Supplemental Information

Cumulative Impacts to Wetlands and Streams

Master Plan Update Improvements
Seattle-Tacoma International Airport

Port of Seattle

Parametrix, Inc.

August 2001

SUPPLEMENTAL INFORMATION

CUMULATIVE IMPACTS TO WETLANDS AND STREAMS

MASTER PLAN UPDATE IMPROVEMENTS
SEATTLE-TACOMA INTERNATIONAL AIRPORT

Prepared for:

PORT OF SEATTLE
Seattle-Tacoma International Airport
Seattle, Washington 98158

Prepared by:

PARAMETRIX, INC.
5808 Lake Washington Blvd. NE, Suite 200
Kirkland, Washington 98033-7350

August 2001

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

EXECUTIVE SUMMARY

The Seattle-Tacoma International Airport (STIA) has updated its Master Plan to meet future aviation needs. This report has been prepared to provide information requested by the U.S. Army Corps of Engineers (ACOE) regarding cumulative effects to wetlands, streams, and habitat as a result of the STIA Master Plan Update. This information also responds to public concerns addressed to ACOE and the Washington Department of Ecology (Ecology) during the recent public comment period. This report analyzes cumulative impacts of past, present, and future actions to wetlands, streams, and the fish, aquatic, and wildlife habitat they provide. The report updates earlier cumulative impact analyses completed in support of the National Environmental Policy Act (NEPA)/State Environmental Policy Act (SEPA), Final Environmental Impact Statement (FEIS) (FAA 1996), and Final Supplemental Environmental Impact Statement (FSEIS) (FAA 1997) for the Master Plan.

Specific information requested by ACOE and addressed in this report relating to cumulative impacts is:

- *What has happened to the Miller Creek, Walker Creek, and Des Moines Creek watersheds in the past?*
- *Estimate the types of impacts that have occurred to the wetlands and streams in the past, from both airport-related construction as well as other development.*
- *How much of the watershed has been developed?*
- *How much impervious surface is in the watershed?*
- *How will the proposed project increase these impacts?*
- *How do any future proposed projects add to these impacts?*
- *What does all of this mean to the watershed?*
- *How does this cumulatively affect the avian populations in the area? [Of particular concern for the watershed is the need to eliminate avian habitat from within 10,000 ft of an active runway.]*

The watersheds of concern have undergone large ecological changes since pioneer settlement beginning in the 1870s. The most dramatic impacts to the natural history of the area would have occurred in the late 1800s and early 1900s, when forestland was clear-cut and much of the watersheds were developed as farmland. These actions would remove wildlife habitat, alter wetlands and streams, and eliminate some wildlife populations. Several larger wetlands were drained to improve soils for farming. Several other wetlands have been mined to extract horticulturally valuable peat.

As the watersheds urbanized, a continued loss of habitat occurred. Urbanization, including airport development and road building, resulted in the filling of some wetland area, as well as the loss of wildlife habitat. Most of this development occurred without environmental mitigation and has contributed to cumulative losses of wetland, stream, and habitat resources.

The development of Seattle-Tacoma International Airport has contributed to wetland, stream. and habitat impacts at levels that appear proportionate to other development that has occurred in the watersheds. While the large footprint associated with the development of airport facilities (constructed primarily between 1946 and 1972) resulted in wetland loss and stream modifications, such losses were also common to many of the private- and public-sector development projects that occurred prior to the establishment of environmental regulations. The need for large buffers as part of noise remedy programs near STIA has resulted in purchase of wetlands associated with agricultural and residential land uses by the Port of Seattle. The removal of these land uses has resulted in the revegetation and preservation of several wetland areas.

The historical impacts to wetlands, streams, and wildlife habitat are typical for urban areas in King County. Clearing of forestland to accommodate agricultural uses has occurred throughout the Puget Sound region. As has occurred in the Miller, Walker, and Des Moines Creek watersheds. the development of agriculture in the region routinely included the modification of wetlands. soil drainage, and stream channel conditions to improve land for crop production. Conversion of forest and agricultural lands to urban uses has occurred throughout the Seattle-Tacoma metropolitan areas. These conversions have included wetland filling, stream channel modifications, watershed hydrology modification, and wildlife habitat loss. In the Miller, Walker, and Des Moines Creek watersheds, these impacts have been similar to other localities. The impacts in these watersheds have been less severe than in many areas (i.e., wetland and tideland filling at the mouths of the Puyallup, Duwamish, and Snohomish Rivers, or wetland fill and stream channelization for commercial development in the lower Green River Valley).

Current and future development (including the STIA Master Plan Update actions) must comply with a variety of environmental regulations affecting wetlands, streams, and habitat. These regulations and substantial mitigation requirements reduce the potential that additional cumulative impacts would occur. For the Master Plan Update projects, wetland, stream, and hydrologic mitigation improves wetland and stream functions by enhancing wetlands and streams and by retrofitting previous development lacking stormwater quality and quantity controls to meet current standards. This mitigation should prevent losses of stream or wetland functions, and provide habitat for wildlife species.

1. INTRODUCTION

Implementation of the Seattle-Tacoma International Airport (STIA) Master Plan by the Port of Seattle (Port) will result in the filling of 18.37 acres of wetland and 980 ft of Miller Creek. This report provides information on cumulative impacts to wetlands and streams in the affected watershed to help the U.S. Army Corps of Engineers (ACOE) evaluate the Port Section 404 permit application (Port of Seattle 2000).

Cumulative impacts are defined by the Council on Environmental Quality (1997) and 40 CFR 1508.7 as:

> *...the impact on the environment which results from incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.*

This report has been prepared to provide information requested by ACOE regarding cumulative effects to wetlands, streams, and habitat as a result of the STIA Master Plan Update. This report analyzes information relative to cumulative impacts of past, present, and future actions to wetlands, streams, and the fish, aquatic, and wildlife habitat they provide, and follows guidance provided by the National Transportation Research Board (1998) and the Council on Environmental Quality (1997). This information also responds to public concerns made to ACOE and Washington Department of Ecology (Ecology) during the recent public comment period.

Specific information requested by ACOE (ACOE 2001) and addressed in this report relating to cumulative impacts is:

- *What has happened to the Miller Creek, Walker Creek, and Des Moines Creek watersheds in the past?*
- *Estimate the types of impacts that have occurred to the wetlands and streams in the past, from both airport-related construction as well as other development.*
- *How much of the watershed has been developed?*
- *How much impervious surface is in the watershed?*
- *How will the proposed project increase these impacts?*
- *How do any future proposed projects add to these impacts?*
- *What does all of this mean to the watershed?*
- *How does this cumulatively affect the avian populations in the area? [Of particular concern for the watershed is the need to eliminate avian habitat from within 10,000 ft of an active runway.]*

This report summarizes the existing available information needed to answer these questions. The report is organized in five chapters. Chapter 2 provides an analysis of historic and current land use and impervious area in the watersheds. Chapter 3 evaluates changes in wetland conditions in the watersheds in the project area. Chapter 4 evaluates information on historic and current stream and riparian habitat conditions. Finally, Chapter 5 evaluates past, current, and future impacts to wetland wildlife habitat. A summary of the cumulative effects analysis is provided in Chapter 6.

2. LAND USE CHANGES IN THE MILLER AND DES MOINES CREEK WATERSHEDS

The changes in land use near Seattle-Tacoma International Airport and within the Des Moines, Miller, and Walker Creek Watersheds (Figure 1) are presented in this section. The land use information presented in this chapter addresses questions regarding past and current development in the watershed. It also provides a basis for discussions in Chapters 3, 4, and 5 regarding changes and cumulative impacts to wetlands, streams, and habitat within the watersheds.

2.1 METHODS AND AVAILABLE DATA

Historical information of the early settlement of the Miller, Walker, and Des Moines Creek watersheds is found in Draper (1975), Eyler and Yeager (1972), Kennedy and Schmidt (1989), and USGS (1900). These documents provide general information on some of the early development that would affect watershed conditions (early roads, settlements, lumber mills, bridges, etc.). Due to the anecdotal nature of much of this information relative to the concerns of ACOE, it could not be used as a significant source of information.

More detailed land use changes were determined based on existing information from a variety of sources. The primary data sources used in this report documenting current and historical land use conditions in the watersheds are:

- *Sea-Tac Airport Vicinity Land Use Inventory Project* (prepared by Shapiro and Associates [1994] for the Port of Seattle Aviation Planning Division).
- *King County GIS Land Use Data Base (1995)* (available from King County).
- *1936 Aerial Photographs* (available from Walker and Associates).
- *Soil Survey, King County Washington* (USDA 1952).
- *Habitat Limiting Factors and Reconnaissance Assessment Report: Green Duwamish and Central Puget Sound Watersheds (Land Use Appendix).* King County and Washington State Conservation Commission (2000).
- *Comprehensive Stormwater Management Plan STIA Master Plan Update.* Parametrix (2000a).
- *Land Use Layer, King County Geographical Information System (GIS).* King County Washington.

Historical land use data from Shapiro and Associates (1994) provides analysis of land use changes from 1948 to 1992 (Table 1; Figures 2 through 6). These data were based on review of aerial photographs for an analysis area that includes much of the Miller, Walker, and Des Moines Creek watersheds. Land use categories used in this assessment were:

- **Airports.** STIA and King County International Airport (Boeing Field).
- **Commercial/industrial.** Includes railroad yards, landfills, and other commercial or industrial facilities.
- **Community and public facilities.** Schools, hospitals, cemeteries, park-and-ride lots, government buildings, and other government facilities.

