull 10.0%; Arctic Tern - 5.0%; Violet-green Swallow - 5.0%; Herring/Thayer's Gull - 5.0%.

ES26: Most Dependent Species: Surf Scoter - 20.0% - lw, s; Common Goldeneye - 15.0% - lw, w; Barrow's Goldeneye - 25.0% - lw, lf; Oldsquaw - 10.0% - w. Eagle adults** - 60%; Mew Gull - 35%; Glaucous-Winged Gull - 65.8%; Crow - 15.0%; Red-breasted Merganser - 102; Horned

Grebe – 5%; Bald Eagle immatures** - 15%; Semipalmated Plover - 5.0%; Greater Yellowlegs - 5.0%; Western Sandpiper - 5.0%; Bonaparte's Gull - 5.0%; Arctic Tern - 20.0%; Great Blue Heron - 5.0%; Violet-green Swallow - 10.0%; Caspian Tern - 5.0%; Barn Swallow - 5.0%; Common Merganser - 20.0%; Belted Kingfisher - 5.0%; White-Winged Scoter – 10.0%; Herring/ Thayer's Gull - 5.0%; Raven - 5.0%; Surf Scoter - 5.0%; Bald Eagle - 5.0%; Crow - 5.0%; Canada Goose**, Mallard, American Wigeon, Green-Winged Teal.

ES27: Most Dependent Species: Bald Eagle adults** - 61.9% - s; Bufflehead - 28.5% - w; Common Merganser - 14.2% - w.

Other Waterbird Species: Mallard** - 47.6%; Scaup - 4.7%; Greater Yellowlegs - 4.7%; Goldeneye sp, - 38.0%; Mew Gull - 28.5%; Glaucous-Winged Gull - 69.2%; Red-breasted Merganser - 4.7%; Green-Winged Teal - 9.5%; Arctic Tern - 19.5%; Caspian Tern - 4.7%; Crow - 14.2%; Bald Eagle immatures** - 23.8%; Shorebird sp. - 4.7%; Violet-green Swallow - 4.7%; Common Snipe - 4.7%; Herring/Thayer's Gull - 4.7%; Raven - 4.7%; Canada Goose** - 9.5%; Surf Scoter - 14.2%; Bonaparte's Gull - 4.7%; Canada Goose**, American Wigeon.

ES28: Most Dependent Species: None.

Other Waterbird Species: Canada Goose** - 13.3%; Mallard** - 33.3, Bald Eagle immatures** - 6.6%; Surf Scoter - 6.6%; Bald Eagle adults** - 26.6%; Arctic Tern - 6.6%; Northern Harrier - 6.6%; Mew Gull - 6.6%; Herring/Thayer's Gull - 6.6%; Glaucous- Winged Gull - 26.6%; Bonaparte's Gull - 6.6%; Bufflehead - 6.6%; Common Merganser - 6.6%.

ES29: Most Dependent Species: None.

Other Waterbird Species: Canada Goose** - 26.3%; Mallard** - 31.5%; Bald Eagle adults** - 31.5%; Goldeneye sp. - 10.5%; Northern Harrier - 5.2%;, Greater Yellowlegs - 5.2%; Bald Eagle immatures** - 5.2%; Bufflehead - 42.1%; Semipalmated Plover - 5.2%; Common Merganser - 21.0%; Common Snipe - 10.5%; Glaucous-Winged Gull - 26.3%; Northwestern Crow - 10.5%; Arctic Tern - 5.2%; Savannah Sparrow - 10.5%; Lincoln's Sparrow - 5.2%; Song Sparrow - 5.2%; Great Blue Heron - 5.2%; Herring/Thayer's Gull - 10.5%; Glaucous-Winged Gull - 21.0%; Raven - 15.7%; Mew Gull - 5.2%; Bonaparte's Gull - 5.2%; American Wigeon.

ES30: Most Dependent Species: None*

Other Waterbird Species: Mallard** - 40.0%; Bufflehead - 33.3%; Bald Eagle adults** - 33.3%; American Wigeon - 6.6%; Arctic Tern - 6,6%; Raven - 26.6%; Northern Harrier - 6.6%; Gull - 2.0%; Bonaparte's Gull - 6.6%; Barrow's Goldeneye - 6.6%; Common Merganser - 13.3%.

ES31: Most Dependent Species: None.

Other Waterbird Species: Mallard** - 11.7%; American Wigeon - 5.8%; Common Merganser - 17.8%; Goldeneye sp. - 5.8%; Barrow's Goldeneye - 5.8%; Bald Eagle adults** - 23.5%; Greater Yellowlegs - 5.8%; Mew Gull - 17.6%; Glaucous-Winged Gull - 35.2%; Bonaparte's Gull - 5.8%; Herring/Thayer's Gul1 - 5.8%; Northwestern Crow - 5.8%; Raven - 23.5%; Bald Eagle immatures** - 11.7%; Bufflehead - 29.4%.

ES32: Most Dependent Species: None.

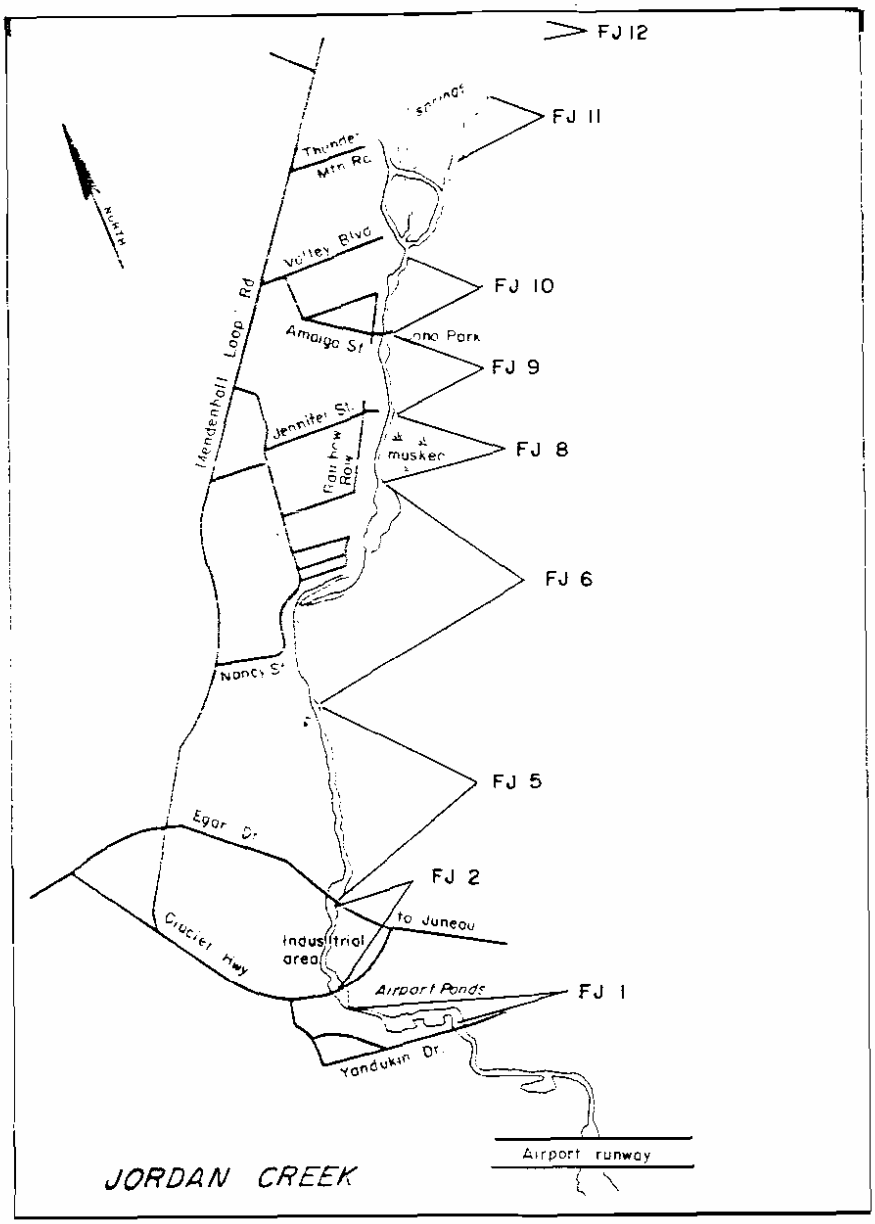
Other Waterbird Species: Mallard** - 5.8%; Bufflehead - 35.2%; Bald Eagle immatures** - 17.6%; Bald Eagle adults** - 17.6%; Greater Yellowlegs - 11.7%; Mew Gull - 23.5%; Glaucous-Winged Gull - 35.2%; Crow - 11.7%; Red-breasted Merganser - 11.7%; Common Goldeneye - 11.7%; Arctic Tern - 11.7%; Herring/ Thayer's Gull - 11.7%; Raven - 23.5%; Barrow's Goldeneye - 5.8%; Common Merganser - 5.8%.

ES33: Most Dependent Species: None.

Other Waterbird Species: Mallard** - 29.4%; Scaup - 17.6%; Surf Scoter - 11.7%; Barrow's Goldeneye - 11.7%; Bufflehead - 41.1%; Glaucous-Winged Gull - 17.6%; Crow - 11.7%; Raven - 11.7%; Red-breasted Merganser - 11.7%; Common Goldeneye - 5.8%; Arctic Tern - 5.8%; Bald Eagle adults** - 29.4%; Common Merganser - 23.5%; Mew Gull - 5.8%; Herring/Thayer's Gull - 5.8%; Killdeer* - 17.6%; Bald Eagle immatures** - 5.8%.

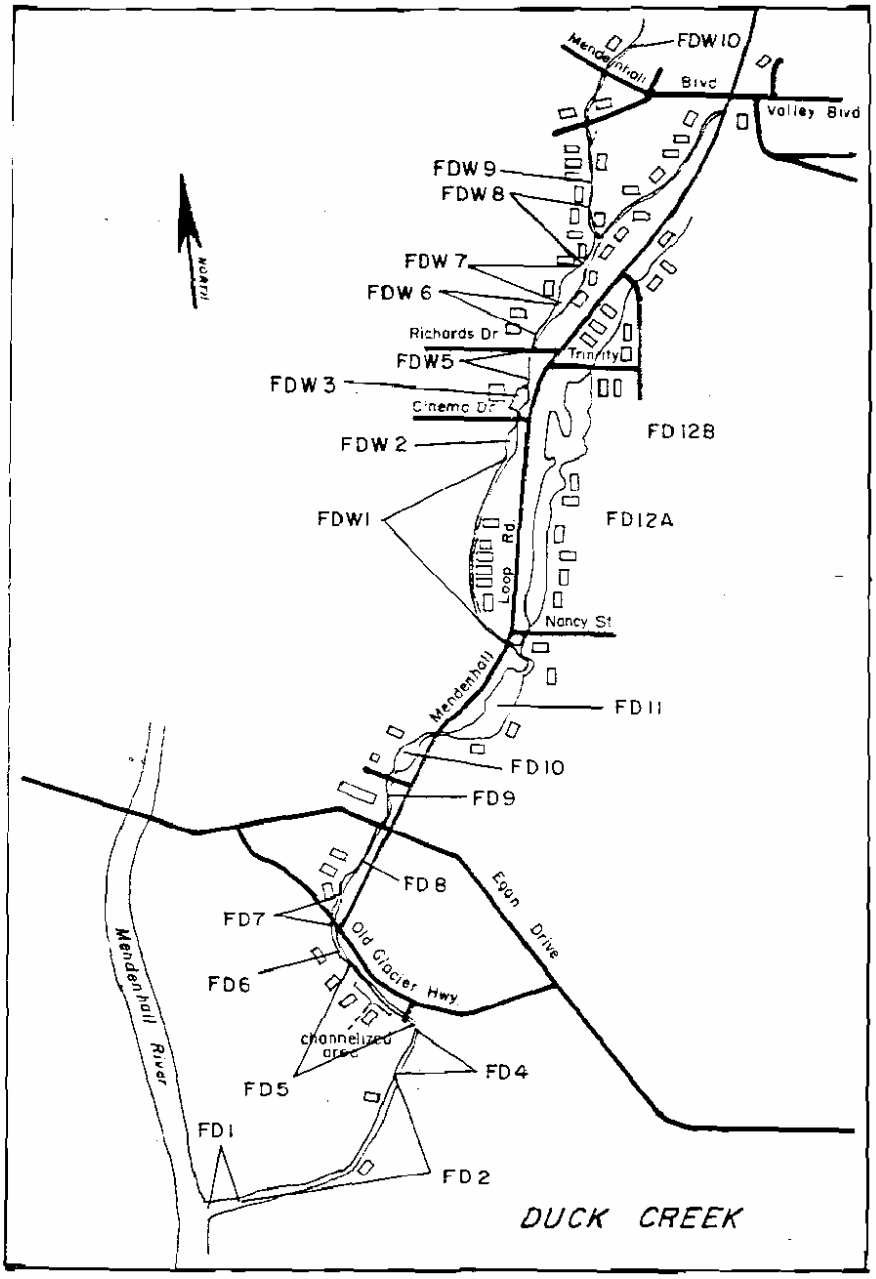
APPENDIX C

Simulation results for surface hydrology:
Jordan, upper, and lower Duck Creeks.



Stream reach identification codes used in hydrologic simulation

C-2

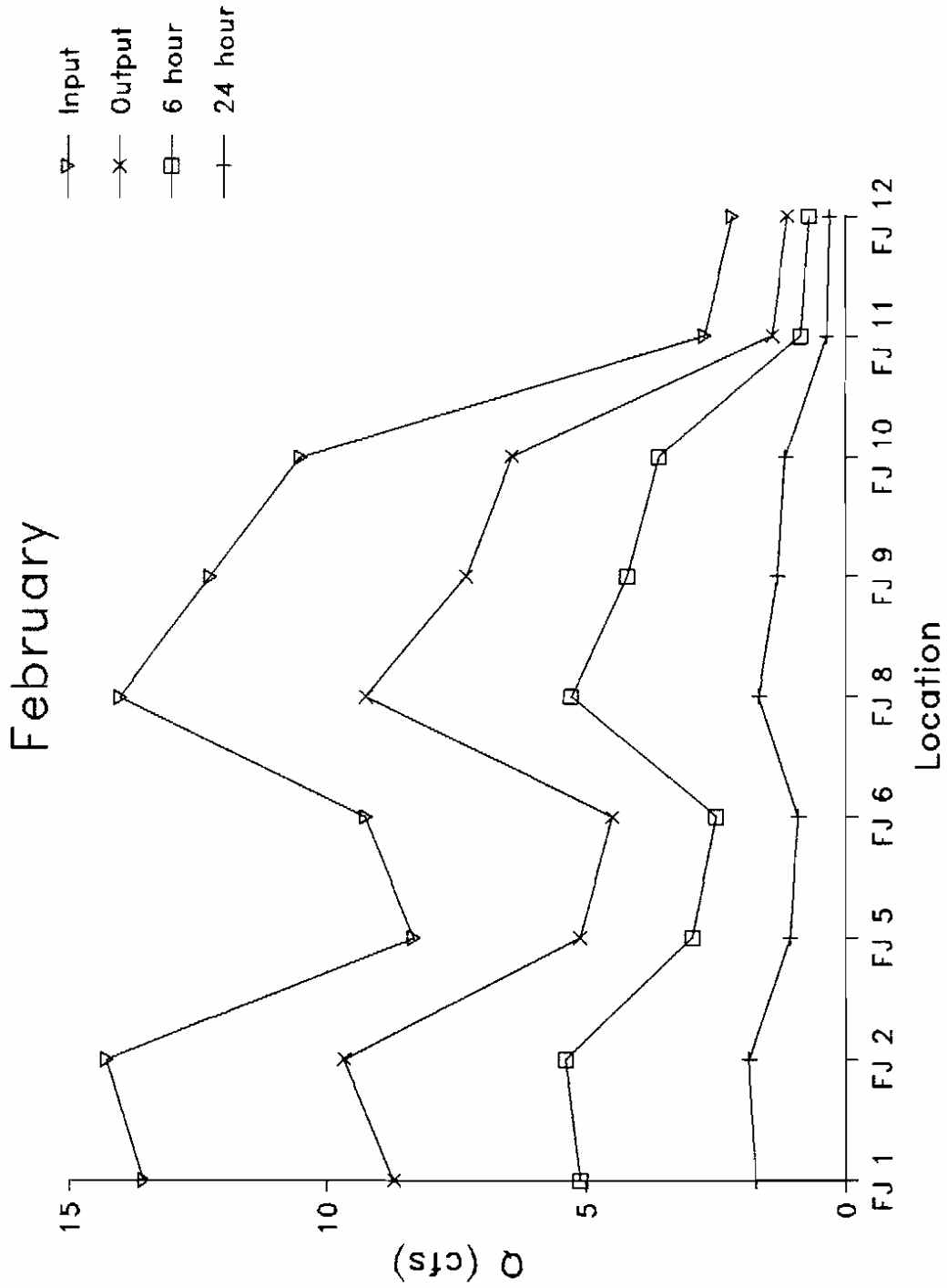


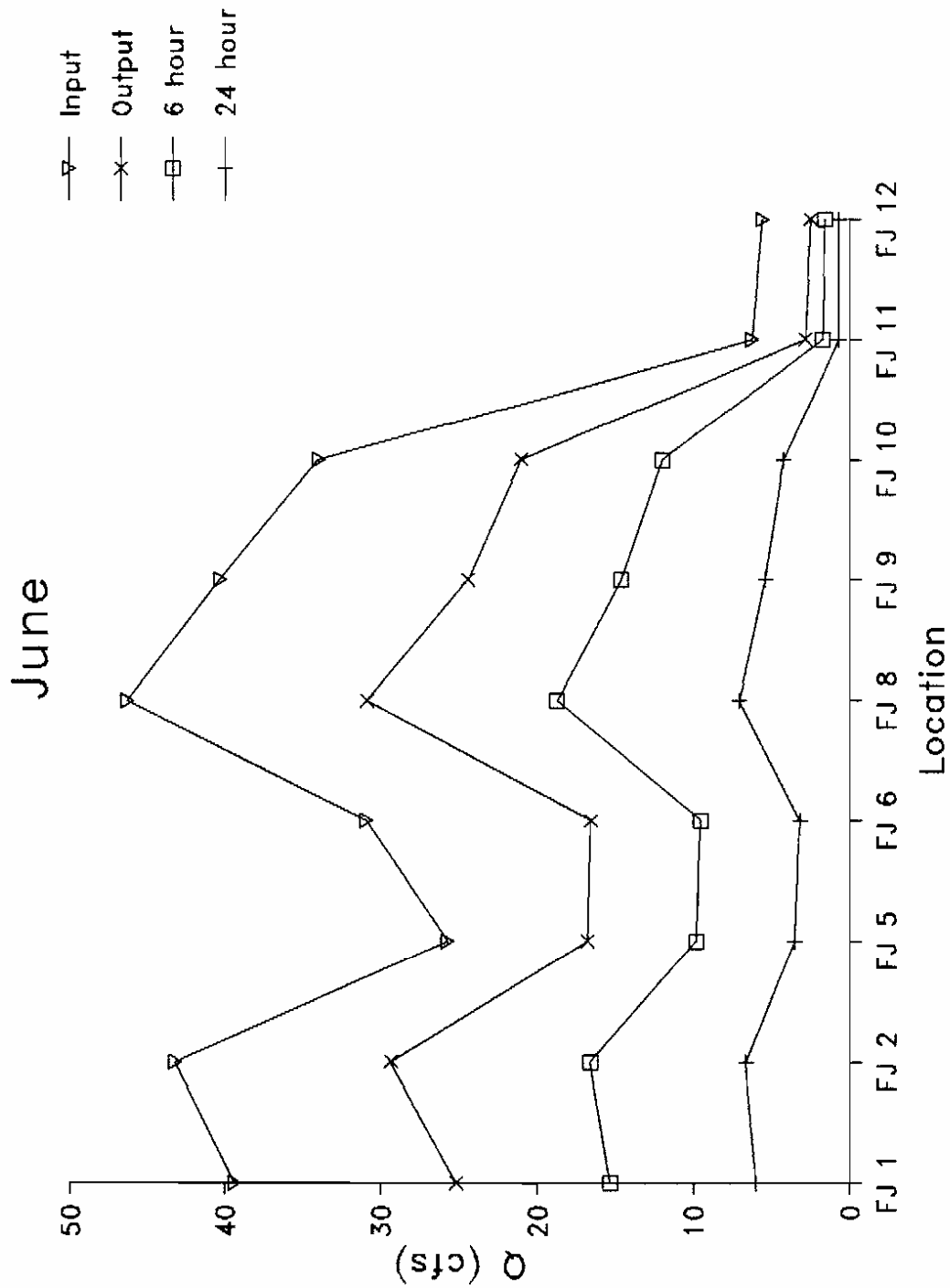
Stream reach identification codes used in hydrologic simulation