Table 1. Historical land uses near Seattle-Tacoma International Airport from 1948 to 1992.

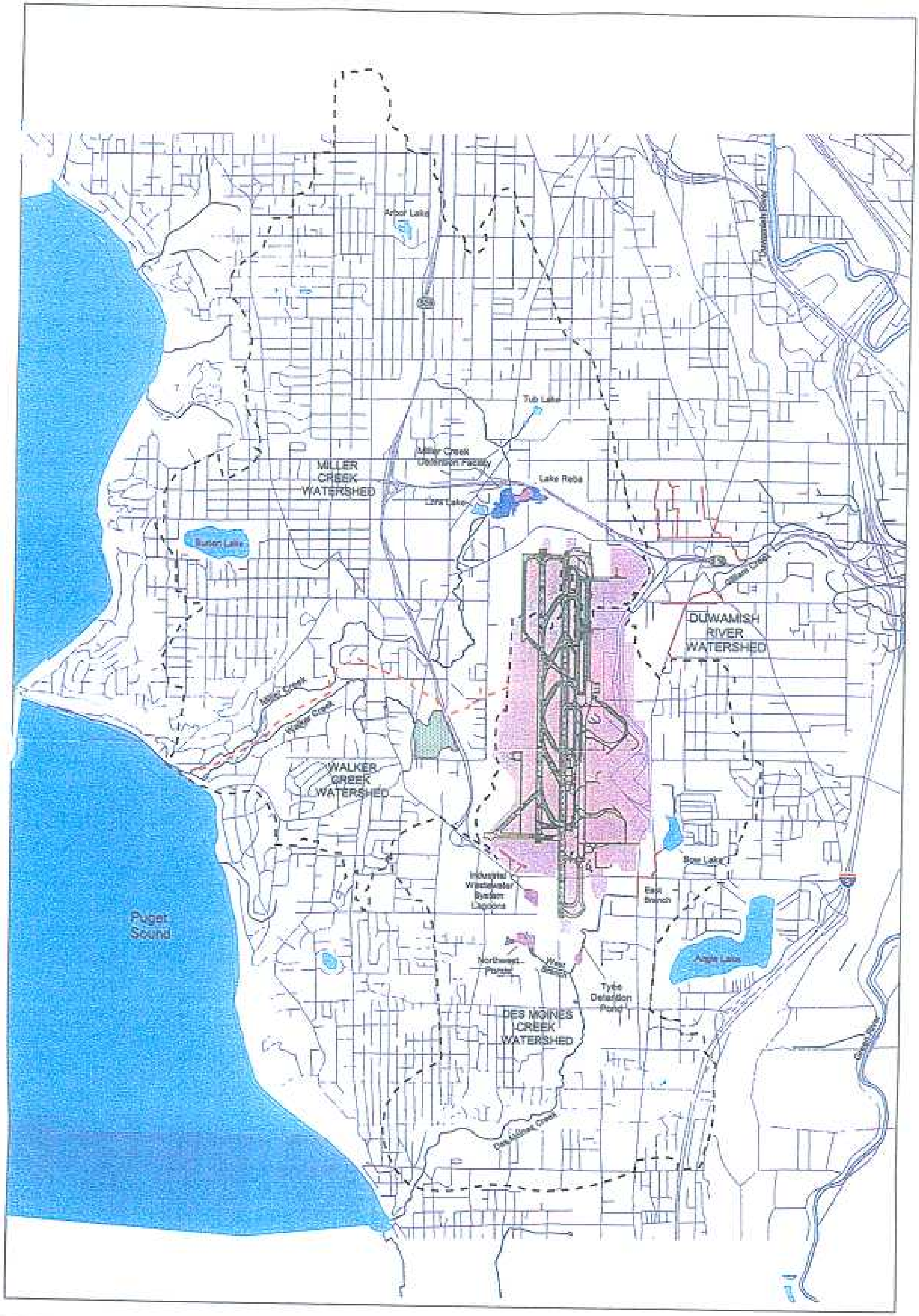
Year	Residential		Undeveloped		Commercial		Public Facilities		Other[b]		Airports[c]	
	Acres	Percent[a]	Acres	Percent[a]	Acres	Percent[a]	Acres	Percent[a]	Acres	Percent[a]	Acres	Percent[a]
1948	7,255	24.4	19,945	67.3	555	1.9	165	0.5	730	2.5	1,000	3.4
1961	11,770	39.7	11,510	38.8	1,980	6.7	655	2.2	2,075	7.0	1,660	5.6
1974	12,855	43.4	7,545	25.4	2,800	9.4	780	2.6	2,780	9.4	2,890	9.8
1982	13,490	45.5	5,360	18.1	3,500	11.8	780	2.6	3,310	11.2	3,210	10.8
1992	14,685	49.5	4,955	16.7	3,750	12.6	815	2.8	2,065	7.0	3,380	11.4

[a] Percent of a 29,650-acre study area, as summarized in Shapiro and Associates (1994).

[b] Includes other land uses, undetermined land uses, major road rights-of-way, and transmission line rights-of-way.

[c] Includes STIA and Boeing Field.

AR 050802



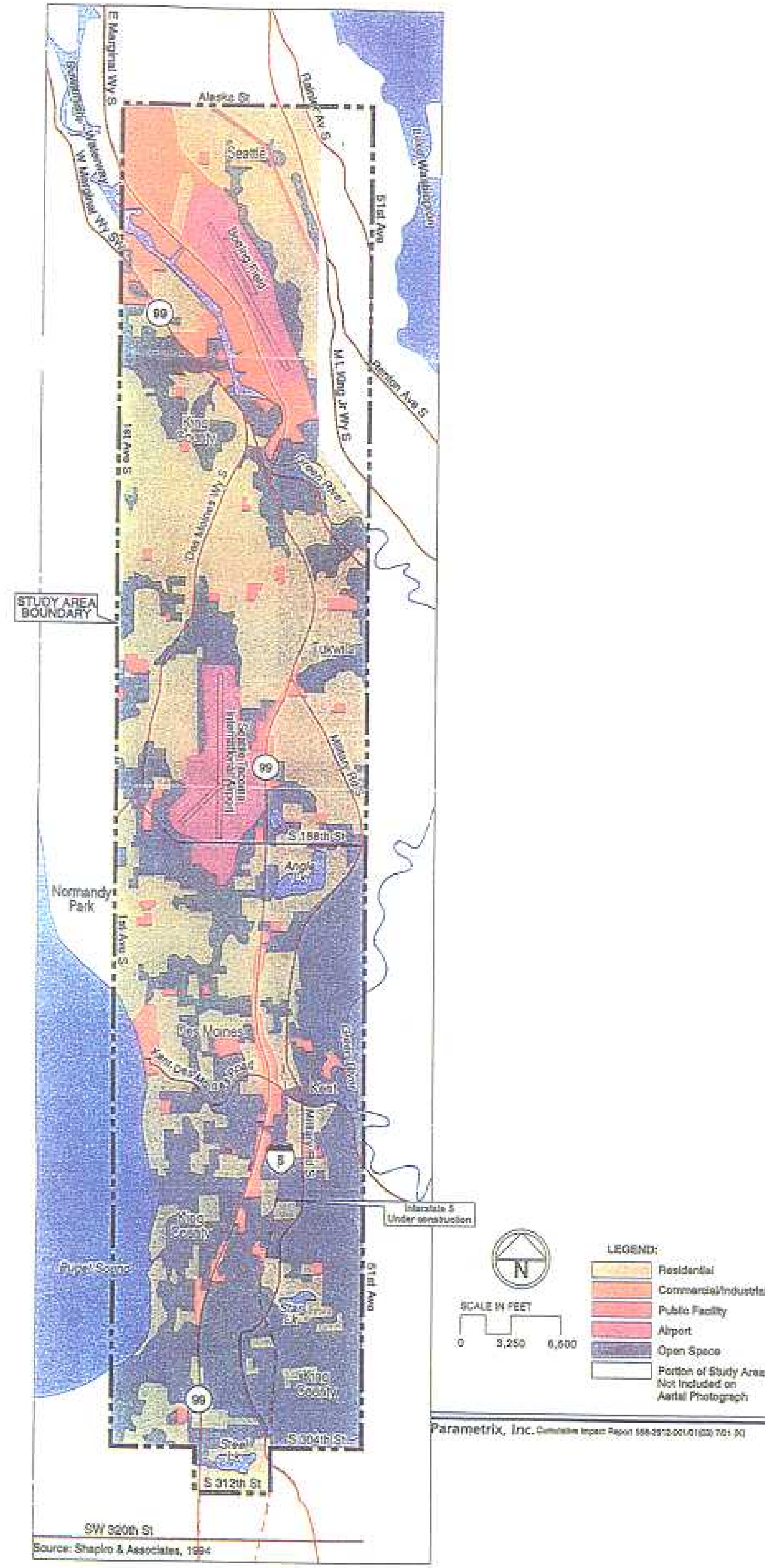
Parametrix, Inc. Sea-Tac Airport [illegible] File: [illegible]
[illegible]: Roads based on King County data. Water bodies derived from USGS topography data.
[illegible] boundaries are approximate. Estimated wetland boundaries are based on field reconnaissance by Parametrix, Inc.

N

1000 0 1000 2000 Feet

- Roads
- Streams
- Subwatershed Boundary
- Watershed Boundary
- Piped Stream
- Constructed Water Feature
- Water Bodies
- Detention Facilities (existing)
- Wetland 43
- Sea-Tac Airport
- Sea-Tac Airport Runway

Figure 1
Miller Creek, Walker Creek Des Moines Creek and their Watershed Boundaries



Parametrix, Inc.

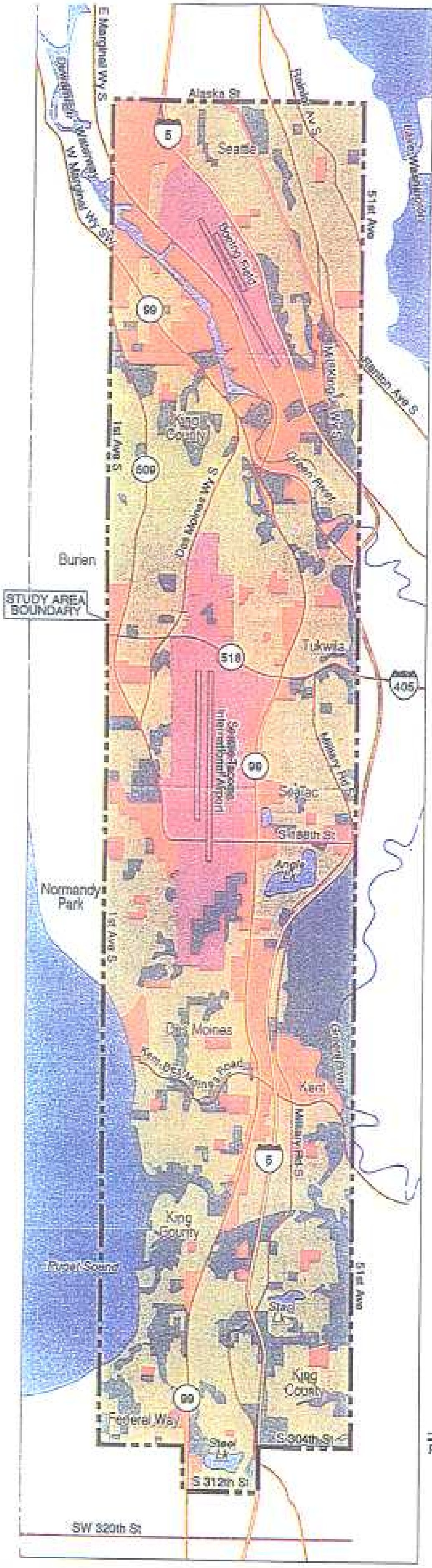
Figure 2
Land Use Near
STIA in 1948

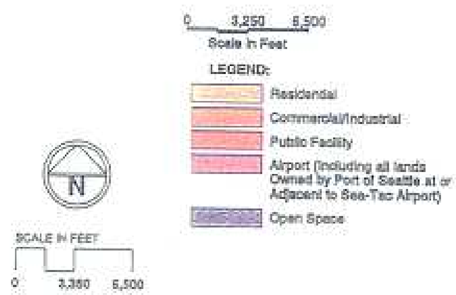
AR 050804

Parametrix, Inc.

Figure 3
Land Use Near
STIA in 1961

AR 050805

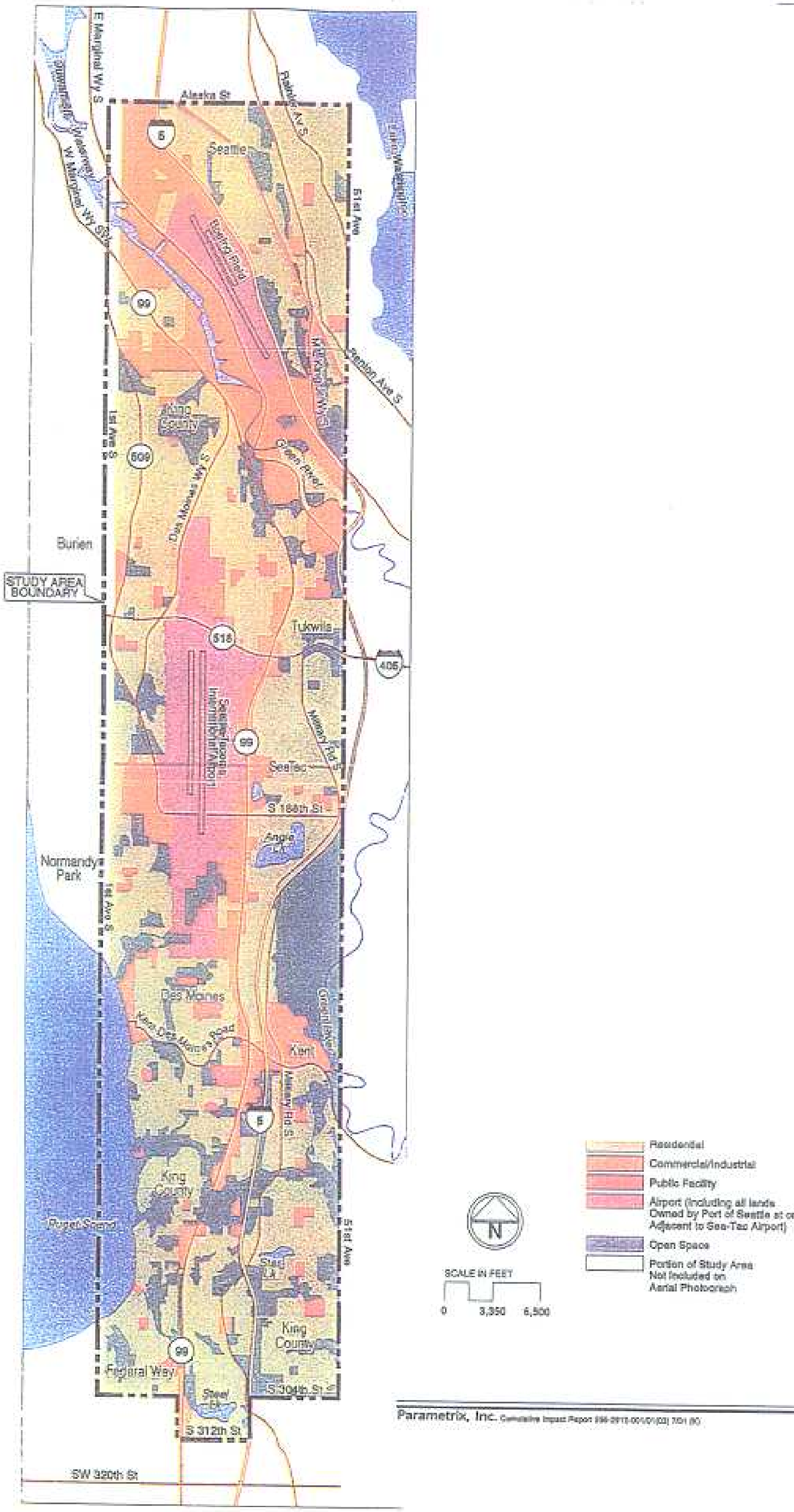




Parametrix, Inc. Cumulative Impact Report 556-2912-001/01(03) 7/01 (K)