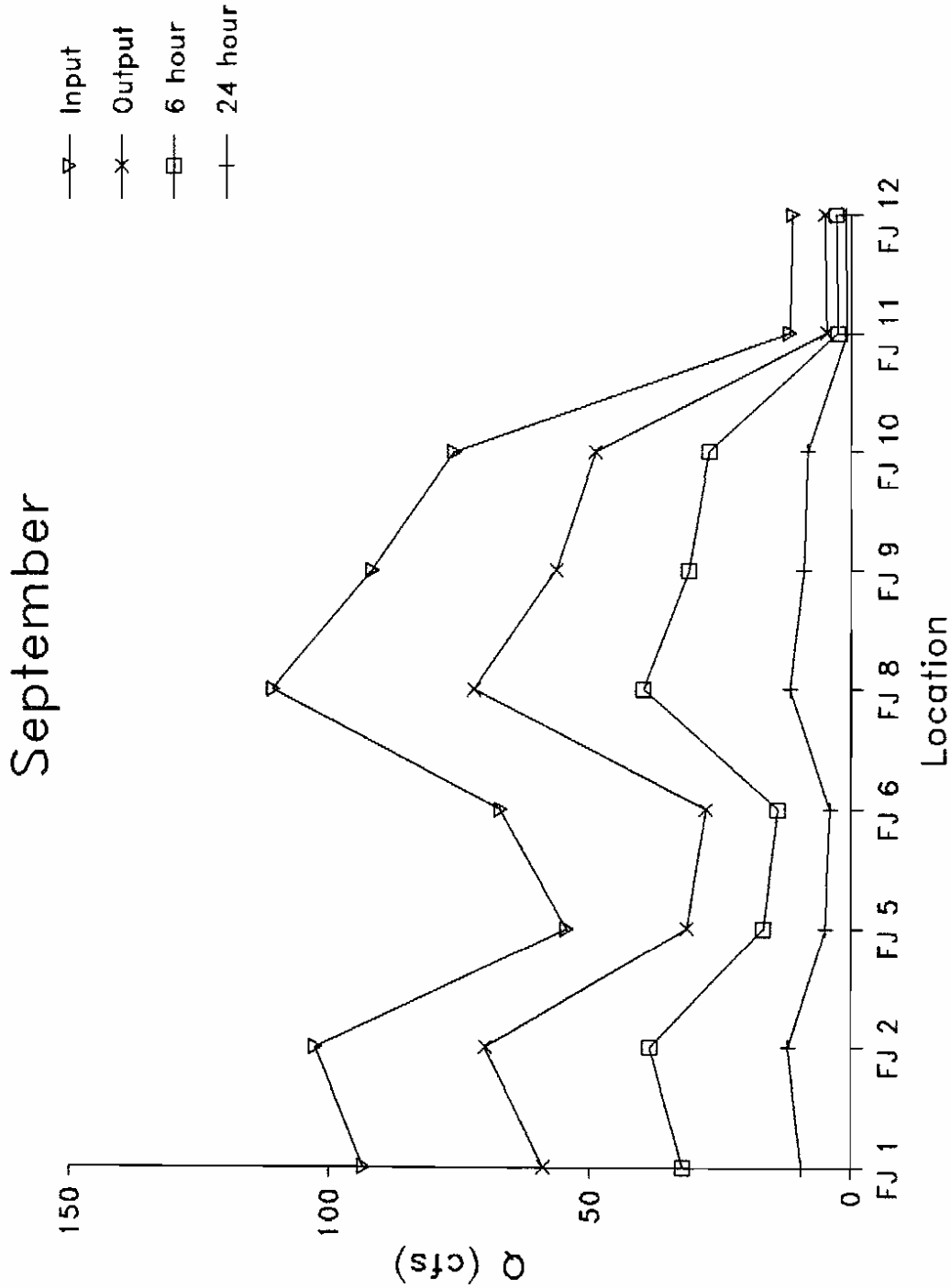
C-3

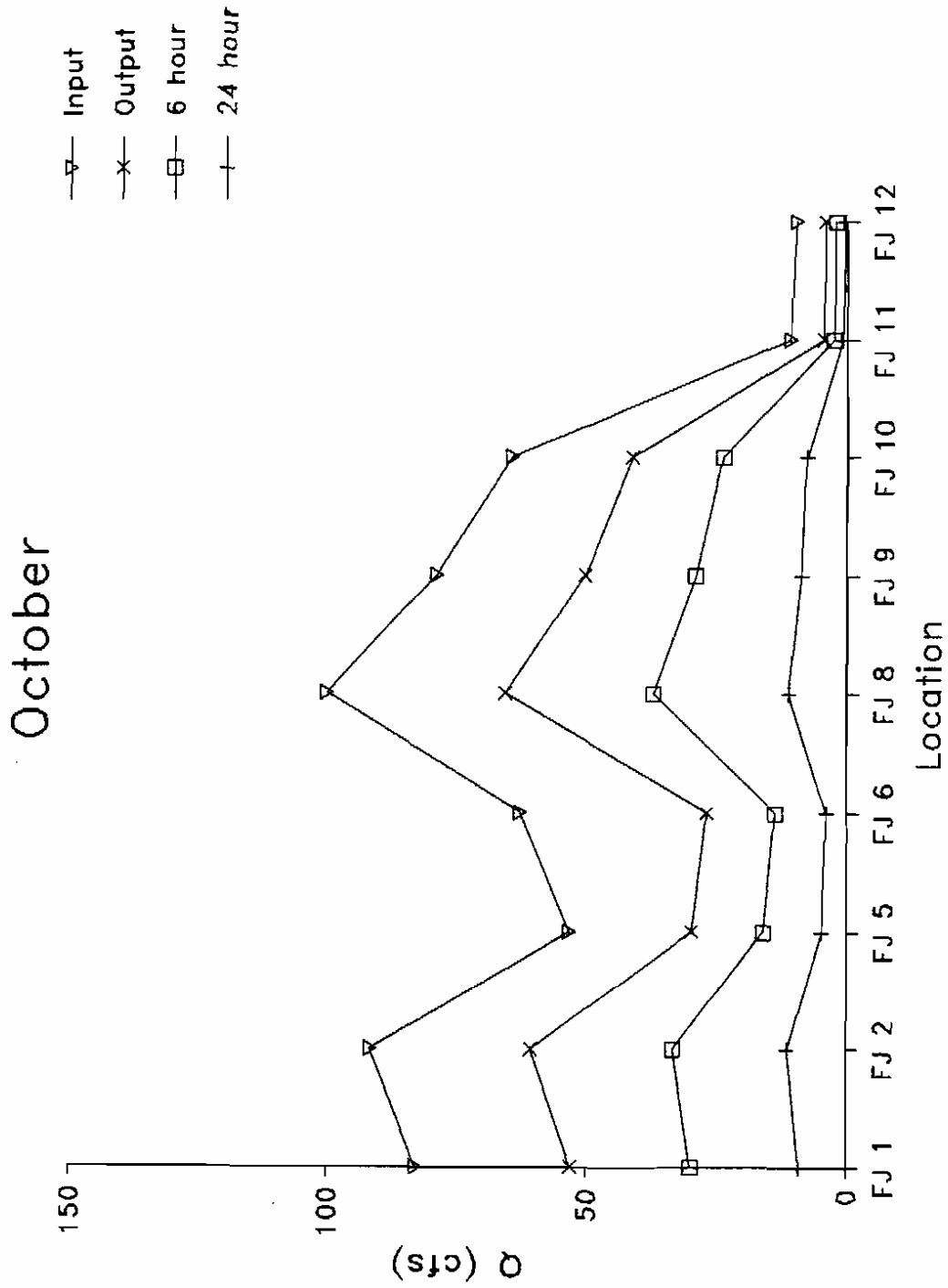
Figures A-F.

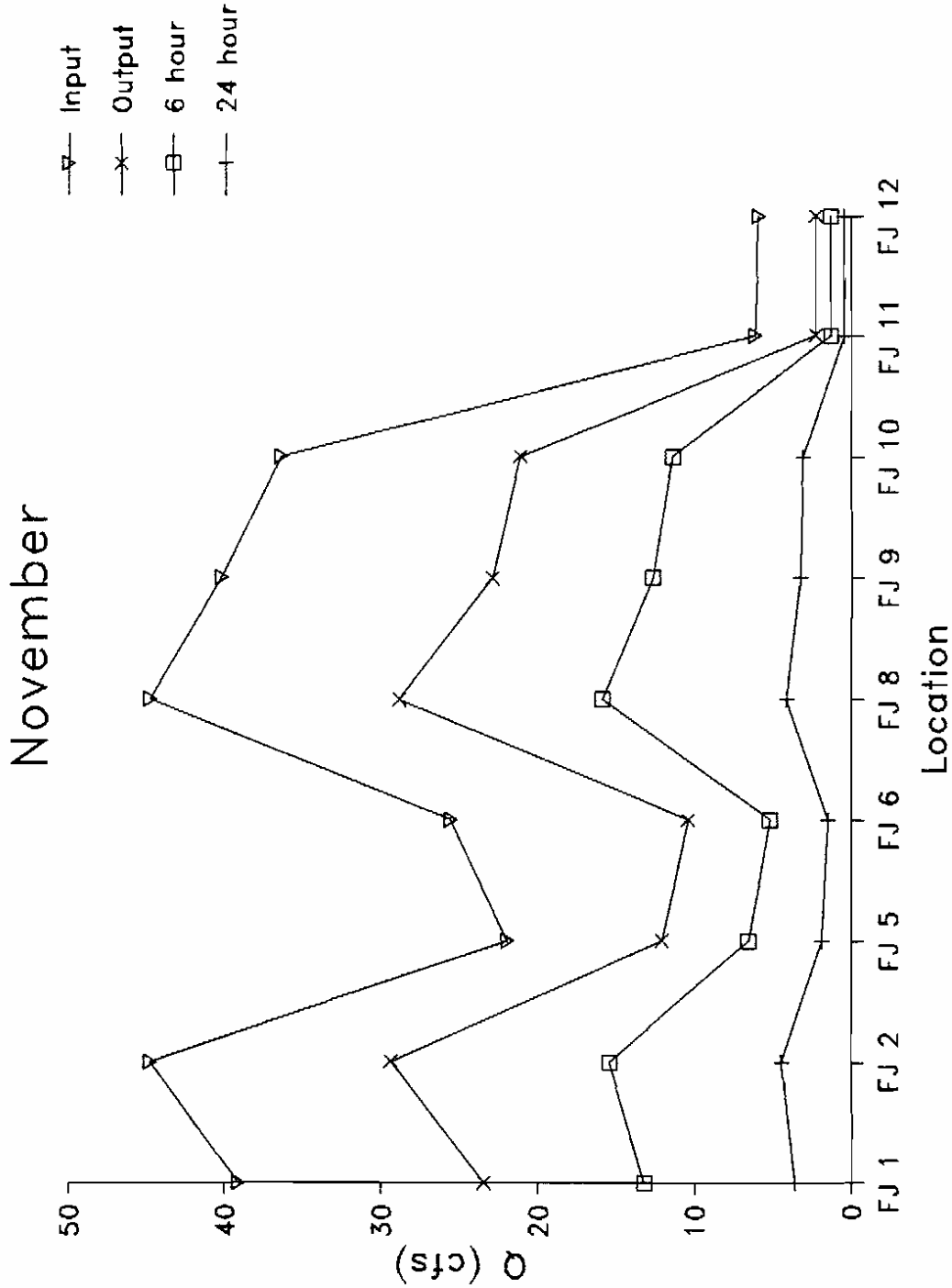
Estimated flows at wetland inlet, outlet during average monthly maximum storms, and maximum storm of record. Jordan Creek wetlands.

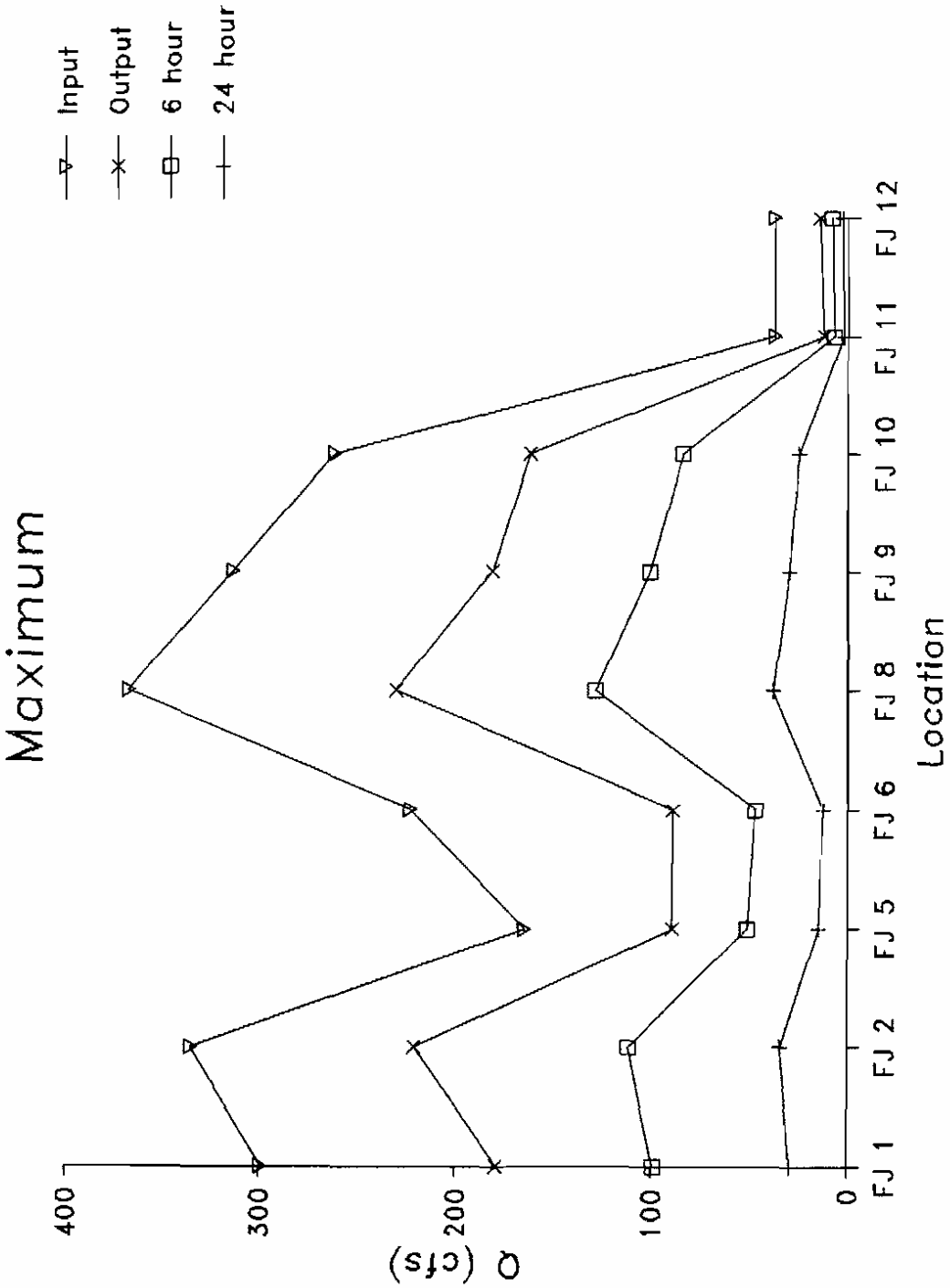

February
Input
Output
6 hour
24 hour
Q (cfs)
15
10
5
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location


June
Input
Output
6 hour
24 hour
Q (cfs)
50
40
30
20
10
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location


September
Input
Output
6 hour
24 hour
Q (cfs)
150
100
50
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location