Source: Shapiro & Associates, 1994

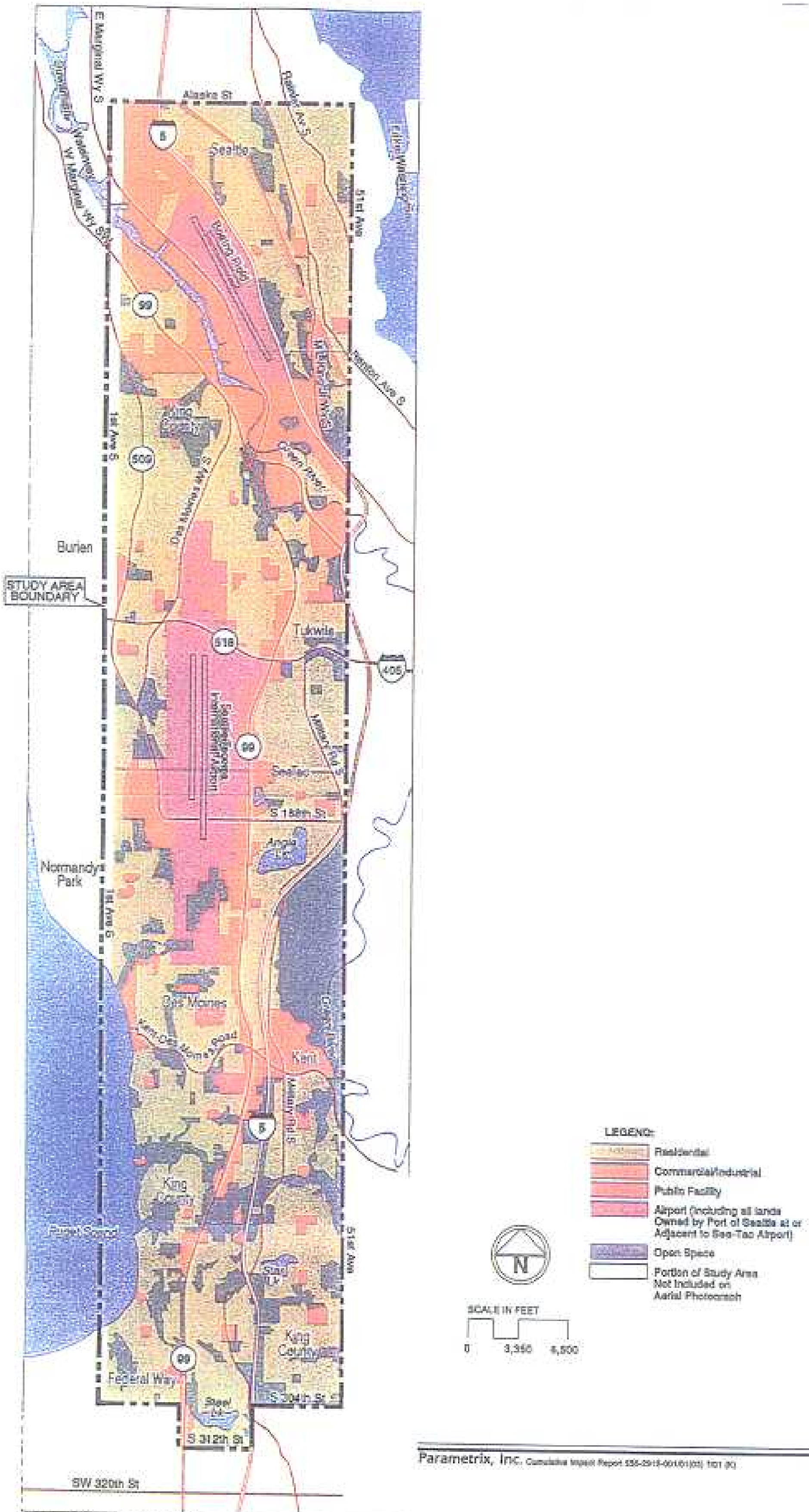
Figure 4
Land Use Near
STIA in 1974



Parametrix, Inc. Cumulative Impact Report 556-2912-001/01(03) 7/01 (K)

Source: Shapiro & Associates, 1994

Figure 5
Land Use Near
STIA in 1982



Parametrix, Inc. Cumulative Impact Report 556-2916-001/01(03) 11/01 (K)

Source: Shapiro & Associates, 1994

Figure 6
Land Use Near
STIA in 1992

- **Open space/agriculture.** Agriculture activity, parks, golf courses, lakes. Excludes parcels where roads and cleared land indicate development is occurring.
- **Community and public facilities.** Schools, hospitals, cemeteries, park-and-ride lots, government buildings, and other government facilities.
- **Residential.** Land settles at varying densities; includes land where roads and clearing indicate development is occurring.
- **Other.** Major arterial and freeway right-of-way; transmission line corridors; other land uses not included in the above categories; undetermined land use.

Land use data for 1995 are available from King County (Figure 7), and are also reported in King County and Washington State Conservation Commission (2000). The 1995 land use data are specific to the Miller Creek (Table 2) and Des Moines Creek (Table 3) watersheds. The King County data for the watershed areas do not correspond to the study area for historical data available from Shapiro and Associates (1994). The classification system for land use data in the King County GIS also differs from historical data, but provides a more detailed analysis of land uses. Thus, direct and quantitative comparisons are not possible.

While historical land use is an indicator of watershed development and changes to wildlife habitat, impervious surfaces (pavement, rooftops, etc.) are indicators of potential hydrologic impacts that can degrade fish and other aquatic habitats. Impervious surfaces generate increased stormwater runoff, and if not adequately managed can impact the hydrology and water quality of receiving waters. The current extent of impervious surfaces in the watersheds is identified in Table 4. This table also includes analysis of the new impervious surfaces created by the Master Plan Update projects. Since much of this impervious surface lacks adequate stormwater management controls for water quality treatment and release, it contributes cumulatively to stream impacts.

Table 2. Current land uses (1995) in the Miller Creek watershed.

Land Cover Description	Area (Mi^2)	Area (Acres)	% Watershed
Industrial & Commercial	1.074	687.36	12.10
Bare Rock/Concrete	0.044	28.29	0.50
City Center, Industrial	0.502	321.20	5.65
Recently Cleared	0.059	37.81	0.67
High-Density Residential	3.431	2,195.82	38.64
Subtotal	*5.11*	*3.270.48*	*57.56*
Low/Medium Density Residential	**2.516**	**1.610.39**	**28.34**
Conifer - Early	**0.002**	**1.54**	**0.03**
Conifer - Mature	**0.000**	**0.00**	**0.00**
Conifer - Middle	**0.000**	**0.00**	**0.00**
Deciduous Forest	**0.669**	**428.46**	**7.54**
Mixed Forest	**0.093**	**59.61**	**1.05**

Table 2. Current land uses (1995) in the Miller Creek watershed (continued).

Land Cover Description	Area (MI^2)	Area (Acres)	% Watershed
Grass - Brown	**0.236**	**150.92**	**2.66**
Grass - Green	**0.095**	**60.54**	**1.07**
Shrub	**0.108**	**69.21**	**1.22**
Open Water	**0.049**	**31.57**	**0.56**
Subtotal	*3.768*	*2,412.24*	*42.47*
TOTAL	8.879	5,682.71	100

Notes: Data compiled from King County Geographic Information System (GIS) data set based on 1995 Landsat satellite imagery.

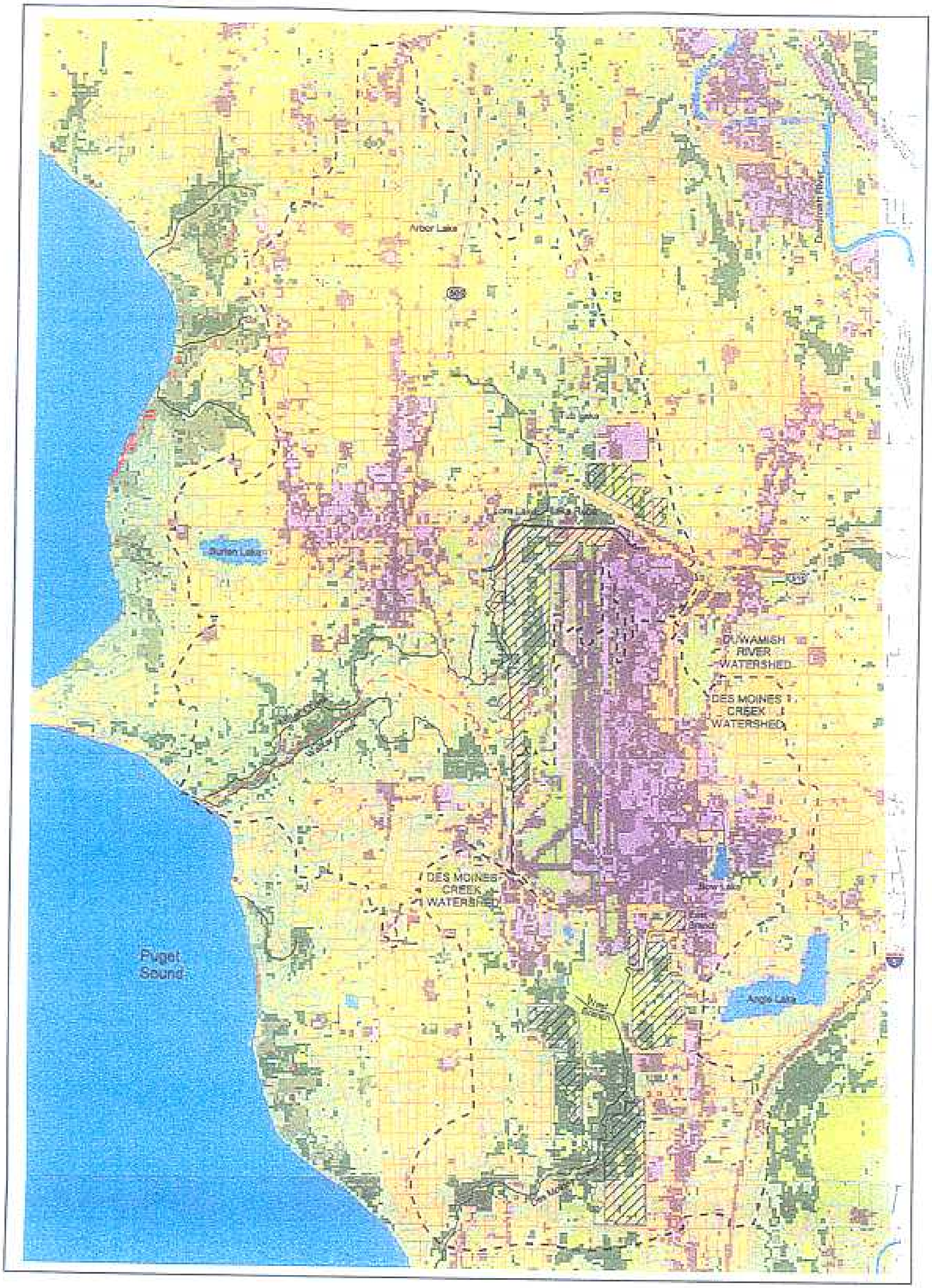
Land uses listed in **bold** are types that are considered to provide low (residential and grass) to moderate or high (remaining types) habitat value to a variety of wildlife (see Chapter 5).

Table 3. Current land uses (1995) in the Des Moines Creek watershed.