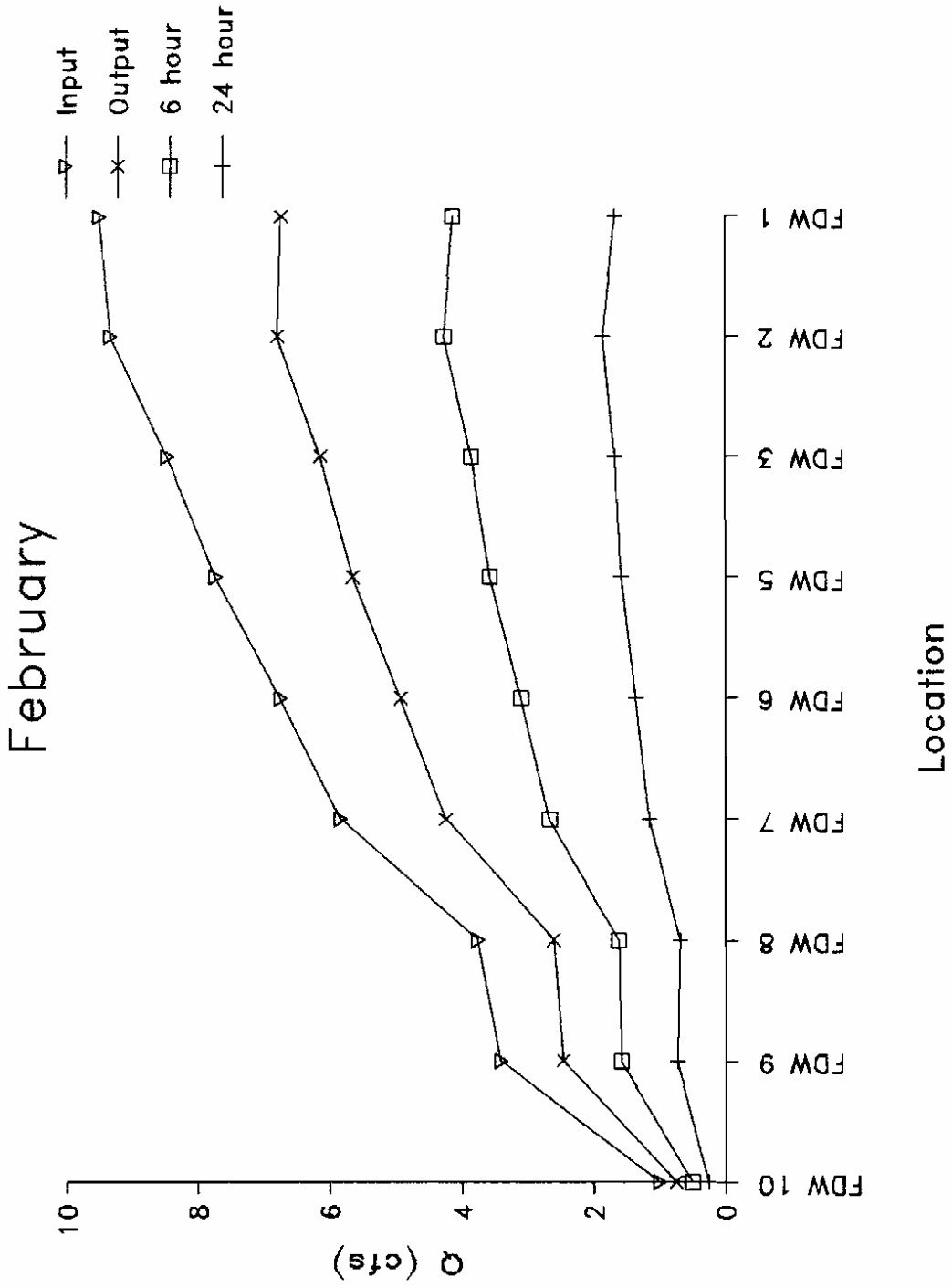

October
Input
Output
6 hour
24 hour
Q (cfs)
150
100
50
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location

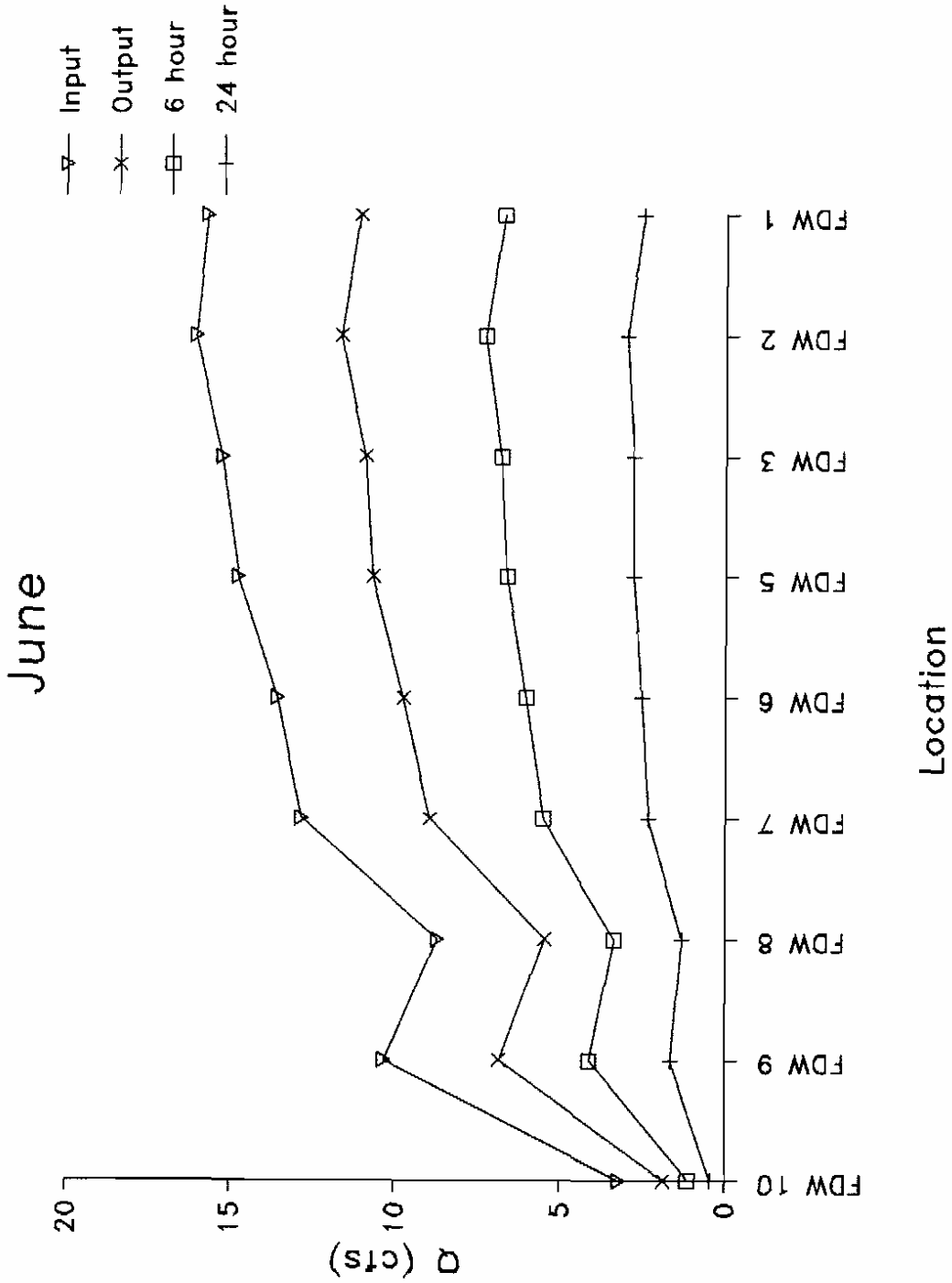

November
Input
Output
6 hour
24 hour
Q (cfs)
50
40
30
20
10
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location

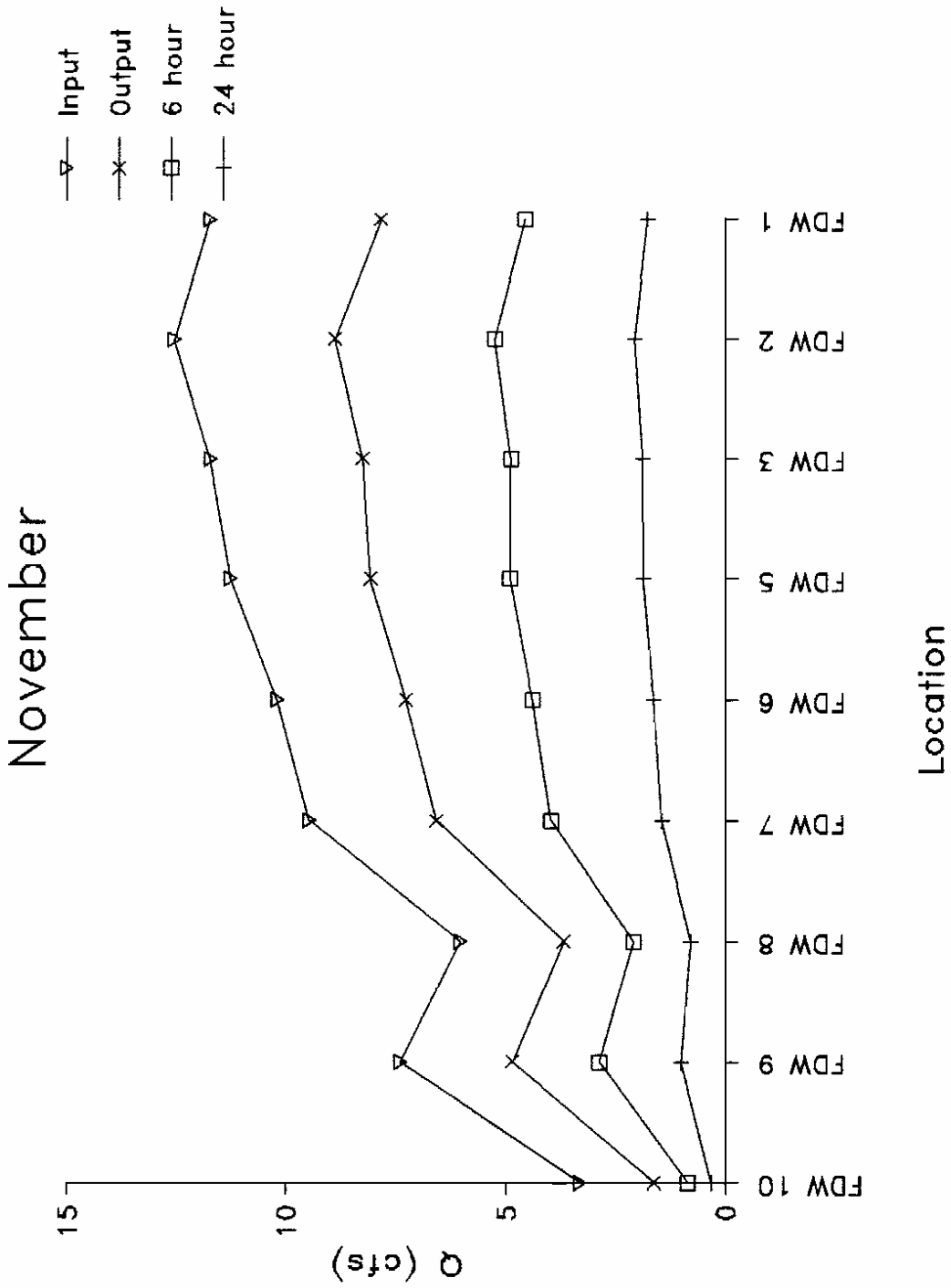

Maximum
Input
Output
6 hour
24 hour
Q (cfs)
400
300
200
100
0
FJ 1
FJ 2
FJ 5
FJ 6
FJ 8
FJ 9
FJ 10
FJ 11
FJ 12
Location

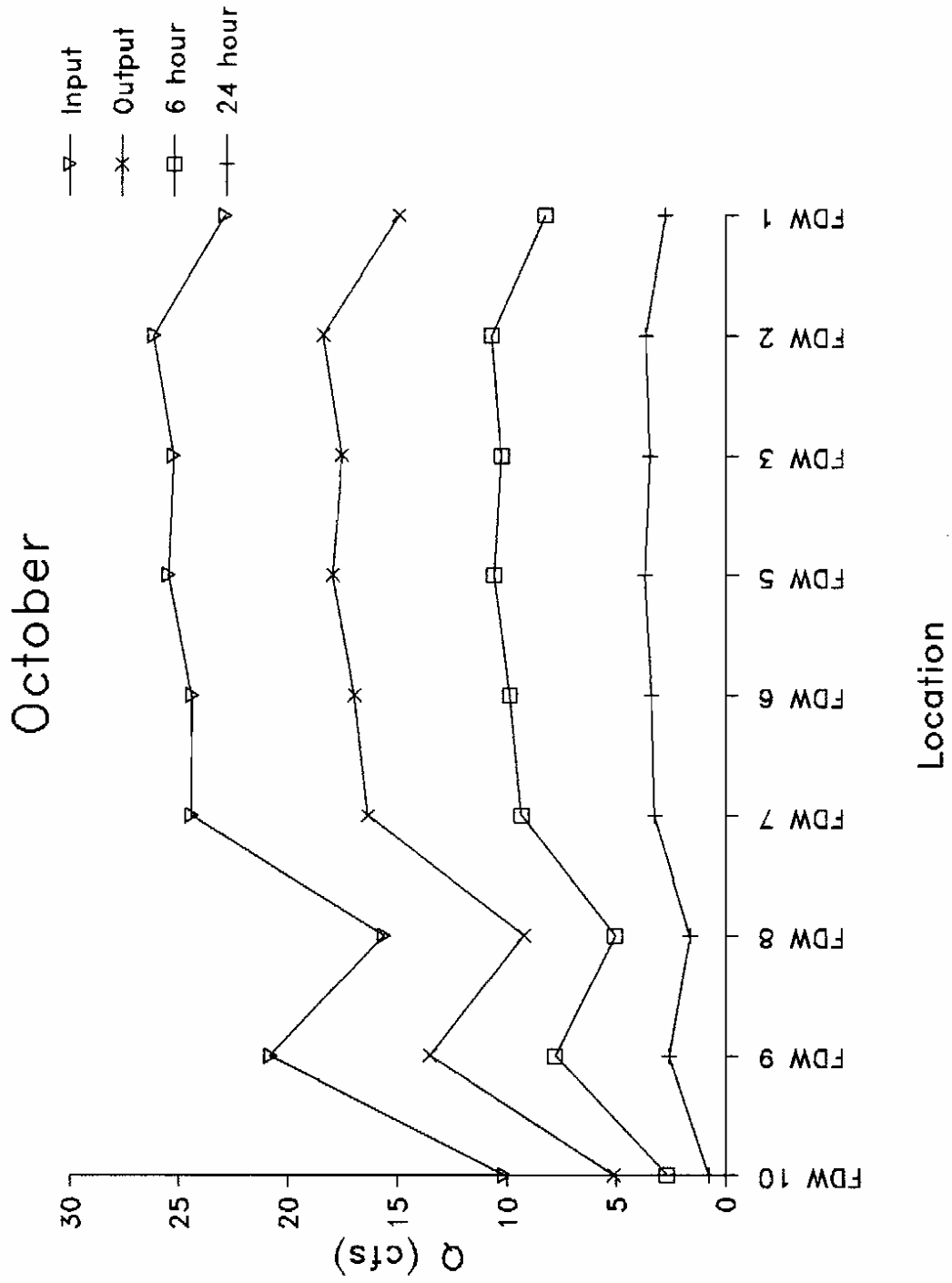
Figures A-F.

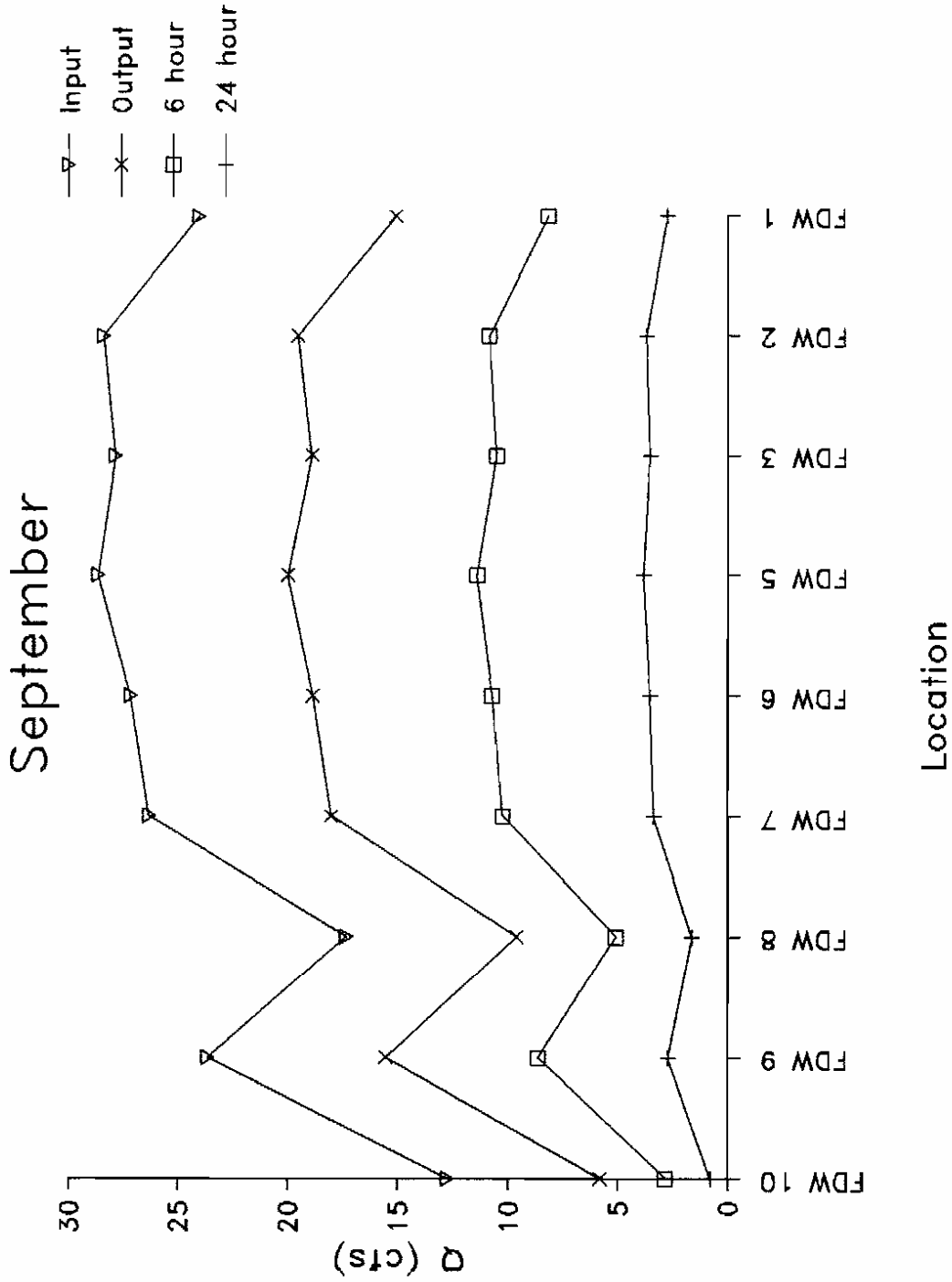
Estimated flows at wetland inlet, outlet during average monthly maximum storms, and maximum storm of record. West Branch of Duck Creek.

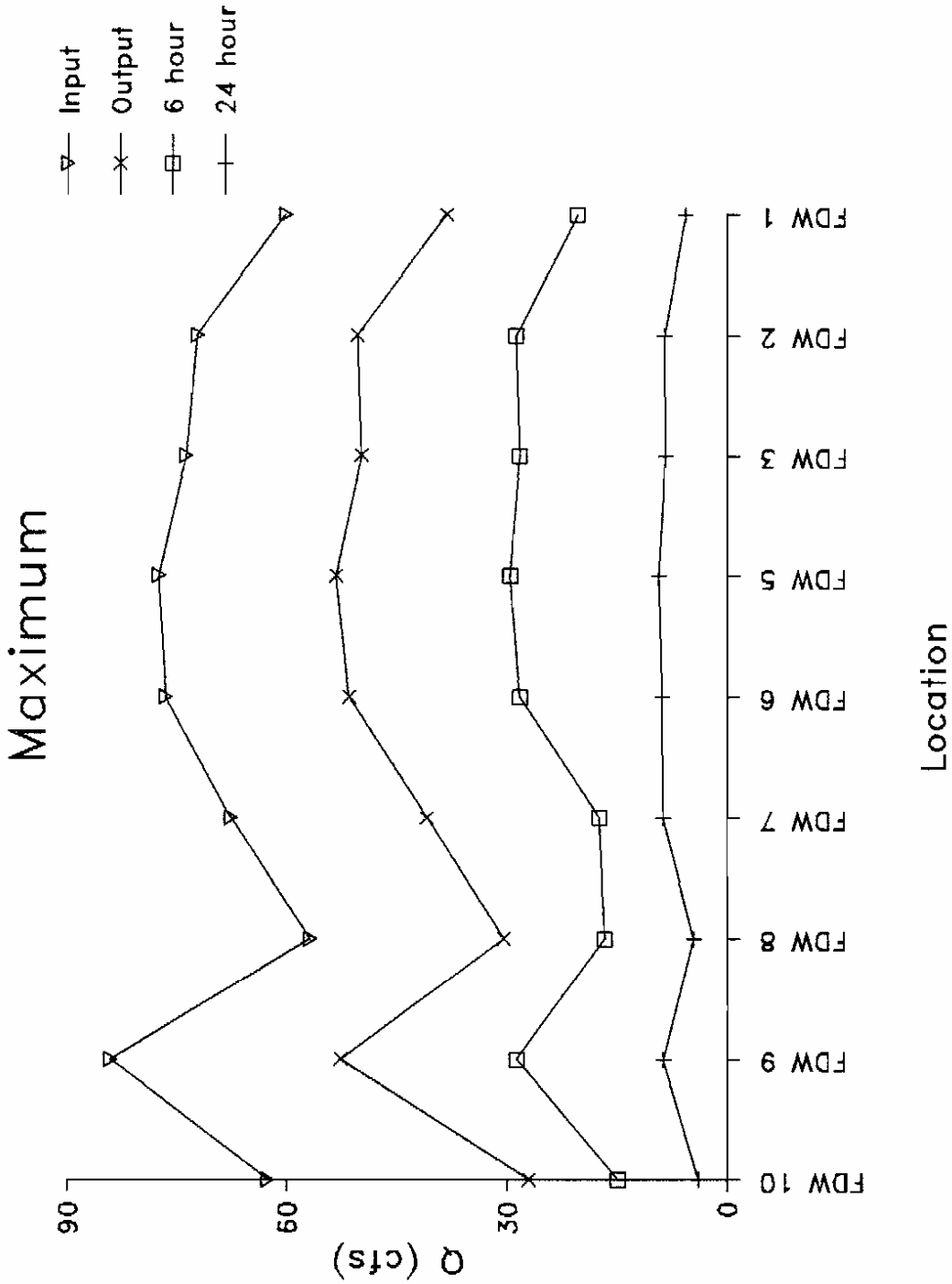

February
Input
Output
6 hour
24 hour
Q (cfs)
10
8
6
4
2
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location


June
Input
Output
6 hour
24 hour
Q (cfs)
20
15
10
5
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location


November
Input
Output
6 hour
24 hour
Q (cfs)
15
10
5
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location

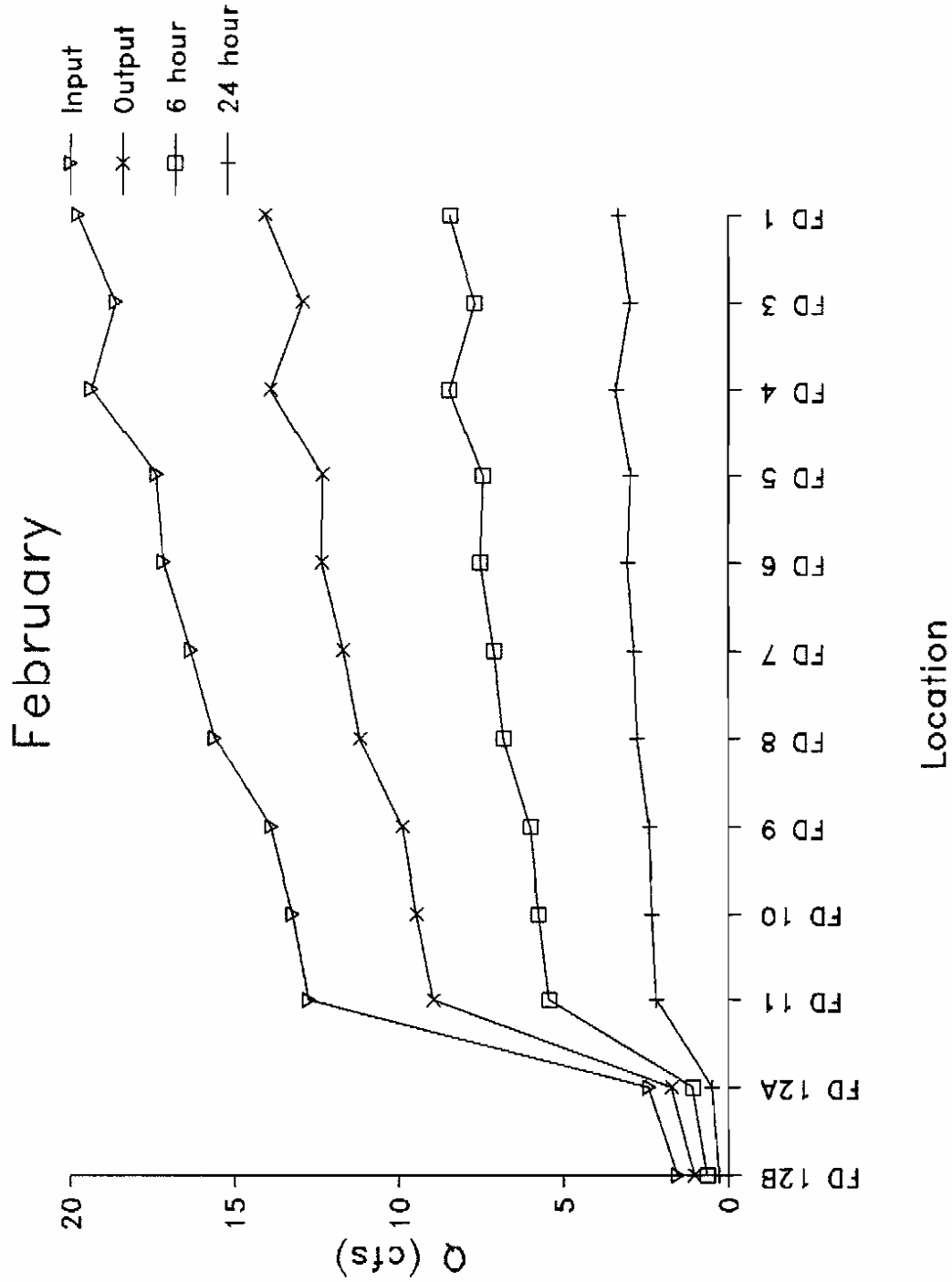

October
Input
Output
6 hour
24 hour
Q (cfs)
30
25
20
15
10
5
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location

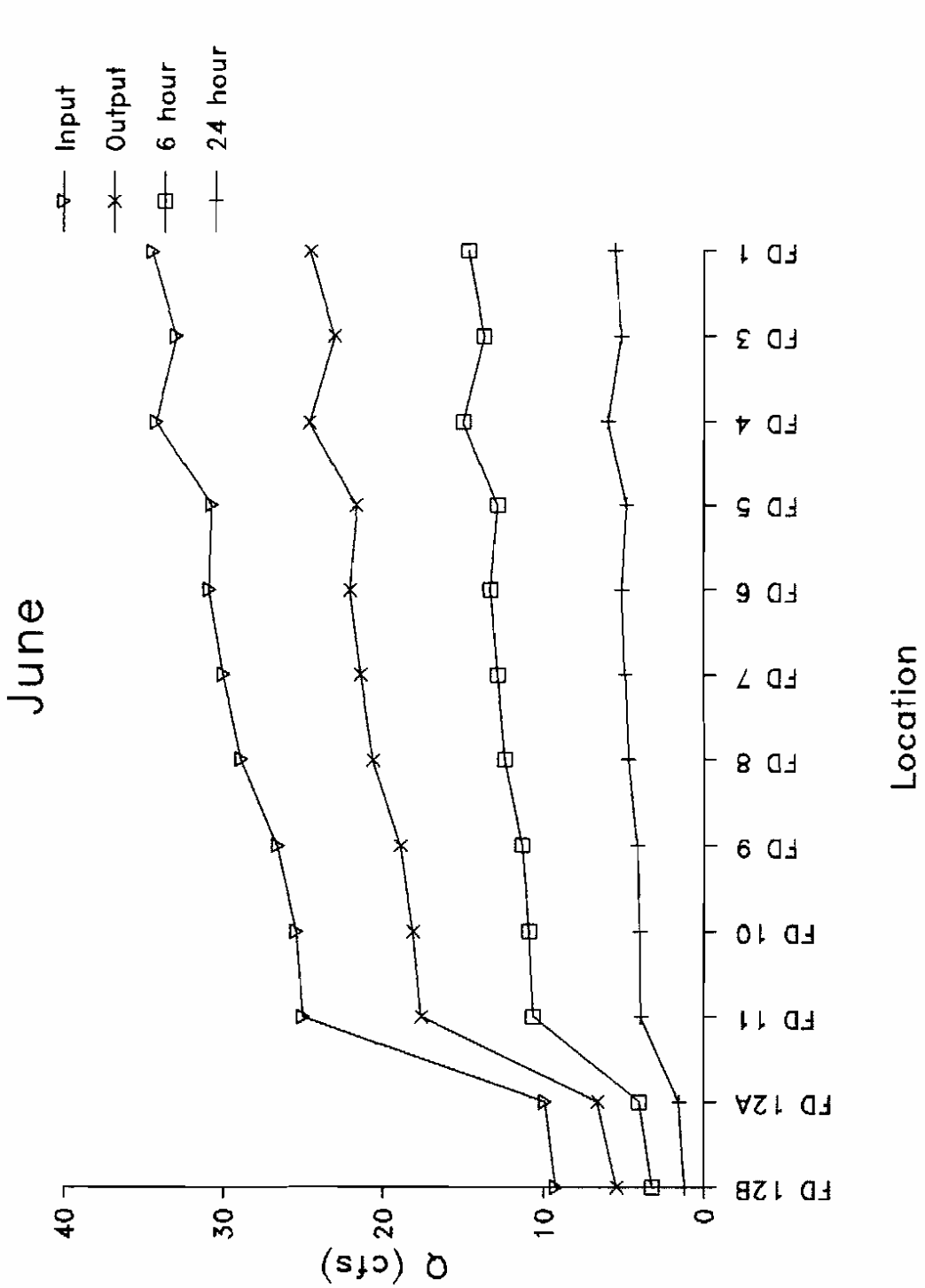

September
Input
Output
6 hour
24 hour
Q (cfs)
30
25
20
15
10
5
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location

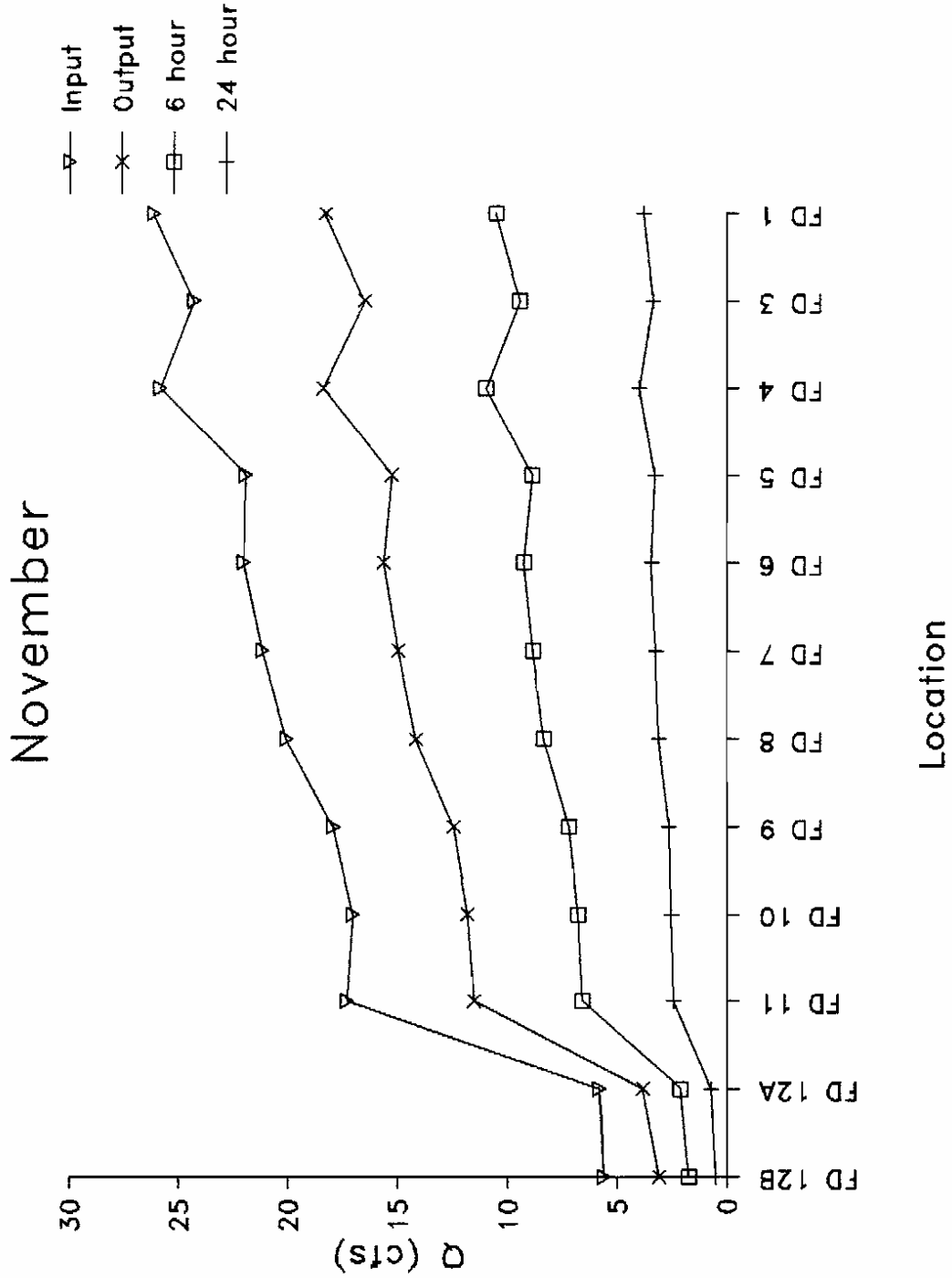

Maximum
Input
Output
6 hour
24 hour
Q (cfs)
90
60
30
0
FDW 10
FDW 9
FDW 8
FDW 7
FDW 6
FDW 5
FDW 3
FDW 2
FDW 1
Location