Land Cover Description	Area (MI^2)	Area (Acres)	% Watershed
Industrial & Commercial	1.373	878.47	23.43
Bare Rock/Concrete	0.056	35.71	0.95
City Center, Industrial	0.600	384.14	10.25
Recently Cleared	0.135	86.37	2.30
High-Density Residential	1.415	905.54	24.16
Subtotal	*3.579*	*2290.23*	*61.09*
Low/Medium Density Residential	**1.043**	**667.67**	**17.81**
Conifer - Early	**0.001**	**0.93**	**0.02**
Conifer - Mature	**0.000**	**0.00**	**0.00**
Conifer - Middle	**0.000**	**0.00**	**0.00**
Deciduous Forest	**0.567**	**362.84**	**9.68**
Mixed Forest	**0.067**	**42.61**	**1.14**
Shrub	**0.099**	**63.30**	**1.69**
Grass - Brown	**0.369**	**236.45**	**6.31**
Grass - Green	**0.114**	**73.02**	**1.95**
Open Water	**0.018**	**11.74**	**0.31**
Subtotal	*2.278*	*1458.56*	*38.91*
TOTAL	5.857	3,748.77	100

Note: Data compiled from King County Geographic Information System (GIS) data set based on 1995 Landsat satellite imagery.

Land uses listed in **bold** are types that are considered to provide low (residential and grass) to moderate or high (remaining types) habitat value to a variety wildlife (see Chapter 5).



Parametrix, Inc./Sea-Tac Airport /556-2912-001 File: K:\Gis\2912\Arcview\ssatac_4_lmlalley
Source: Roads based on King County data. Water bodies derived from USGS hypsography data.
Land Use data interpreted from the 1995 Landsat Satellite imagery, (pixel size 82 feet).

Figure 7
King County
Land Use Data in the Vicinity of STIA - 1995

Table 4. Effective impervious area in the Miller and Des Moines Creek watersheds in 1994 and predicted effective impervious area by 2006 with Master Plan Update improvements.

Year	Sub-Watersheds	Miller/Walker Creek		Des Moines Creek	
		Area	Percent	Area	Percent
1994 Condition	STIA Land	283.65	5.0	624.54	16.6
	Remaining Watershed	787.69	13.9	627.93	16.8
	TOTAL	**1,071.31**	**18.8**	**1,286.03**	**34.3**
2006 Condition	STIA Land	397.75	7.0	848.84	22.6
	Remaining Watershed	787.96	13.9	627.93	16.8
	TOTAL	**1,185.71**	**20.9**	**1,476.77**	**39.4**

Note: Data source is Parametrix (2000b). Effective impervious area is the impervious area that actually drains to stormwater collection systems or surface water, thereby generating hydrologic impacts. Impervious areas that direct stormwater away from collection systems to pervious land where infiltration occurs are not included in effective impervious area.

3. WETLANDS

3.1 LOCATIONS OF WETLANDS

To evaluate the past and current extent of wetlands in the Miller, Des Moines, and Walker Creek watersheds, historic and recent aerial photographs, soil survey maps, topographic maps, and wetland inventories were examined (wetlands and hydric soils near STIA are shown in Figures 8, 9, and 10).

3.1.1 Wetland Inventories

A variety of wetland inventories provide general information on the location of wetlands in the various watersheds. The wetland inventory maps were reviewed and include:

- Historic USGS Topographic Maps (USGS 1900, 1949, 1983) (Appendix A)
- King County Sensitive Areas Map (1990)
- City Sensitive Areas Maps (available at City Planning Departments):
  - SeaTac
  - Burien
  - Tukwila
  - Des Moines
  - Normandy Park
- National Wetland Inventory Map (Des Moines and Seattle South Quadrangles) (USFWS 1987)

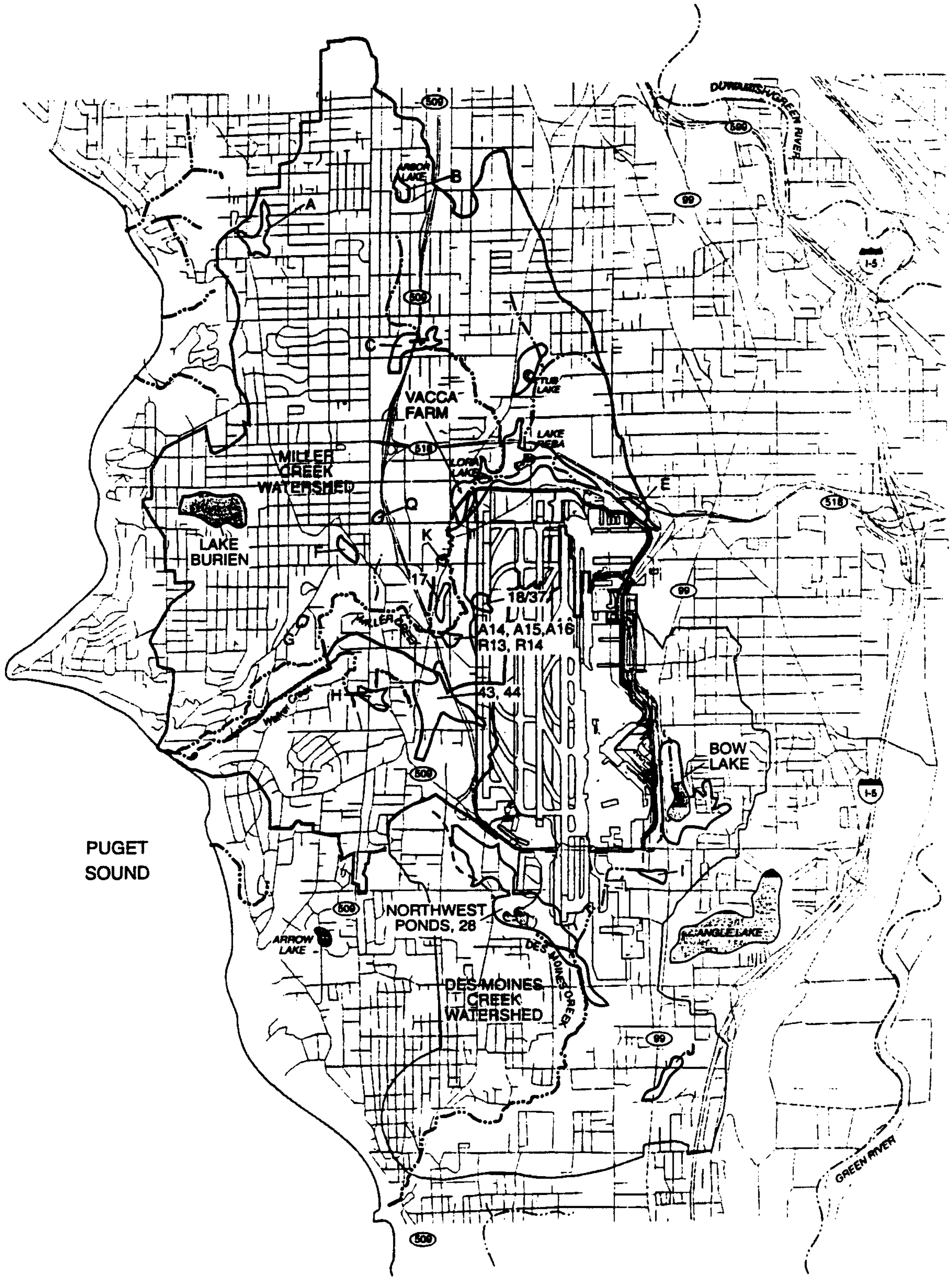
Examination of these inventories found no wetland areas that are not previously mapped or identified as hydric soil areas (see Section 3.1.2).

3.1.2 Soil Survey Maps

Soil surveys and aerial photographs were used to evaluate historic (i.e., mid 1930s) and current (i.e., mid 1990s) wetland conditions in the project vicinity. Soil surveys map and classify soil types according to general physical, chemical, and environmental properties. These surveys typically identify the general drainage properties of soils, including poorly drained wetland soils, and describe soil types that are now classified by the Natural Resources Conservation Service as hydric or non-hydric (NRC 2000). Although subject to some limitations (see below), soil surveys can be used to evaluate the location and extent of hydric soils which typically are potential wetlands. For King County, soil surveys were published in 1952 (USDA 1952) and 1972 (USDA SCS 1973). The 1972 soil survey excluded detailed mapping of the Miller, Walker, and most of the Des Moines Creek watersheds because a large percentage of the area was developed in 1972 and is no longer of special interest to the Department of Agriculture[1].

---

[1]Soil surveys were completed primarily to assist in developing sound and profitable agricultural operations, and as agricultural areas began to urbanize, the soil survey information was no longer updated.