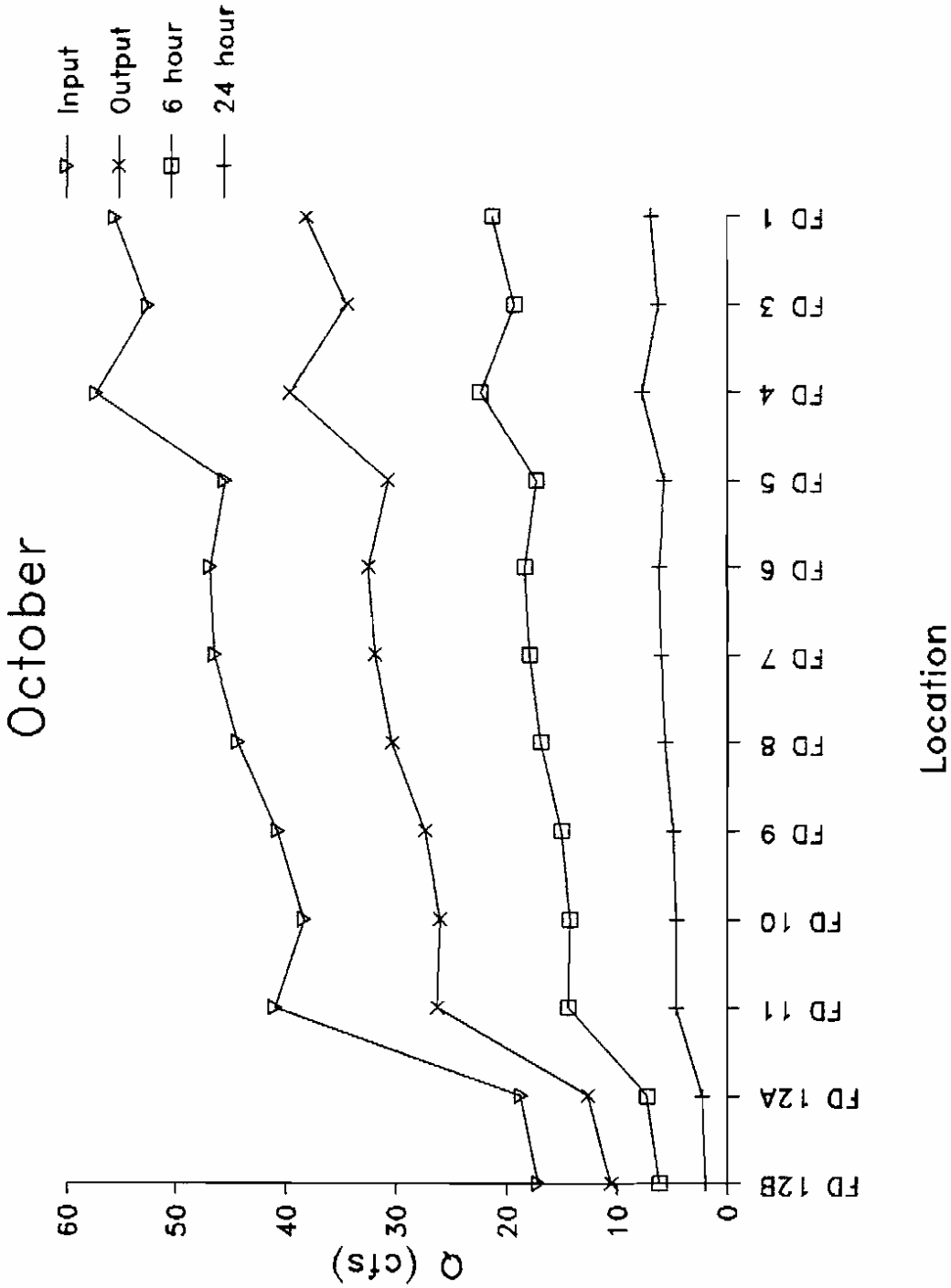
Figures A-F.

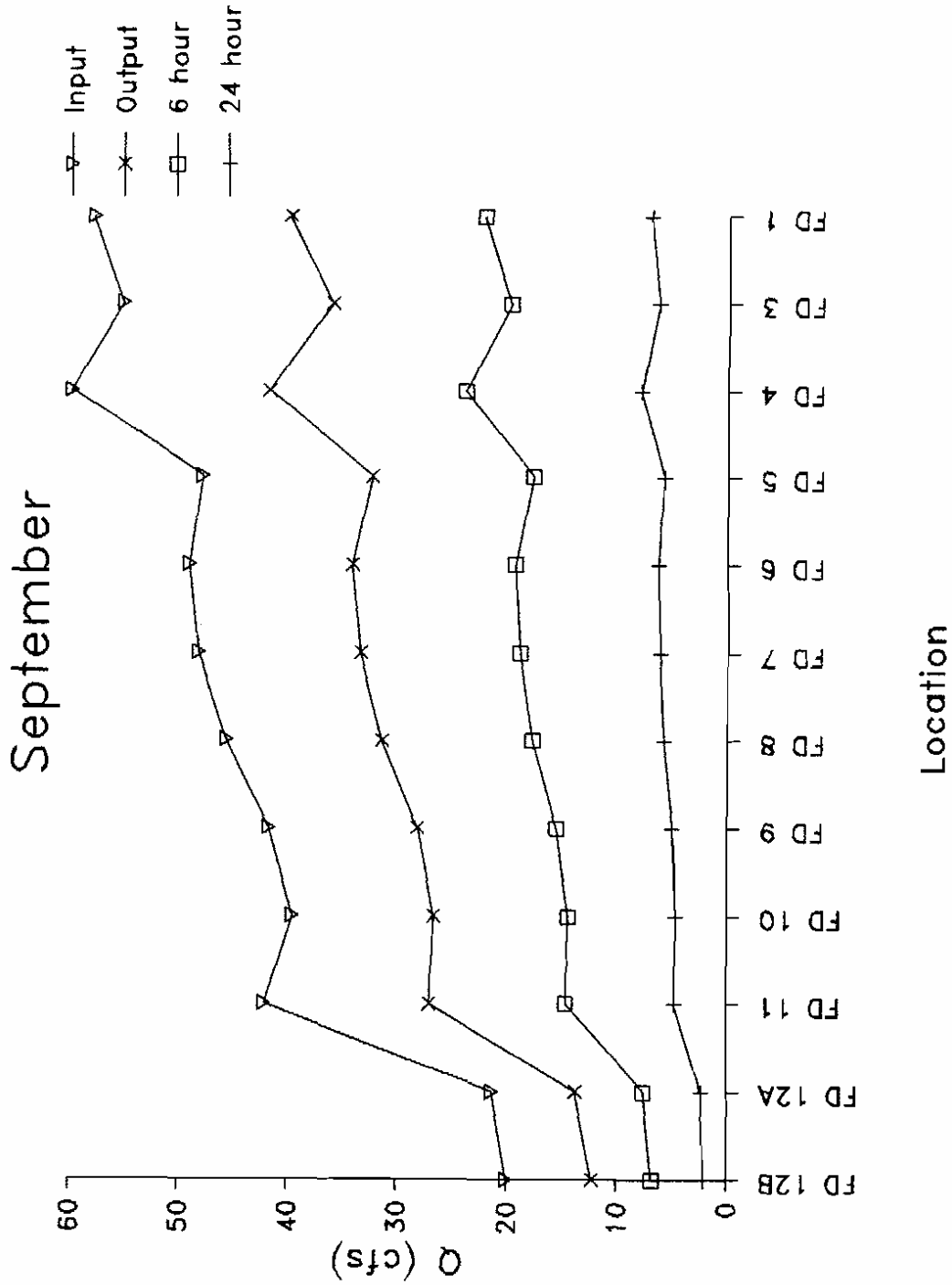
Estimated flows at wetland inlet, outlet during average monthly maximum storms, and maximum storm of record. Lower Duck Creek.

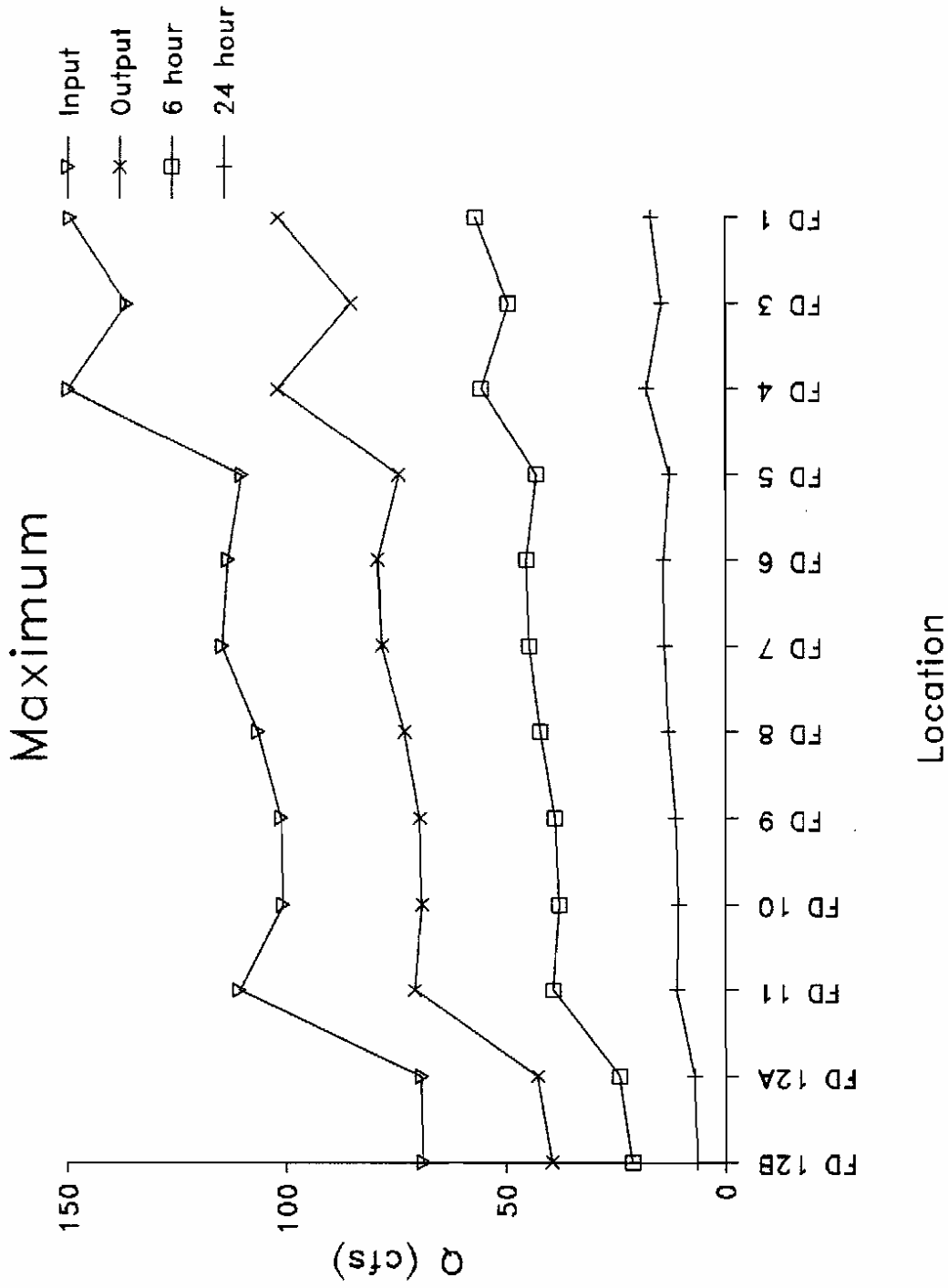

February
Input
Output
6 hour
24 hour
Q (cfs)
20
15
10
5
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location


C-20
June
Input
Output
6 hour
24 hour
Q (cfs)
40
30
20
10
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location


November
Input
Output
6 hour
24 hour
Q (cfs)
30
25
20
15
10
5
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location


October
Input
Output
6 hour
24 hour
Q (cfs)
60
50
40
30
20
10
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location


September
Input
Output
6 hour
24 hour
Q (cfs)
60
50
40
30
20
10
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location


Maximum
Input
Output
6 hour
24 hour
Q (cfs)
150
100
50
0
FD 12B
FD 12A
FD 11
FD 10
FD 9
FD 8
FD 7
FD 6
FD 5
FD 4
FD 3
FD 1
Location

APPENDIX D

RAPID ASSESSMENT METHOD FOR SOUTHEAST ALASKA

The following questions, when answered for a particular wetland, will give a preliminary, qualitative estimate of the wetland's functional values. These questions are based partly on results of the Juneau field work, but the criteria as presented in the interpretation keys here have been extended to cover other non-alpine wetland situations which might occur elsewhere in Southeast Alaska. The basis for this extension is the author's interpretation of existing technical literature, rather than new field studies outside Juneau. Considerably more research on wetlands elsewhere in Southeast Alaska is needed to improve the accuracy of rapid assessment methods for wetland functions in the region.

The user of the procedure below is referred to the wetland evaluation technique (WET) developed in the lower 48 states (Adamus et al. 1987) for definitions, bounding procedures, and general instructions.

I. GROUND WATER EXCHANGE

1. TIDAL CONDITION. Is the wetland's water level influenced by tide? (If Yes, skip remaining questions)

2. PIEZOMETER MEASUREMENTS. Does the water table as measured in piezometers constructed at the water table, slope away from the wetland on most of its sides, with no downslope water table divide occurring in the immediate vicinity, and/or is the depth to ground water progressively deeper in a cluster of wells drilled consecutively at the same location .but to different depths? (If answerable, skip remaining questions)

3. SPRINGS. Does the wetland contain a spring; or, water temperatures are cooler in summer and/or warmer in winter than in similar nearby wetlands, and may be 1ess seasonally and diurnally variable? CAUTION: If temperature criteria are used, consider the biasing effects of upstream shade and snow/ice melt on summer water temperature; and of darker sediments, substrate, or depth on winter water temperature (via solar absorption). (If answerable, skip remaining questions in the ground water section)

4. WATER QUALITY Is the specific conductance and the ratios of Ca, Mg, Fe, Cl, SO^4, and MCO^3 in the wetland more similar to those from nearby wells than to those from nearby wetlands of similar type?

5. LOSING STREAM. (Skip this question if wetland has no channel.) Is the measured flow (cfs) at the outlet of this wetland or stream reach less than the flow simultaneously measured at the inlet or areas upstream (by more than 10%?), and the loss cannot be attributed to evapotranspiration or artificial factors?

6. BREAK IN SLOPE. Is the wetland located within a few hundred feet of the base (inflection point) of a slope angle of generally greater than 20%?

7. HYDRAULIC CONDUCTIVITY. Within this wetland's watershed, does the hydraulic conductivity of the soils decrease, moving from the watershed divide in a downslope direction toward the wetland? (If unknown, assume that decreased conductivity is represented by increased prevalence of marine clays, fine-particled soils, positioning atop a perpendicular fault, or shallower depth to bedrock; or decreased prevalence of talus or alluvial sediments such as occur at the mouths of canyons in glacial moraine areas, or at the base of avalanche paths.)

8. IMPOUNDED. Has this wetland been created by a landslide or intentional blockage of natural drainage ways?

9. SOIL SERIES (Skip if wetland is riverine.) Is the wetland situated on mineral soil, or on a soil series not considered "hydric" by USFWS, or at the base of an avalanche path?

II. SURFACE HYDROLOGIC CONTROL

Opportunity

1. MEASURED INPUT. (Skip this question if wetland has no channel.) Are annual peak flows greater than 500 times annual base flows? (If yes, skip questions 2-3)

2. RUNOFF POTENTIAL. In the wetland's watershed (within five miles) are the predominant soils: (a) in hydrologic group D, (b) primarily covered with impervious surfaces, (c) drained by extensive ditches or subsurface drains, or (d) situated generally on slopes steeper than 201?

3. OTHER STORAGE. Do other wetlands and lakes comprise at least 7% of the watershed, or does a control structure located upstream regulate flows at this site?

Effectiveness

1. OUTLET LACKING. Is this wetland unconnected to any other body of water, and the wetlands gradient is less than 1%? (If yes, skip questions 2-7)

2. NONTIDAL CONDITION. Is the wetland's water level influenced by tide? (If yes, skip questions 3-7)

3. MEASURED HYDROGRAPH. (Answer only if both inlet and outlet are present and data are available from several storms.) Does this wetland have a flatter storm hydrograph (longer recession time, greater lag affect) than other wetlands in the watershed?

4. FLOOD RATIO. Is the ratio of the wetland's seasonally flooded area to its permanently flooded area (including contiguous open water areas) greater than 2?

5. SEASONAL SLOUGH CONSTRICTION. Does floodwater from an adjoining body of water enter most of the AA as a massive sheet of surface flow (e.g., as when a river or lake overtops a natural levee or sill over a wide area and pours Into a backwater slough) and exits the AA through a more constricted outlet(s) or not at all?

6. FLOODPLAIN ROUGHNESS. (Skip if channels are absent.) Is the floodplain of the wetland almost entirely covered by woody vegetation?

7. MEANDERING. (Skip If channels are absent.) Is channel sinuosity within this wetland greater than the channel's sinuosity above or below the wetland, within five miles?

8. PERMANENT CONSTRUCTION. (Skip if channels are absent.) Is this wetland located just above the narrowest point on the channel, within five miles In either direction, or anywhere within the watershed?

9. SOIL TYPE. Does the wetland contain primarily peat soils?

10. VEGETATION. Are deciduous shrubs the predominant vegetation cover type within the wetland?

11. SLOPE ANGLE. Is the wetland located on a slope or flat area with slope angle of?

11.1 Less than 3%?

11.2 Less than 7%1

12. GROUND WATER is ground water discharge known to occur within the wetland?

13. EXCESS STORAGE. Does the wetland comprise at least 1% of its watershed?

14. LOCATION. Is the wetland located within 10 vertical feet of sea level?

III. BANK OR SHORELINE SENSITIVITY

1. CHANNEL CONDITIONS. (Skip if nontidal channels are absent.)

1.1 Are a majority (5+) of the following conditions (a-h) present?

a. Upper Banks. Slope angle exceeds 60%; or are composed of glacial till, highly weathered bedrock, or other fine sediments.

b. Lower Banks. Almost continuous bank cutting, or cutting at toe of slide areas at meander bends.

c. Lower Bank Composition. Sands, silt, clay (20% gravel).

d. Streambed Substrate. Sands, silt, clay, fine gravel.

e. Channel Form. Width-depth ratio is greater than 25 and channel is moderately to highly sinuous, gradient is less than 3%.

f. Channel Deposits. Gravel or sand bars present, unvegetated, and generally at least three feet high.

g. Debris. Logs and debris are positioned such as to cause scouring and bank cutting.

h. Vegetation. Alders, devil's club, bare ground, pavement, or open stands of spruce predominate on gentle floodplains.

1.2 Are only 3 or 4 present?

1.3 Are a majority (5) of the following conditions present?

a. Upper Banks. Slopes less than 60% which appear stable, or bedrock.

b. Lower Banks. Few unvegetated banks.

c. Lower Bank Congestion. Muskeg, grasses, or sediments larger than 2.5-inch in diameter.

d. Streambed Substrate. Coarse, unrounded rocks or bedrock, moderately to well-packed.

e. Channel Form. Width-depth ratio less than 15 and gradient greater than 5%.

f. Channel Deposits. Gravel bars absent or densely vegetated.

g. Debris. Incorporated into banks and streambed influence I 20% of channel.

h. Vegetation. Dense grass flats or muskeg.

1.4 Are only 3 or 4 present?

2. SEDIMENT CONVEYANCE. (Skip if nontidal channels are absent.) Is channel gradient greater than 10%, and peak flows exceed 100 cfs annually?

3. FETCH. (This pertains only to non-riverine wetlands) Is the deepwater edge of the wetland adjacent to open waters at least one mile wide? (Answer "no" if open water is absent)

4. ALTERATION. Is the wetland (a) located along a reservoir or other water body whose water levels are artificially manipulated a great deal, or (b) have tributaries to the wetland been straightened, dammed, or diked, or (c) has the acreage of impervious surface (e.g., from urbanization) in the watershed increased by at least 1% a year during the last five years, particularly in areas closest to the wetland or its tributaries.

IV. SEDIMENT RETENTION

Opportunity

1. 1. INPUT TURBIDITY. (Skip If channels are absent.) In tributaries to this wetland, is measured turbidity generally greater than 25 NTU during the growing season?

2. GLACIAL INFLUENCE. Is glacial meltwater a major source of water and sediment for this wetland?

3. SEDIMENT SOURCES. Within the AA's input zone, is there any feature that by its nature would be considered a potential source of Inorganic sediment? Consider: storm water outfalls, mines, or at least one acre (or 2X of buffer area) (cumulative) of any of the following: exposed soils associated with lands cleared within the last two years, soil-slope conditions classified by as eroding or erosion hazard, (e.g., subclass "e" in the SCS Land Classification Codes), stream or road banks; or surface water inputs significantly loaded by the above.

* Input zone: any land within 300 feet of the wetland or Its immediate tributaries.

Effectiveness

1. MEASURED ACCRETION. Does examination of airphotos of the wetland from different points In time (many years apart) 1ndicate 1ong-term fi1ng 1n of open water areas, or do analyses using 137 Cesium or similar dating techniques suggest long-term accretion? (If yes, skip questions 2-7)

2. SUSPENDED SOLIDS DIFFERENTIAL. (Skip if channels are absent.) Are levels of inorganic suspended solids, measured at the wetland's outlet(s) (especially during Intense storms), less than those measured simultaneously at the 1nlet(s), or have markers (e.g., iron chains, painted rocks) placed in the wetland become coated with sediment within a few weeks, and remained so for months? (If yes, skip questions 3-7)

3. SURFACE HYDROLOGIC CONTROL. Was SURFACE HYDROLOGIC CONTROL effectiveness (see third section of this appendix)?

3.1 Rated HIGH with A-level certainty? (If yes, skip questions 4 - 7)

3.2 Rated HIGH with B or C-level certainty?

3.3 Rated LOW?

4. SEDIMENT STABILITY. Was BANK OR SHORELINE SENSITIVITY (see proceeding section) rated:

4.1 LOW?

4.2 HIGH?

5. LOAD EQUILIBRIUM. Was SEDIMENT RETENTION opportunity rated HIGH (see above)?

6. DEPOSITIONAL GRADIENT. (Skip if nontidal channels are absent.) Does channel gradient change suddenly from a relatively steep gradient In this wetland's tributaries to a channel gradient (within most of the wetland) less than shown below, or from a velocity upstream of greater than ft/sec to markedly less than that within the wetland?

Type of Inflowing Sediment	Type of Wetland	Necessary Wetland Gradient
Silt	No Channels	0.003
Silt	Small Channels	0.001
Sand	Small Channels	0.009
Sand	Large River	0.001

7. SALINITY. Is salinity during most of the year In the 0.4 - 0.6 ppt range? (Or specific conductance Is 500-1000 uM/1.)

8. VEGETATION. Is the wetland mostly vegetated (I.e., not mostly open water) or lacustrine?

V. NUTRIENT REMOVAL AND TRANSFORMATION

Opportunity

1. INPUT NUTRIENTS. In this wetland or its immediate tributaries, are measured levels of nutrients greater than 0.1 mg/L (total phosphorus) or 5 mgA (total nitrogen) during any part of the growing season?

2. SOURCES. Within the wetland's watershed, is there any feature that by its nature would be considered a potential source of nutrient runoff?

   Consider: numbers of spawning salmon, presence of active pastureland, dumps, septic fields, fertilized soils; sewage treatment plants; soils tilled, burned, or cleared within the last two years, or surface water inputs significantly contaminated by the above; or actual observation of nuisance algal blooms.

3. BUFFERING. Are any of the sources described above located within 50 feet of the wetland, or are they located on. soils or sediments having the following description? Fractured bedrock, rockslides, rock-rubble, or gravels without fines and with finer overburden of less than a two foot depth; or organic (peat) soils; or seasonally flooded (or high water table) soils; or slopes exceeding 20%.

Effectiveness

1. RETENTION TIME. Was SEDIMENT RETENTION sediment retention effectiveness (proceeding section) rated:

1.1 HIGH?	1.1.1	with A-level certainty?
	1.1.2	with Level B/C certainty?
1.2 LOW?	1.2.1	with A-level certainty?
	1.2.2	with Level B/C certainty?

2. BIOLOGICAL ACTIVITY. Is turbidity during the growing season usually less than 30 NTU, or mean water depth is less than three feet?

3. DRAWDOWN. Are most of the sediments of the wetland exposed to air for more than two days annually, or surface water always absent?

VI. SALMONID HABITAT: COHO/CUTTHROAT REARING

1. ACCESS. Does this wetland contain a channel identified as containing anadromous fish, as shown in ADFG's Atlas, or is this wetland accessible to fish at least seasonally? (Skip the remaining questions if this was answered "no".) NOTE: Consider accessible if fish actually seen, or if all the following are true: minimum water depth is (at 1 east seasonally) greater than four inches; barriers higher than four feet are absent; current velocities are sometimes less than 7 ft/sec; channel gradient is less than 20%; dissolved oxygen is sometimes greater than 3 mg/L.

2. DEPTH. Within 0.5 stream-miles of the wetland, are there water depths accessible to salmonids and deeper than 7 inches during July - Nov?

3. VELOCITY.

3.1 During July-November, are there waters within 0.5 stream-miles of the wetland which are accessible and have flow velocities of 1.2 - 1.7 ft/s?

3.2 During the winter (November - March), are there waters within 0.5 stream-miles of the wetland which are accessible and have flow velocities of:

3.2.1 Less than 0.2 ft/s?

3.2.2 Less than 1.2 ft/s?

4. TEMPERATURE. Are water temperatures almost always less than: 13°C between Sept and May, and 16°C between May and Sept?

5. SALINITY. Is salinity "fresh" most of the year?

6. BASE FLOW; (Skip if channel flow is absent.) Is the ratio of: Oct - Mar flow (peak) to Oct - Mar flow (average daily) less than 8?

7. UPWELLING. Was ground water discharge (first section of Appendix) rated HIGH, or is there evidence within the wetland of upwelling (i.e., cooler subsurface water which is discharging from a gravel bar or riverbank).

8. NUTRIENTS. Do levels of nitrate generally exceed 200 ug/L?

9. LARGE ORGANIC DEBRIS. (Skip if channel is absent.) Do logs (greater than four inch in diameter) occur?

9.1 More than 10 (or 2000 ft3) per 100 feet of stream?

9.2 More than one per 1000 feet of stream?

10. MACROINVERTEBRATES. Do densities of bottom-dwelling Invertebrates exceed $2000/m^2$ at any time of the year, or (particularly 1akes) do Cladocera dominate? (If this was answered, skip question 11.)

11. TURBIDITY. Is the turbidity during the growing season usually less than 30 NTU?

12. ECOTONES. Is the wetland located within 2000 feet of (and accessible to) a beaver flowage, gravel pit pond, calm backwater, wet meadow or estuarine emergent marsh having a gradient of less than 0.06?

13. COVER.

13.1 Does the wetland or Its channel have at least 10 square feet (or 10% of Its area) as aquatic vegetation (partly submerged), undercut banks, bridges, boulders, or vegetation that overhangs the water and Is within three vertical feet of Its surface?

13.2 Do such features comprise more than 90% of the wetland or channel?

14. pH. Is the pH greater than 5.5?

VII. PRODUCTION EXPORT

1. VEGETATION. Is at least 10% of the vegetated wetland comprised of Carex lygbyei or does the net annual primary productivity exceed 1000g/m2/yr?

2. ALGAL PRODUCTION. (Skip if channel is absent.) Is the wetland located on a stream having stream order three or higher? (i.e. streams low in watershed)

3. CANOPY. Is at least 10% of the wetland exposed to the sun daily during the growing season?

4. DIVERSITY. Are all three of the following plant groups present within 20 feet of open water (or channel(s)), or are flooded seasonally by channel overflow?

   a. Evergreens
   b. Alder or cottonwood
   c. Salmonberry or other herbaceous plants

5. MACROINVERTEBRATES. Do densities of bottom-dwelling invertebrates exceed 2000/m2 at any time of the year?

6. TURBIDITY. Is the turbidity during the growing season usually less than 30 NTU?

7. pH. Is the pH usually above 6?

8. NUTRIENT SOURCES, Was Nutrient Transformation opportunity (Section V) rated HIGH or MODERATE?

9. DISPERSAL. Does water leave the wetland as surface flow at any time of the year (and is transported into other wetland or deepwater areas)?

VIII. GENERAL WILDLIFE DIVERSITY/ABUNDANCE

1. SIZE. If forested, is the wetland (plus any connected upland forest larger than one acre, or if unforested, is the wetland plus any open water that it fringes upon), greater than 5 acres?

2. CORRIDOR. (Skip if unforested-type wetland.) Is any part of the wetland connected to other wetlands (or stream reaches) by a corridor of woody vegetation at least 300 feet wide?

3. LOCATION. Is the wetland located within 300 feet of tidal water, or is it part of the delta of a third-order or larger stream or river?

4. VEGETATION PERCENT. Does partly-inundated vegetation at any season comprise 30 - 70% of the wetland area, the rest consisting of open water (either within the wetland or adjacent) or non-inundated vegetation?

5. HORIZONTAL INTERSPERSION. Are open water and/or various wetland types well-intermixed, like a checkerboard? (e.g., consider not intermixed if nearly all water flows through the wetland in a single unvegetated channel with no adjoining low, brushy or dense herbaceous vegetation).

6. ISLANDS. Are Islands of wetland grasses or other vegetation present within the wetland and separated from dry land by at least a 300 foot wide reach of deep water?

7. SNAGS. Is the number of dead trees in the wetland

7.1 At least 20 per acre, having a diameter of 20+ inches and height of 50+ feet?

7.2 At least 10 per acre, having a diameter of 6+ inches and height of 10+ feet, or, at least one tree situated 1n the open or along a shoreline and having a height of 50+ feet and diameter of 20+ inches?

8. SPECIAL FEATURES.

8.1 Is the wetland comprised of forest older than 150 years (or younger than 30 years), or directly adjoins such forest, and is below 1000 feet elevation on slopes of less than 20%?

8.2 Do any of the following plants comprise at least one acre- or 10% of the wetland?

8.2.1 Vacclnum, Cornus, Rubus, Coptis, Alnus, Sambuscus, and tree canopy closure is more than 50%, with more than 50% ground cover.

8.2.2 Carex lyngbyei (or other duck foods)

8.3 Is the wetland's vegetation primarily scrub-shrub, and includes a channel or pond primarily bordered by scrub-shrub vegetation?

9. TYPE RICHNESS. Does the wetland contain any of the following?

(a) All three of the Level 1 vegetation types (Viereck et al 1986)

(b) 7 of the 9 Level 2

(c) 12 of the 19 Level 3

10. TYPE UNIQUENESS. Does the wetland contain the only stand of any of the Level 2 or 3 types in the watershed (if the watershed is at least 10 square miles) or the only stand of any of the types (any level) on an island?

11. OASIS. (The following pertains only to palustrine wetlands) Within one mile of the perimeter of this wetland, do wetlands comprise less than 1% of the landscape?

12. ICE-FREE. Does this wetland or adjoining waters support a late-season run of salmon (Nov-Dec), or does it completely freeze over for fewer than 30 days most winters?

13. NUTRIENT/WATER LEVEL FLUX. Does the wetland's area normally expand by at least 50% during the annually wettest time? (i.e., areas that are dry or without surface water during most of the year become saturated or covered with surface water)

14. ECOTONE. Is the wetland tidal (estuarine) emergent and directly abuts a nontidal (palustrine) emergent wetland, or is nontidal emergent and abuts a tidal emergent wetland?

IX. RIPARIAN SUPPORT

1. OPEN WATER OUTLET. Is the wetland connected at least seasonally by surface water to a permanent water body? (I.e., a channel or standing water connection is visible, connection is not merely saturated)

2. VEGETATION COVERAGE. Is most of the wetland water surface and/or subsurface sediment shaded by overhanging or submerged plants during the late growing season?

2.1 (Skip if No. 2 answered "no".) Is most of the shade created by herbaceous vegetation and/or the following woody species: alder, willow, black cottonwood, and salmonberry?

3. RIPARIAN COVER. Does most of the watershed's riparian area (i.e., the area within 50 feet of channels and other surface waters) contain:

3.1 Evergreen vegetation?

3.2 Minimal vegetation (e.g., lawns, roads, rockslides)? 4. SALT MARSH. Is this a tidal emergent wetland?

X. DOWNSLOPE BENEFICIARY SITES

1. POTABLE WATER. Downstream (or downslope) from this wetland and within the same watershed, are there (within 2 miles) domestic wells or surface waters used for domestic supply?

2. PROXIMITY. Is this the closest wetland upslope from economically sensitive floodable property?

3. STORAGE CONTEXT. Is this the largest (or widest or lowest-gradient) wetland upstream from floodable economically sensitive property, or designated ecological area, and located within about one mile (if on a small stream), or within five miles (if on a larger stream)?

4. WAVE INTERCEPTION. Does this wetland occur on a delta accreting into a lake or estuary, with economically sensitive property on the leeward side?

5. BANK EROSION. Are economically sensitive properties located directly behind the wetland and are potentially affected by waves or currents?

6. PROXIMITY. Is this the closest wetland upslope from a navigation channel, drinking water supply (surface water), ground water recharge site, sediment-sensitive ecological habitat (e.g., fish spawning area), or area with water quality inferior to that of this wetland (with regard to sediment)?

7. STORAGE CONTEXT. Is this the largest (or widest or lowest-gradient) wetland upstream from a navigation channel, drinking water supply (surface water), ground water recharge site, sediment-sensitive ecological habitat (e.g., fish spawning area), or area with water quality inferior to that of this wetland (with regard to sediment); located within about one mile (if on a small stream) or within five miles (if on a large stream)?

8. SPECIES. Are any officially-designated threatened or endangered species present in the wetland annually?

9. SUBSISTENCE. Is this wetland's wildlife used by communities recognized by ADF&G as having a primarily non-cash economy?

10. DESIGNATION. Has this wetland been officially designated a Critical Habitat Area by ADF&G, USFWS, or 955/4-19/PA#d

INTERPRETATION KEYS. See Adamus et al (1987) for general instructions. Slashes mean "or". Underlines pertain only to wetlands having channels: y = yes, n = no.

GROUND WATER RECHARGE

RATINGS	A-Certainty	B-Certainty	C-Certainty
HIGH	2y	5y/(8y)	8y
MOD			(all other conditions)
LOW	1y/2n/3y	4y/(6y + 7y)	6y/7y/9y

GROUND WATER DISCHARGE

HIGH	2y/3y	4y/(6y + 7y)	7y+9y
MOD			(all other conditions)
LOW	2n	5y/(8y)	1y/8y

SURFACE HYDROLOGIC CONTROL (Peak Flow Attenuation) - Opportunity

HIGH	1y	2y + 3n	2y
MOD			(all other conditions)
LOW	1n + 2n + 3y	2n + 3y	2n

SURFACE HYDROLOGIC CONTROL (Peak Flow Attenuation) - Effectiveness

RATING	A-Certainty	B-Certainty	C-Certainty
HIGH	(1y + 11.1y) or 3y	5y	4y + (6y/7y) + 11.1y or (9y/10y) + 11.1y
MOD	--	--	(all other conditions)
LOW	2y	3n + 4n + 5n	(6n + 7n + 8n) or (9n + 12y) or (14y) or (11.2n) or (11.1n + 13n)

		BANK OR SHORELINE SENSITIVITY	
HIGH	(1.1y + 2y)/4y	(1.2y + 2y)/3y	
MOD	(1.2y + 1.4y) and other conditions		
LOW	1.3y	1.4y	3n

SEDIMENT/TOXICANT RETENTION - Opportunity

RATING	A-Certainty	B-Certainty	C-Certainty
HIGH	1y + 2y	3y	
MOD	1y		
LOW	1n	2n + 3n	

SEDIMENT/TOXICANT RETENTION - Effectiveness

HIGH	1y/3.1y	(2y + 4.1y) or (2y + 3.2y)	4.1y + 6y + (5y/7y)
MOD			4y + 6y
LOW	1n/4.2y/6n	6n or 8n	3n

NUTRIENT REMOVAL AND TRANSFORMATION - Opportunity

RATING	A-Certainty	B-Certainty	C-Certainty
HIGH	1y	2y + 3y	
MOD		2y	
LOW	1n	2n	

NUTRIENT REMOVAL AND TRANSFORMATION - Effectiveness

HIGH	1.1.1y or (1/2/1y + 2y + 4y)	1.2.1y	(1.2.1n/1.2.2n) + 2y + 3n +4n
MOD			(all others)
LOW	1.2.2y	1.2.2y + (4y)	1.2.2y/3y

SALMONID HABITAT: COHO/CUTTHROAT REARING

RATING	A-Certainty	B-Certainty	C-Certainty
HIGH	1y + all of List A	1y + most of List A	1y + most of List B
	[LIST A: 2y, 3.1y, 3.2y, 4y, 5y, 6y, 7y, 8y, 9.1y, 10y, 11y, 12y, 13.2y, 14y]		
	[LIST B: 3.2.2y, 5y, 6y, 9.2n, 11y, 12y, 13.1y, 14y]		
MODERATE			(all other conditions)
LOW	1n	--	1y + most of List C
	[LIST C: 2n, 3.1n, 3.2.2n, 4n, 5n, 6n, 7n, 8n, 9.2n, 10n, 11n, 12n, 13.1n, 14n]		

GENERAL WILDLIFE DIVERSITY/ABUNDANCE

RATING	A-Certainty	B-Certainty	C-Certainty
HIGH	Most of List A	All of List B	Most of List B
	[LIST A: 1y, 2y, 3y, 4y, 5y, 6y, 7.1y, 8.1y, 8.2.1y/8.2.2y, 8.3y, 9y, 10y, 11y, 12y, 13y, 14y]		
	[LIST B: 1y, 2y (5y/9y/12y), (7.1y/8.1y/8.2.1y), (3y/10y/11y), 13y]		
MODERATE			(all other conditions)
LOW	--	None of List A	None of List B

JUNEAU WETLANDS:
FUNCTIONS AND VALUES

APPENDIX E

CORRECTIONS TO THE SEPTEMBER 1987 JUNEAU WETLANDS FUNTIONS AND VALUES

Prepared by Adamus Resource Assessment, Inc.
Prepared for City and Borough of Juneau, Alaska
March 1988

Corrections to the September 1987

JUNEAU WETLANDS:
FUNCTIONS AND VALUES

Prepared by Adamus Resource Assessment, Inc.
Prepared for City and Borough of Juneau, Alaska
Revised: March 31, 1988

Clearly, much of Juneau's growth has occurred on land that formerly was wetlands. Two graphics illustrate this fact. Both were prepared by U.S. Fish and Wildlife Service, Anchorage. Figure 1 depicts study wetlands area in 1948. Wetlands which since then have been filled are indicated. The second graphic is Table 1. Some salient points from this table are:

- Wetlands in 1948 comprised 59% of the study area.