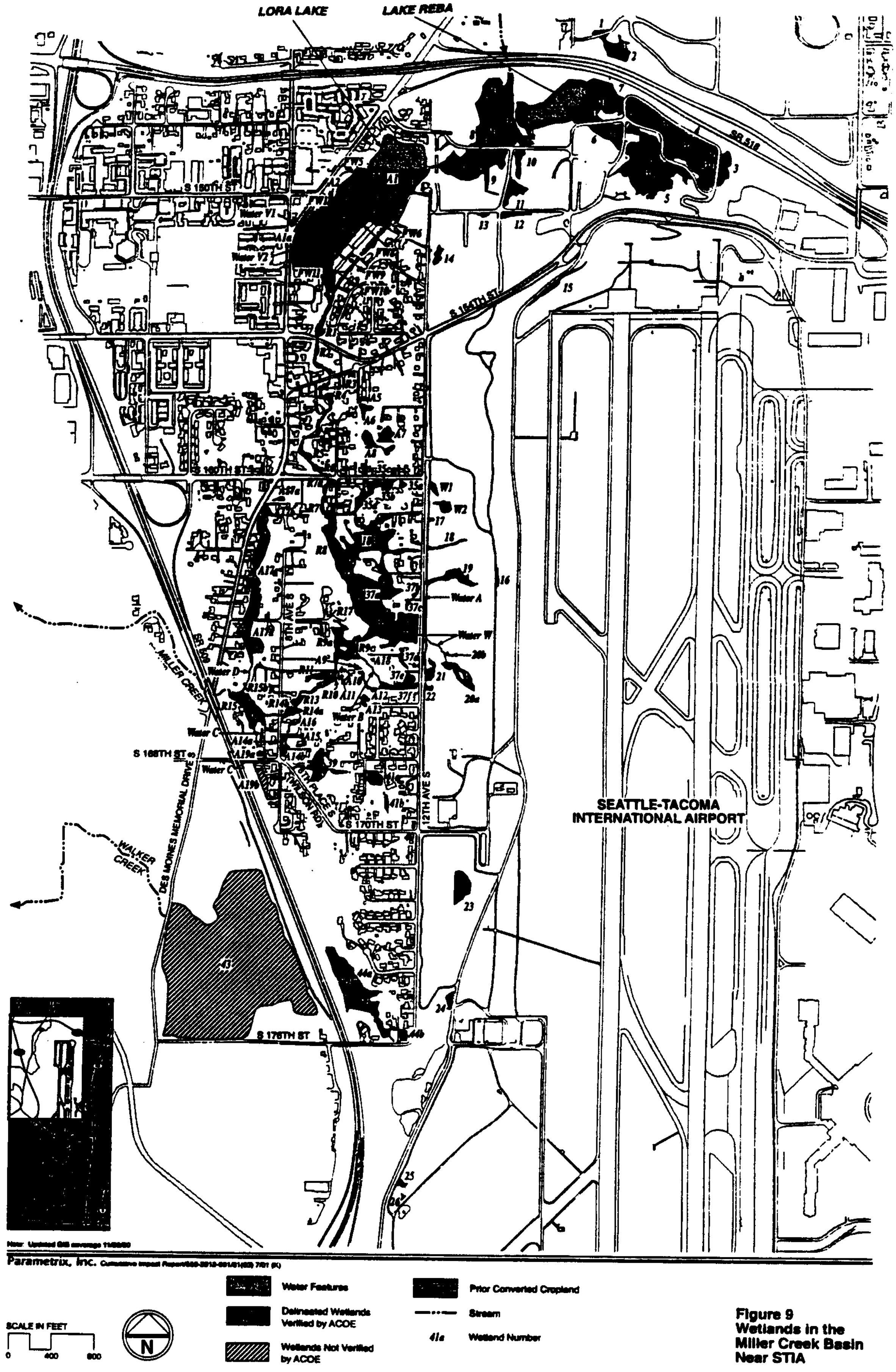
Parametrix, Inc.

SCALE IN FEET
0 1500 3000

N

Watersheds Boundary
Stream
Piped Stream
Hydric Soil and Wetland Name
Lake

Figure 8
Hydric Soils in the Des Moines Creek, Miller Creek, and Walker Creek Watersheds (1952)



Parametrix, Inc.

Figure 9
Wetlands in the Miller Creek Basin Near STIA

AR 050815

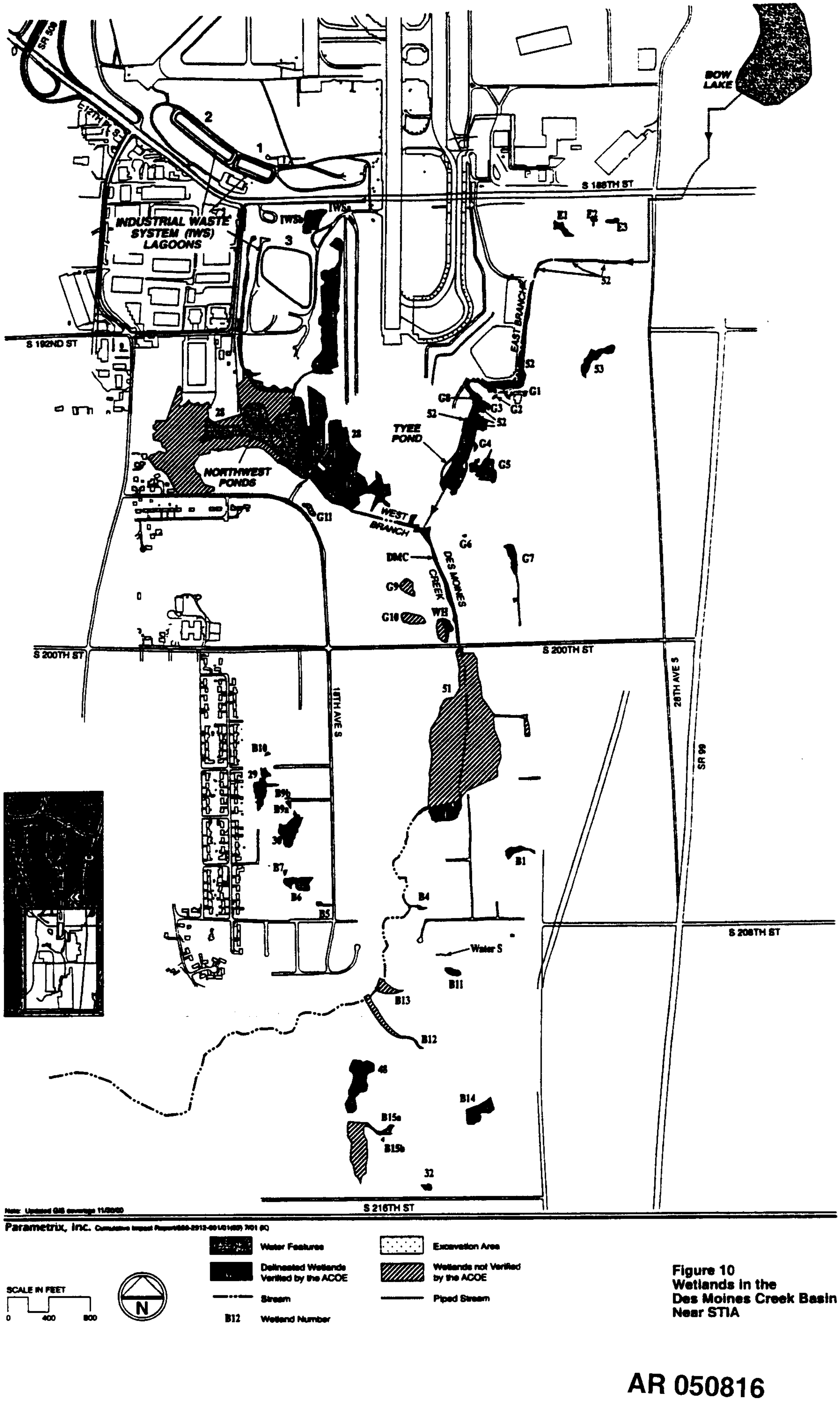


Figure 10
Wetlands in the Des Moines Creek Basin Near STIA

Soil surveys and wetland soil maps are generalized and prepared at a scale insufficient to map all areas that meet wetland criteria. The 1952 King County survey maps soil types on 1:63,360 scale maps (1 inch = 1 mile). At this scale, an acre would be mapped as a square 0.4- x 0.4-inches, and thus the irregular shape and size of even moderate sized wetlands cannot be accurately represented.

In addition, soil surveys do not attempt to map all wet soil areas. In particular, inclusions of wetland soils in non-hydric soils are not generally mapped separately. For example, Poulson (USDA 1952) describes the Alderwood soil-mapping unit (the most common soil type in the three watersheds of concern) as containing between 2 and 15 percent poorly drained soils (potential wetland soil types). The amount of poorly drained soil inclusions found in the Alderwood soil type depends on the slope of the area, with the greatest amounts occurring on flatter terrain:

- Up to 15 percent poorly drained soils on 0 to 6 percent slopes.
- Up to 3 percent poorly drained soils on 6 to 15 percent slopes.
- Up to 2 percent poorly drained soils on 15 to 30 percent slopes.

The preparation of soil maps for the *Soil Survey of King County, Washington* (USDA 1952) (see Figure 8, and Appendix B) were begun in 1937. Fieldwork for the survey is reported as being completed in 1937 and 1938[2], and predates the construction of STIA. The soil survey map was assembled from aerial photographs, and generally does not map the now-developed portion of STIA as containing hydric soil (potential wetlands). It is probable the 1936 aerial photographs examined as part of this report (see Section 3.1.4) were printed from the same negatives used to create the USDA (1952) soil survey. The soil survey would not be expected to accurately map the precise area of all wetlands (especially smaller wetlands), as discussed above. It is possible special attention was made to poorly drained soils in preparation of the survey, as these wetland soils are, when properly drained, some of the most productive agricultural soils. They would have been of special interest in identifying the agricultural capabilities of the region.

The soil survey maps several small areas of hydric soils that are known to correspond to small wetlands. However, the survey map is not expected to identify all wetlands, nor to represent a wetland delineation because wetland delineation criteria were not considered at the time the map was made. Soil types are generally mapped based on general morphology that may not correlate to specific hydric soil criteria. Further, neither wetland vegetation nor wetland hydrologic conditions are thoroughly considered when mapping soils.

3.1.3 Mapped Peat Resources

Several of the larger wetland areas in the vicinity of STIA were mapped as peat resources by Rigg (1958). Peat lands identified in the 1958 study include:

- Sunnydale Peat Area (Tub Lake) – 26 acres
- Miller Creek Peat Area (Vacca Farm/Lake Reba area) – 56 acres
- Bow Lake Peat Area – 36 acres

[2] See notes on soil survey maps included in USDA (1952).