- About 1,162 of the original 9,208 wetland acres (those present in 1948) have been filled (12.6%) for an annual loss rate of 0.3% per year.

- In all subunits of the study area (except Douglas Island and Lower Montana), there is more undeveloped upland remaining than undeveloped palustrine wetland. However, much of this upland has severe engineering limitations or consists of invaluable open space.

- Development since 1948 has been wetland-focused in the East and West Mendenhall subunits, but upland-focused elsewhere. These two subunits in 1948 had a greater percentage of their area in wetlands than did the other subunits.

The following should be kept in mind when interpreting these two graphics: (a) These estimates are based on interpretation of aerial photography, in which wetlands (particularly forested ones) are not always clearly identifiable, (b) the 1984 acreages for wetlands may differ from those derived from the 1984 Corps of Engineers maps, which had a greater degree of field verification but used a more conservative definition of "wetland," (c) The acreages reflect only direct destruction of wetlands due to roads, gravel pits, and residential/commercial development; they do not reflect the degradation (or perhaps in some cases, improvement) of some wetland functions which has occurred as an indirect result of development.

The Juneau study area's wetland loss rate (0.3% per year) is less than the national loss rate. In addition, it represents the loss rate from a very localized area chosen specifically for its large wetland acreage and expected high loss rates. Southeast Alaska generally is expected to have lower wetland loss rates than the national average, despite widespread, usually indirect, impacts from resource extraction activities.

- About 4,579.6 acres of study area wetlands (49.7%) have been protected since 1948 by conveyance into parks, greenbelts and a game refuge. See Table 1b, and figure 2(E).

Juneau is not unique in having a large portion of its land as wetland. However, around other cities with formerly great percentages of wetland (e.g., San Francisco, New Orleans

TABLE 1. Juneau Wetland Losses 1948-1984

Data courtesy U.S Fish and Wildlife Service, except the last column, which was developed by CBJ Department of Community Development. See Figure 2 for boundaries of statistical units and text for discussion.

		Wetlands Filled Since 1948		Development Since 1948 – Location of Development			Remaining Undeveloped Areas			
Subunit	**Subunit Size**	**Acres**	**Acres/Yr**	**% in Wetlands**	**% in Upland**	**Wetlands as % of Study Area (1948)**	**Total**	**Upland[1]**	**Palustrine[2]**	**Developable Upland[3]**
Duck (D)	1,690	320.6	8.9	28.0	71.7	27	508	379	95	51
Jordan (J)	484	4.3	0.1	9.5	90.5	32	484	332	152	0
Lower Montana (LM)	1,019	6.3	0.2	6.6	93.0	56	918	346	496	45
Upper Montana (UM)	1,207	6.5	0.1	7.8	92.0	37	1,101	656	444	110
Auke Bay (A)	1,208	30.2	0.8	43.8	56.0	42	1,115	642	307	202
West Mendenhall (WM)	1,901	119.6	3.3	73.0	26.8	58	1,710	728	524	137
East Mendenhall (EM)	2,712	318.2	8.6	66.6	33.3	81	1,997	126	84	126
Lemon (L)	2,049	309.9	8.6	35.1	64.9	58	1,146	258	226	134
East Douglas Island (DE)	2,002	21.2	0.6	42.1	57.9	75	1,952	477	1,038	24
West Douglas Island (DW)	1,334	25.1	0.7	60.9	39.1	78	1,292	280	564	232
TOTAL	15,606	1,261	32.3	38.3	61.7	59	12,223	4,224	3,930	1,061

[1] Much of this upland acreage may be unbuildable due to ownership, geotechnical limitations, and other factors.

[2] Palustrine wetlands basically are freshwater wetlands that are not lakes or rivers.

Table 3. Relative confidence in ratings assigned to Juneau wetlands.

Function	A. Confidence when Wetland Measured Directly	B. Spatial Confidence when extrapolated from Superficial characteristics	C. Temporal Confidence (Confidence when A. is Extrapolated to other seasons.)
Ground Water Recharge, Discharge	very high	moderate-high	moderate
Surface Hydrologic Control	moderate	low	moderate
Sediment/Toxicants, Nutrients	high	low	high
Riparian Support	moderate	moderate	moderate
Salmonid Habitat	high	moderate-high	N/A
Disturbances Wildlife	very high	moderate-high	N/A
Regional Ecological Diversity	moderate	low	N/A
Erosion Sensitivity	low-moderate	low	N/A
Ecological Replacement Cost	very high	very high	very high
Recreational Use	very high	very low	moderate
Downslope Beneficiary Sites	high	high	high

Specific reasons for diminished confidence in some ratings are given in Section 2.2.

Usable wetland maps were a prerequisite for beginning the field work. The most convenient ones available were the draft version of the Corps of Engineers maps, at a scale of 1 inch = 200 feet. We did not make any wetland determinations as part of this project; the wetlands shown are exclusively those delineated by the Corps. After we had used the draft maps for field studies, the Corps in November released a final version (based on their subsequent field-checking) which had several changes. As a

PROTECTED LAND USE

MONTANA (FIGURE 1)

1) Montana Cr. Greenbelt--	297.50ac.
2) Montana Cr. /Mendenhall R. Greenbelt--	57.51ac.

AUKE BAY (FIGURE 2)

3) Auke Lake Greenbelt--	57.00ac.
4) Auke Lake Beach Access--	.67ac.
5) Auke Lake Beach Access--	1.50ac.
6) Spaulding Meadows Trail--	4.10ac.
7) Spaulding Meadows Trail--	1.39ac.
8) Auke Bay Beach Access--	.36ac.
9) Auke Bay Beach Access--	.14ac.

WEST VALLEY (FIGURE 3)

10) Mendenhall R. Greenbelt--	5.42ac.
11) Wildmeadow Park--	40.00ac.
12) Mendenhall Pen. Beach Access	.58ac.
13) Men. State Game Refuge--	397.00ac.

EAST VALLEY (FIGURE 4)

14) Mendenhall R. School--	2.90ac.
15) Melvin Park--	7.90ac.
16) Duck Creek Greenbelt--	11.20ac.
17) Adair/Kennedy Park--	28.19ac.
18) Glacier Valley School--	6.06ac.
19) Park Place Pond--	8.50ac.
20) Justice Diamond Park--	61.06ac.
21) Men. Loop Park--	4.51ac.
22) Men. State Game Refuge--	1321.00ac.

LEMON CREEK (FIGURE 5)

23) Sunny Point--	3.13ac.
24) Pinewood Park--	22.76ac.
25) Switzer Cr. Greenbelt--	17.00ac.
26) Lemon Cr. Greenbelt--	4.60ac.
27) Vanderbilt Cr. Area--	10.10ac.
28) Men. State Game Refuge--	578.00ac.

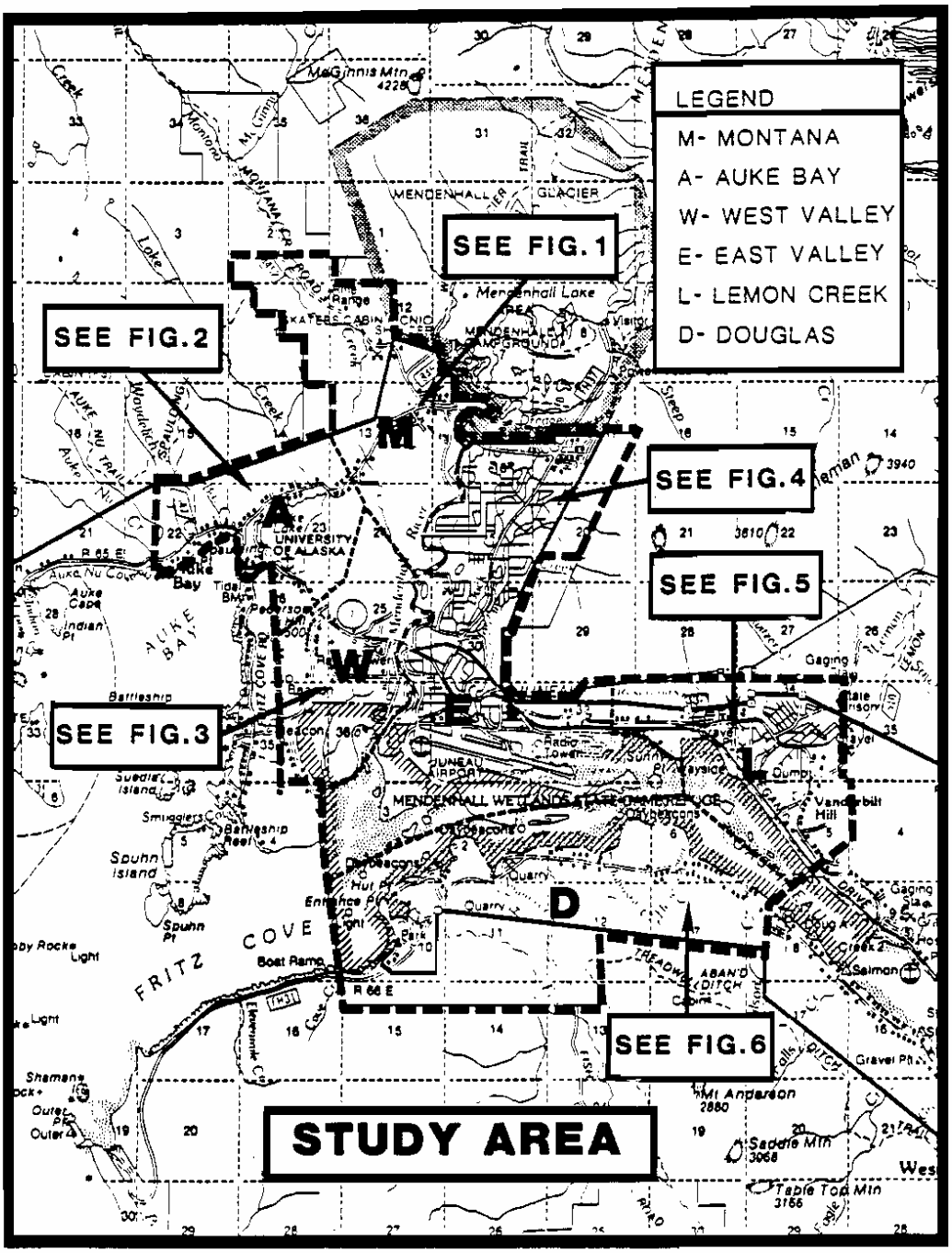
DOUGLAS (FIGURE 6)

29) Bayview Area--	83.47ac.
30) Fish Cr. Greenbelt--	32.15ac.
31) Johnson Cr. Greenbelt--	8.70ac.
32) Hendrickson Cr. Grnblt.--	15.60ac.
33) Neilson Cr. Greenbelt--	8.25ac.
34) Treadwell Ditch Trail--	1.60ac.
35) Men. State Game Refuge	1467.00ac.

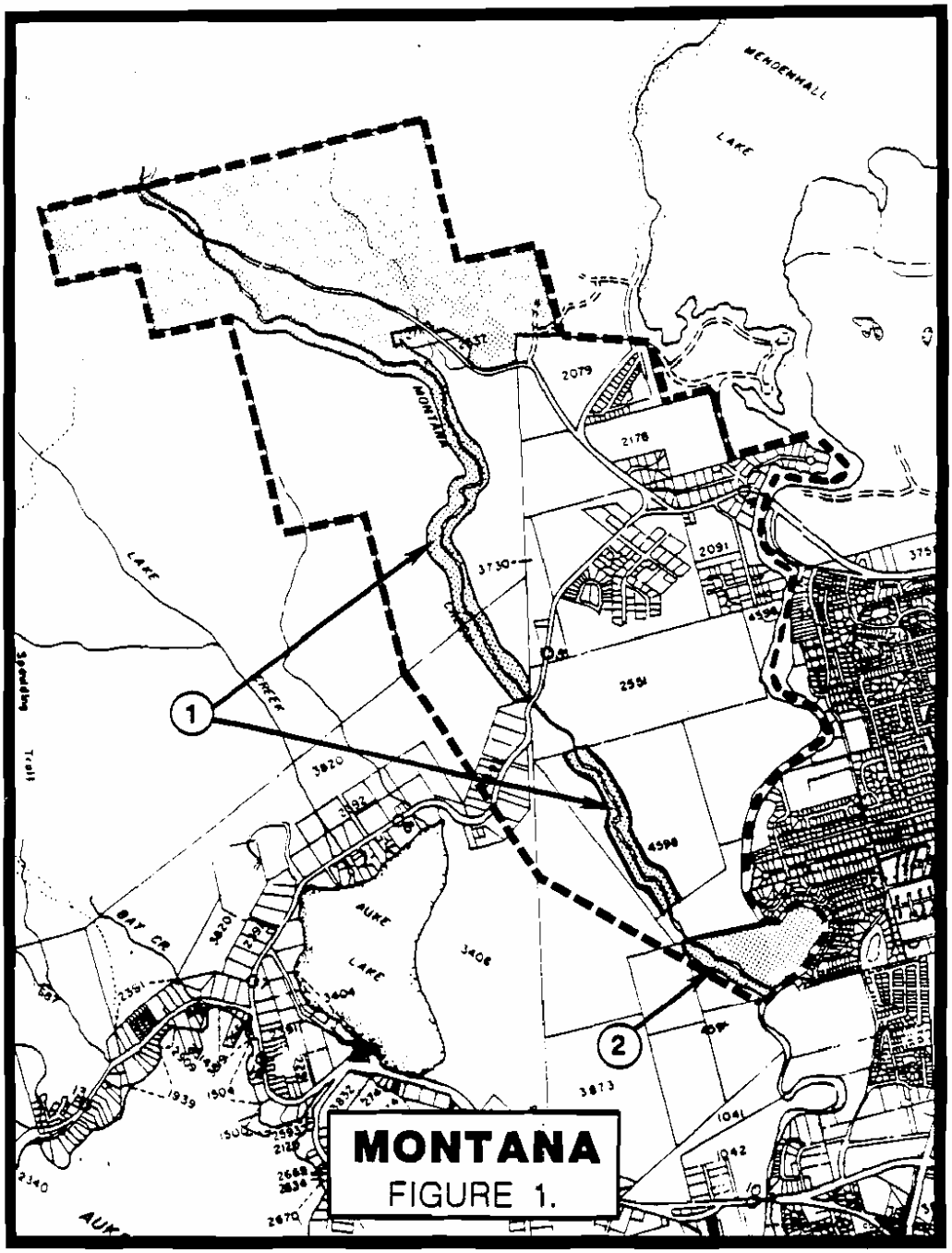
TOTAL

MONTANA	355.01ac.
AUKE BAY	65.16ac.
WEST VALLEY	443.00ac.
EAST VALLEY	1451.32ac.
LEMON CREEK	635.59ac.
DOUGLAS	1616.77ac.

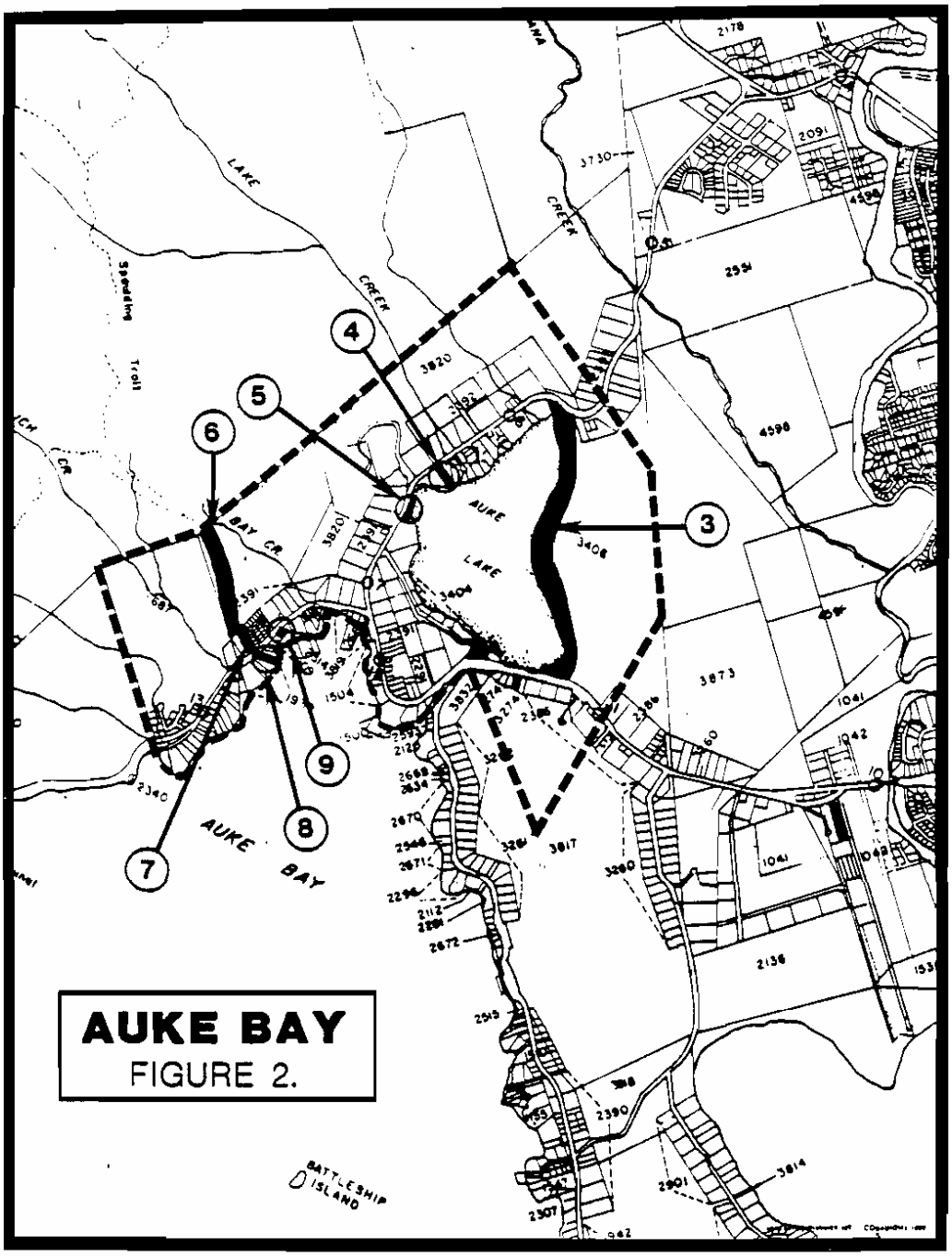
1(b)


LEGEND
M- MONTANA
A- AUKE BAY
W- WEST VALLEY
E- EAST VALLEY
L- LEMON CREEK
D- DOUGLAS
SEE FIG. 1
SEE FIG. 2
SEE FIG. 3
SEE FIG. 4
SEE FIG. 5
SEE FIG. 6
STUDY AREA
M
A
W
E
D
MENDENHALL GLACIER
Mendenhall Lake
UNIVERSITY OF ALASKA
AUKE BAY
FRITZ COVE
JUNEAU AIRPORT
MENDENHALL WETLANDS
Vanderbilt Hill
Mt Anderson
Saddle Mtn
Table Top Mtn

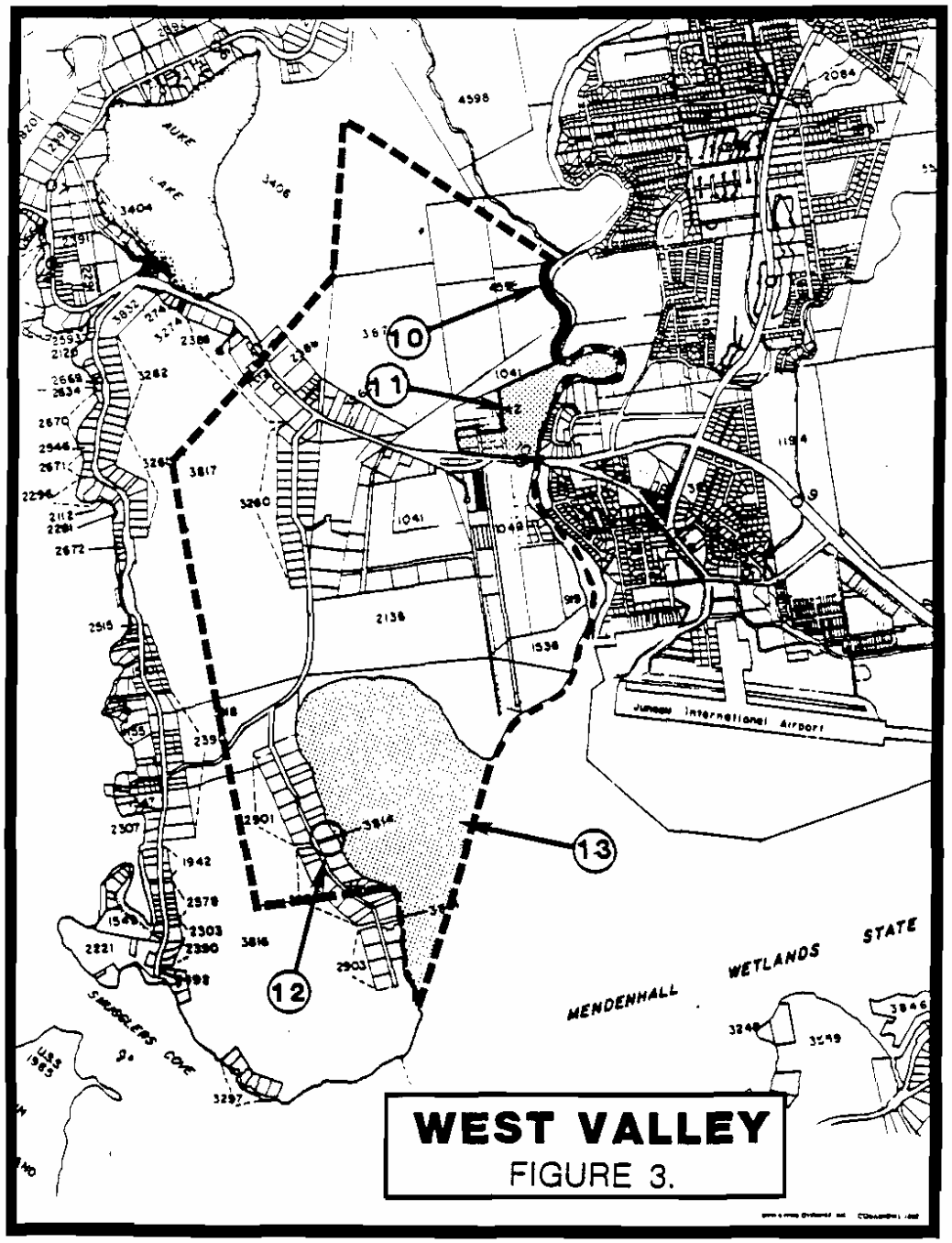
2 (E)


MONTANA
FIGURE 1.
MONTANA
LAKE
AUKE
LAKE
BAY CR
Speedway
Trail
1
2

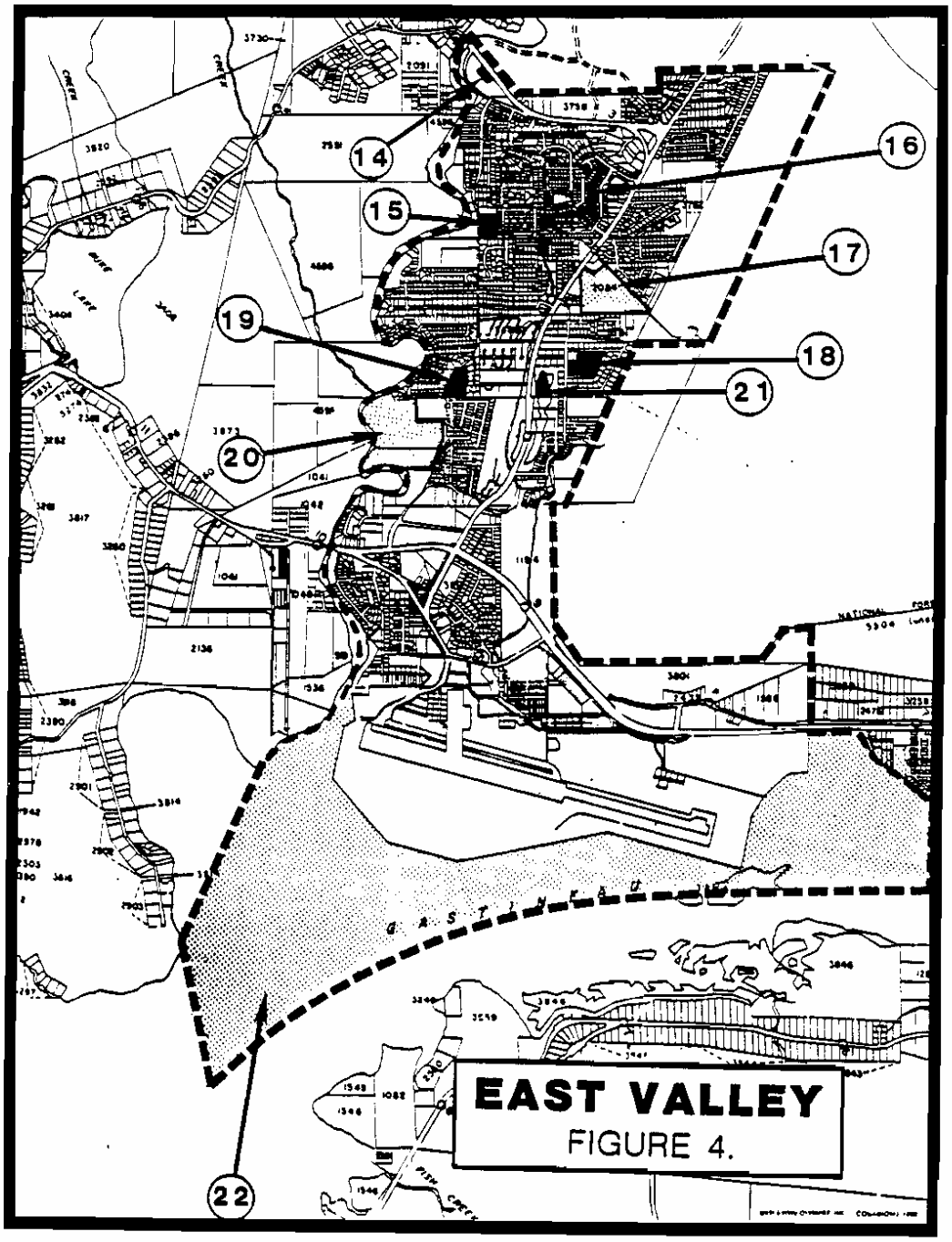
2 (F)


AUKE BAY
FIGURE 2.
LAKE CREEK
AUKE LAKE
BAY CR
AUKE BAY
BATTLESHIP ISLAND
Spaulding Trail
3
4
5
6
7
8
9

2 (G)


AUKE
LAKE
10
11
12
13
Juneau International Airport
MENDENHALL
WETLANDS
STATE
SMUGGLERS COVE
WEST VALLEY
FIGURE 3.

2 (H)



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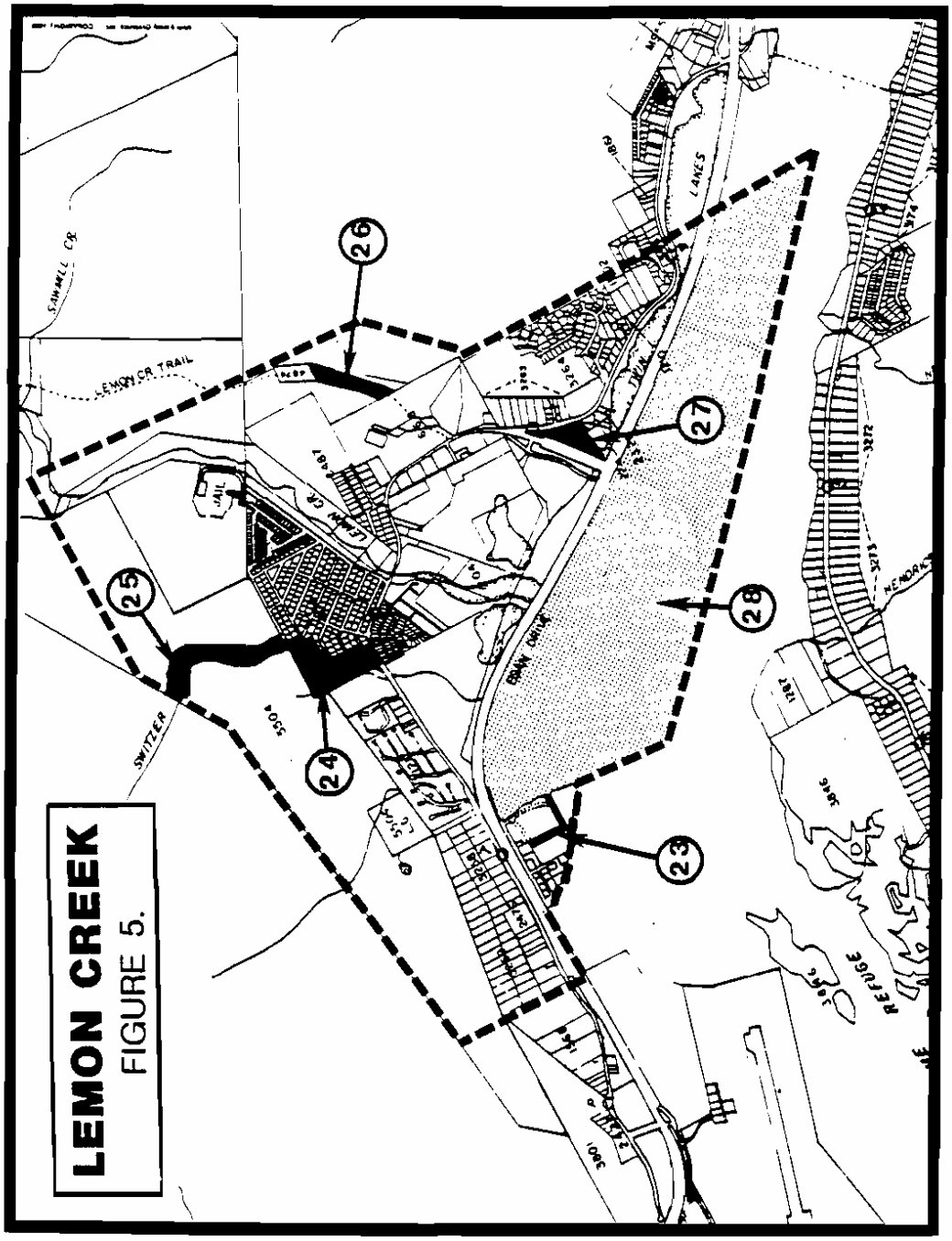
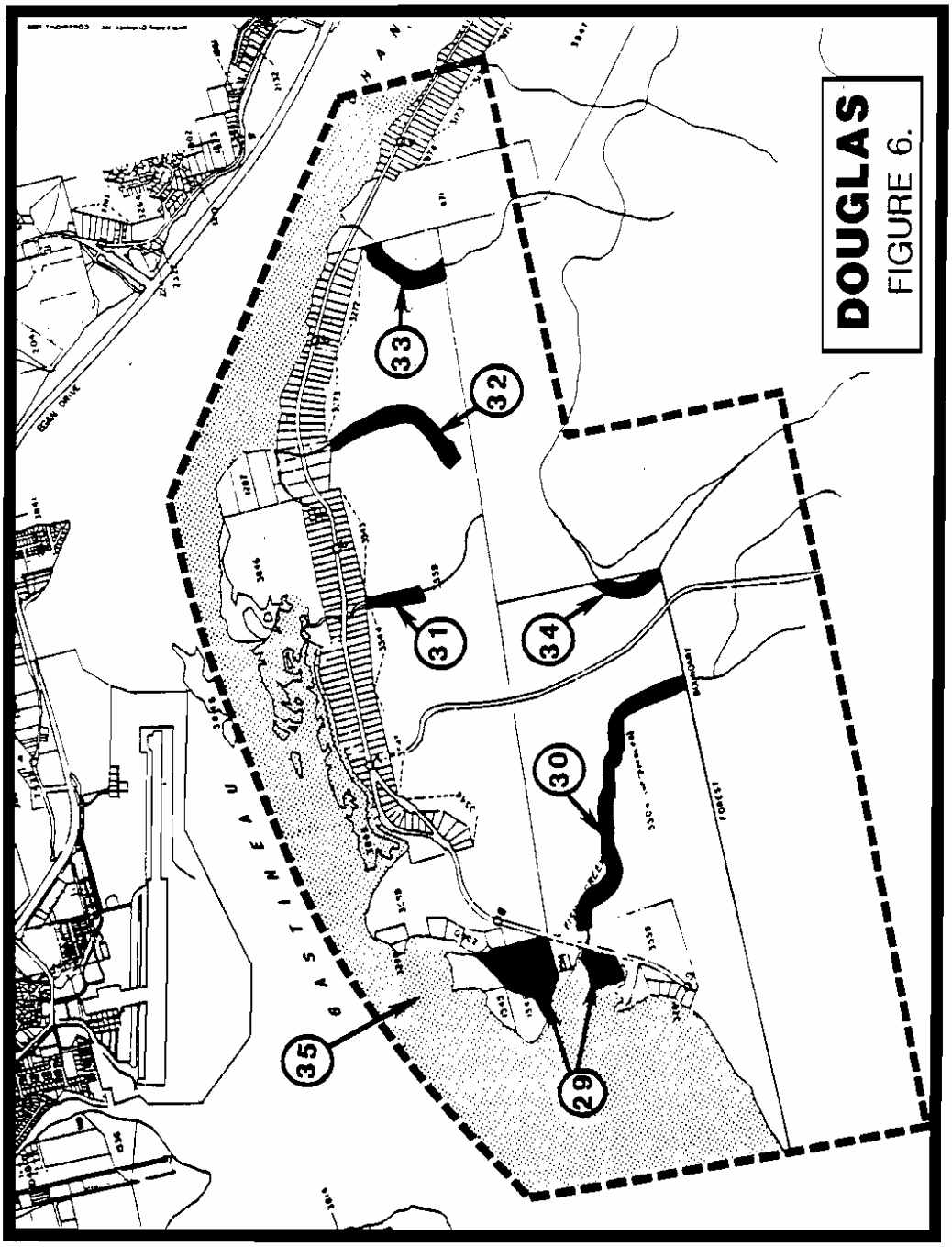

LEMON CREEK
FIGURE 5.
SWITZER
LEMON CR. TRAIL
SAWMILL CR.
LEMON CR.
CRAIG DRIVE
LANES
REFUGE
MENDENHALL
23
24
25
26
27
28

2 (J)



2 (K)