Changes in these peat lands from 1936 to 1995 were evaluated by examining the aerial photographs for changes in vegetation and land use within the peat lands. In addition, changes in land use and vegetation adjacent to the peat lands were noted (see Section 3.1.4).

3.1.4 Aerial Photographs

A variety of historical aerial photographs is available for the Miller, Walker, and Des Moines Creek watersheds. These photographs were examined to evaluate changes to wetlands over time and to generally understand the changes in watershed conditions over time. Photographs from four general time periods were evaluated in detail to describe stream and wetland conditions (Table 5):

- Photographs taken prior to any airport development (1936)
- Photographs taken shortly after development of STIA (1948-1947)
- Photographs taken prior to second runway construction (1961)
- Photographs taken in 1995

Table 5. Dates of aerial photographs reviewed for the cumulative effect analysis.

Year	Date	Scale: 1 Inch Equals (ft)	Scale: Ratio[a]
1936	June 19 and 23	806	1:9,675
1948	Unknown	972	1:11,664
1961	August 7	400	1:4,800
1965	May 11	3,900	1:46,920
1970	Unknown	400	1:4,800
1972	August 30	1,890	1:22,690
1979	June 26	2,080	1:24,960
1985	August 14	1,970	1:23,636
1995	April 28	400	1:4,800
1995	April 25	920	1:11,025

[a] Scales are approximate and may vary within or between photographic images.

The historic wetlands in the project area identified from soil survey maps and the 1936 aerial photographs are described in Table 6 (see also Figure 8). The photographic sequence from 1936 to 1995 was then examined, using general methods described in Lillesand and Kiefer (1979) to identify vegetation and land use in wetlands from 1936 to 1995. Major changes from 1936 to 1995 in wetland vegetation and land use, as well as land use surrounding the wetlands are described in Tables 7 to 24.

Table 6. Historic wetlands occurring in the Seattle-Tacoma International Airport project area.

Wetland	Vegetation Types	Soil Types
Wetland A	Open Water Farmland	Carbondale Muck Norma Fine Sandy Loam
Wetland B	Open Water Shrub Forest	Greenwood Peat
Wetland C	Open Water Farmland	Norma Fine Sandy Loam
Wetland D	Forest Farmland	Norma Fine Sandy Loam
Tub Lake	Open Water Shrub Forest	Greenwood Peat
Wetland E	Forest	Rifle Peat
Wetland F	Forest Shrub Farmland	Norma Fine Sandy Loam
Wetlands 1-14, A1 (Vacca Farm, Lake Reba)	Farmland	Rifle Peat Carbondale Muck Norma Fine Sandy Loam
Wetland G	Forest Shrub Farmland	Norma Fine Sandy Loam
Wetland H	Farmland	Mukilteo Peat
Wetlands 18, 37, and 20	Forest Farmland	Norma Fine Sandy Loam
Wetland A17, K	Farmland	Norma Fine Sandy Loam
Wetlands R14, R15	Farmland	Norma Fine Sandy Loam
Wetlands 43, 44	Farmland	Rifle Peat
Wetland I	Farmland	Norma Fine Sandy Loam
Bow Lake ,	Open Water Shrub Forest Farmland	Rifle Peat Bellingham Silty Clay
Wetland J	Forest Shrub Farmland	Carbondale Muck
Wetland 28 - Tyee Golf Course	Forest Shrub Farmland	Norma Fine Sandy Loam Bellingham Silty Clay Carbondale Muck
Lake Burien	Open Water	-

Note: Wetlands, wetland vegetation types, and soil types were identified on the 1952 King County soil survey (USDA 1952) and 1936 aerial photographs. Wetlands are identified in this table and Figures 9 and 10 as follows: (1) for wetlands identified in the *Wetland Delineation Report* (Parametrix 2000a), the wetlands are named according to that report; (2) for wetlands that are not included in the delineation report, the wetlands are given letter designations. Wetland vegetation types were identified from the 1936 aerial photographs and were classified by Cowardin (Cowardin et al. 1979) wetland classes. Soil types were identified from the 1952 soil survey.

Table 7. Changes to Wetland A (located near Ambaum Boulevard and 128th Street South) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	The wetland is farmed and ditched. Surface water is present in the southeast portion of the wetland: it appears to result from excavation for a farm pond. Farmland, farm buildings, and houses border all areas except the northeast side of the wetland. The northeast side of the wetland is bordered by forestland.
1948	Conditions are generally similar to those of 1936. The farm pond has been enlarged.
1961	The north part of the wetland has been filled for school buildings, parking lots, and play fields. The south part of the wetland includes orchards, agricultural land, shrub wetland, and a farm pond.
1995	The majority of this wetland has been filled for a parking lot, buildings, and sports fields. It appears that two rectangular portions of the wetland remain. The wetland consists of abandoned agricultural land, and is vegetated with emergent and forest vegetation.

Table 8. Changes to Arbor Lake (near 3rd Avenue South and South 124th Street) and adjacent wetlands between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	The wetland contains forest, shrub, emergent, and open water wetland communities. The wetland is located in a well-defined basin. Roads are located on the south and west sides of the wetland. In most places, the bordering uplands have been recently logged and consist of early stage forest regeneration. A fringe of trees and shrub vegetation borders the wetland.
1948	The area surrounding this wetland has been developed with houses, and portions of the north and south sides of the wetland have been filled. Greater amounts of open water are present compared to 1936 and it appears that emergent vegetation was removed from portions of the wetland, forming a small lake.
1961	Conditions are generally similar to 1948.
1995	Additional areas bordering the lake (including wetlands) have been developed as a park. Vegetation in the park consists of lawn with trees fringing the shoreline. Residential development is located adjacent to the park.

Table 9. Changes to vegetation and land use in Wetland C (located near SR 509 and South 140th Street) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	This wetland is mapped as the source of a tributary to Miller Creek. The wetland occurs on a broad ravine that is farmed. The upland areas surrounding the wetland are farmland or recently harvested forestland, and there is little woody vegetation present. Several farms and houses occur near the perimeter of the wetland. The area at the northern section is in row crops, pasture, and housing. It appears that a portion has been filled for a house.
1948	Land use in and surrounding the wetland is largely agriculture, but there is an increase in the number of barns, houses, and outbuildings.
1961	Land use in the wetland is largely agriculture. Increasing amounts of adjacent upland areas have been developed. Some areas of farmland appear abandoned and may be revegetating with shrub vegetation.
1995	Upland areas surrounding the wetland are developed with residential, school, and commercial buildings. Much of the original wetland was filled as part of this development. The State Route (SR) 509 road fill bisects the wetland. Remaining areas consist of fragments of forest-, shrub-, and grass-dominated wetlands. A narrow and fragmented riparian corridor occurs along a stream channel that flows to the southeast. Between South 144th Way and Des Moines Memorial Drive, a small parcel of forest remains.

Table 10. Changes to vegetation and land use near Tub Lake (located near Des Moines Memorial Drive and South 144th Street) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	Tub Lake is surrounded by shrub dominated wetland, but patches of forested wetland also border the shrub wetland. Upland areas bordering the wetland consist of forestland, pastureland, orchard, recently harvested forestland, and several farms. A gravel mine is located north of the wetland. A dock is located in Tub Lake.
1948	The wetland area remains similar to 1936; however, the adjacent upland areas include greater development to the east. Several streets are under construction northeast of the wetland, and much of the forested areas around the wetlands have been cleared.
1961	A school has been constructed near the east side of the wetland, and some clearing and wetland fill has occurred in this area.
1995	The wetland itself remains largely intact. Shrub communities appear to have a greater number of small trees, and in three locations near the west side, excavations have created new areas of open water. Portions of the wetland perimeter have been filled at the north end for the construction of Sunset Park. The Sunny Terrace school, constructed east of the wetland, has removed much of the upland buffer vegetation. Some houses have been removed from uplands bordering the west side, and the land is now abandoned. Houses and other buildings along Des Moines Memorial Drive have been removed, the land is revegetating to more natural conditions, and there is less development here than in 1948.

Table 11. Changes to vegetation and land use in Wetland D (located near 1st Avenue South and South 154th Street) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	A portion of the wetland is forested, but most is farmed and consists of agriculture fields, pasture, and orchards.
1948	Portions of the farmed wetland appear to have been abandoned, and there are greater amounts of shrub and forested vegetation in the wetland. The upland areas surrounding the wetland have greater amounts of development, including a school and running track located near the west edge of the wetland.
1961	The wetland consists of forest and shrub communities. Fill has been placed in portions of the wetland to accommodate widening of 1st Avenue South.
1995	This wetland has been filled for SR 509, and no evidence of it remains.

Table 12. Changes to vegetation and land use in Wetland E (previously located near South 124th Street and 24th Avenue) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	This wetland is located in a linear depression. South 154th Street was constructed through the northern third of the wetland. The majority of the wetland is undeveloped forestland. The area has been recently logged. A fringe of small trees lines the edge of the wetland.
1948	The wetland has been excavated to create three open water ponds. A forested buffer is present on the southwest side, but the remaining upland buffer has been logged. A small road surrounds the wetland, and a house is present on the north side.
1961	The northern portion of the wetland was filled by South 154th Street. The southern portion was filled for houses. About eight houses surround the wetland. The perimeter is nearly all landscaped.
1995	This wetland has been filled for the construction of SR 518 and the SR 518 interchange to the North Access Freeway and South 154th Street.

Table 13. **Changes to vegetation and land use in Wetland F (located near Ambaum Boulevard and South 157th Street) between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	The wetland consists of forest and shrub vegetation, with farmland around its perimeter.
1948	The wetland has greater amounts of forest vegetation, and the wetland no longer appears to be farmed.
1961	About two-thirds of the wetland has been filled and developed with parking areas and buildings. The remaining wetland is forested.
1995	The remaining portion of the wetland has been filled for commercial development.

Table 14. **Changes to vegetation and land use in Wetland G (located near Sylvester Road and 6th Avenue South) between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	The wetland consists of forest and farmland located between several houses.
1948	Little change since 1936.
1961	The area is similar to previous years. Greater amounts of forest are present.
1995	Portions of the wetland have been filled for residential development. Remaining portions appear to be lawn and landscaping.

Table 15. **Changes to vegetation and land use in Wetland H (located near 1st Avenue South and 166th Place) between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	This wetland occurs in a ravine and is associated with Walker Creek. Fill associated with 1st Avenue South bisects the wetland. The wetland consists of farmland with farm buildings, and farmland is located in adjacent upland areas. The west and south sides of the wetland are bordered by forestland.
1948	Farming in the wetland area has ceased, and the area has reverted to forest and shrub vegetation. An orchard is located on uplands east of the wetland and farmland is present north of the wetland.
1961	The area consists of forest and shrub wetland.
1995	Forest vegetation in the wetland has matured. The perimeter is primarily residential houses. South 174th Street was constructed south of the wetland.

Table 16. **Changes to vegetation and land use in Wetland I (located between Highway 99 and 28th Avenue South) between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	This area is located in a shallow depression that is downgradient from Bow Lake (see Table 21). The majority of the area is in agriculture use and pasture. Upland areas surrounding the wetland are farmland, recently clear-cut forestlands, roads, and farmsteads.
1948	The entire area is predominately pasture, with some roads, and houses and outbuildings constructed along the wetland edges.
1961	Portions of the wetland have been filled and developed. Areas that remain as farmland appear to be ditched.
1995	The wetland has been filled and the wetland and adjacent upland areas developed.

Table 17. **Changes to vegetation and land use in Wetland J (located near Highway 99 and South 208th Street) between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	This wetland is in a shallow and linear topographic depression and is divided into three sub-areas by South 204th Street and Highway 99. The northeast portion is forested and shrub wetland, the central portion is farmland, and the southeast portion is forested. A small pond is located near the eastern end of the wetland.
1948	Most of the wetland is farmed, and a small pond has been excavated in the central portion. The area west of Highway 99 has been filled. A pond has been excavated in the east end where forest and shrub communities are also present.
1961	Portions of the wetland near Highway 99 and South 208th have been filled and developed. Open water is not visible in the 1961 photograph, but it is present in the 1970 photograph.
1995	The majority of the area has been filled for commercial and multi-family developments. Three small isolated wetlands remain. The isolated wetlands contain shrub and forest areas surrounded by multi-family development.

Table 18. **Changes in vegetation and land use near Lake Burien between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	This lake is located in a shallow depression. Farmland, roads, and residential houses are located around the lake. Most houses are present along the north shore of the lake, and about 15 docks are located on the lake. Some of the south shore is bordered by forested upland.
1948	The majority of the shoreline is developed with single-family houses. Other uses include orchards and farm fields. A patch of forest and some farmland borders the south side of the lake. About 25 to 30 docks are located on the lake.
1961	Conditions are similar to 1948, but additional residences are present.
1995	The entire shoreline is surrounded by residential development. Approximately 45 to 50 docks and piers are located on the lake.

Table 19. **Changes in vegetation and land use in Wetland 28 and the Northwest Ponds between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	Wetland 28 is farmed and there is no open water present. There are a few small areas of shrub or forest vegetation present in the wetland. Des Moines Creek is largely ditched across the wetland, though in areas, there are remnants of a meandering channel. Areas surrounding the wetland are farmland, orchard land, or recently harvested forestland.
1948	The west branch of Des Moines Creek has been channeled and a tributary to the stream near South 196th Street has disappeared (i.e. was piped, filled, or drained). Wetland 28 is in agriculture production with row crops. North and south of the wetland, additional single-family residences have been constructed.
1961	The eastern portion of Wetland 28 is in agricultural use, while the western portion is forested. A small area of open water is present in the central portion.
1995	Most of the Northwest Ponds area was excavated within Wetland 28 between 1961 and 1970. The area south and west of the ponds is forested. Portions of the north side of the wetland have been filled by runway construction. Portions have also been filled for the Industrial Waste System (IWS) lagoon and as part of commercial development located to the west. The eastern portion of Wetland 28, on the Tyee Valley Golf Course, is an emergent wetland. The remainder consists of open water, emergent, forest, and shrub wetland communities.

Table 20. Changes in vegetation and land use in Wetlands 52, 53, and the east branch of Des Moines Creek between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	The area north of South 200th Street is farmland and forestland. The stream channels appear to be confined to ditches. Dense riparian cover is present along the riparian corridor from the confluence to the east. Wetland 52 is farmland and shrubland, while Wetland 53 is farmland.
1948	This riparian corridor consists of agriculture land with row crops, pasture, and orchard. An intermittent forested corridor occurs along the stream from the confluence with the west branch upstream to Highway 99. The stream channel is not visible above its confluence with the west branch. Wetlands 52 and 53 are a mixture of farmland and shrubland.
1961	Airfield construction channelized the stream, and portions of Wetland 52 have been excavated. Wetland 53 is farmed.
1995	The stream has been channelized and the golf course has been constructed. The Tyee Detention Pond has been constructed along the channel, and about 200 ft of the channel is culverted. A narrow band of riparian vegetation is present along most of the channel. Upstream of the golf course, the channel has been constructed between several parking lots and several hundred feet are culverted.

Table 21. Changes in vegetation and land use near Bow Lake between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	An emergent and shrub wetland extends up to about 1,500 ft north of the perimeter of the lake and along the west side. Agricultural areas occur in the south and east portions of the wetlands that surround the lake. Upland areas surrounding the lake consist of agricultural land, recently cut forestland, and second-growth forest. The shoreline of the lake itself consists of a narrow fringe of aquatic vegetation and shrubs. A drainage ditch has been constructed to convey water from Bow Lake southwest under Highway 99 via culvert, forming the east branch of Des Moines Creek. Other ditches are present in some areas of farmed wetland.
1948	Much of the farmed wetlands near the lake appear to have been abandoned. North and west of the wetland, grading and building activities in uplands immediately adjacent to the wetlands are present. Little natural buffer remains around the wetland because most of the area is in agricultural production, and forested areas to the east of the wetland have been recently cleared. A small pond appears to have been excavated east of the wetland.
1961	Much of the northern third and east side of the wetland surrounding the lake have been recently filled and are currently under development.
1995	Most of the buffer and wetland surrounding Bow Lake are developed with commercial and residential land uses, including parking lots and a stormwater detention pond. A portion of the east side has developed as a shrub wetland that surrounds an excavated pond. Some forested buffer is present along the north edge of the lake. Several hundred feet of the east branch of Des Moines Creek has been culverted beneath a parking lot.

Table 22. Changes in vegetation and land use in Wetlands 43 and 44 between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	The majority of the area is farmed wetland. The farmland appears ditched, and there is no evidence of a natural stream crossing the area. Some forested wetland occurs in the central portion of the wetland, and shrub wetland occurs south of South 176th Street. Upland areas adjacent to the wetland are a mix of pastureland, cropland, small orchards, and forest patches. Drainage from the wetland appears to pass under Des Moines Memorial Drive and into Walker Creek.
1948	The wetland is generally similar to that in 1936. The area is farmed with ditches running along the edges of the farmed fields. There is a forested fringe along the steep slope to the east, but some areas in the central portion of the wetland are pastureland instead of cropland. Ditches through the central portion of the site are well defined. There is additional agriculture land use northwest of the wetland. Walker Creek appears to originate west of Des Moines Memorial Drive and flow west through a mixture of agriculture fields and forest.
1961	Agricultural use in the southern portion of the wetland has been abandoned, and the area is forest- and shrub-dominated. The remaining wetland appears to be farmed or pastured. A small stream channel bordered by a band of shrubs may represent the location of Walker Creek.
1995	SR 509 has been constructed and divides the wetland area with fill. Most agriculture has been abandoned and the wetland consists of emergent, forested, and shrub-dominated wetland. Some areas of pasture remain in the northern portion of the wetland. Commercial development has filled the wetland located south of 176th Street. A small stream channel is visible in emergent wetland located near the northwestern portion of the area.

Table 23. Changes in vegetation and land use in Wetlands 1 through 14 and A1 (Vacca Farm and Lake Reba area) between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	Most of the area is farmed, though forested wetlands are present in Wetlands 3, 4, and 5. Several of the agricultural fields are ditched, and there are no natural stream channels present. Areas adjacent to the wetlands consist of farmland and forestland in various stages of regeneration. The wetlands are crossed by 16th Avenue South. No ponds or other inundated wetlands are present.
1948	The condition and land uses are generally similar to 1936. There are greater amounts of development near the wetland areas and a portion of Lora Lake has been excavated.
1961	The area in general continues to be farmed. Increasing amounts of houses and small areas of fill are present near streets and the perimeter. Portions of Wetlands 3, 4, and 5 are forested.
1995	SR 518 has been constructed across the north portion of the area. Lake Reba and Lora Lake have been excavated. Much of the wetland east of Lora Lake has revegetated to forest, shrub, and emergent communities. Shrub riparian wetlands have developed near the south portions of the area.

Table 24. Changes in vegetation and land use in Wetlands 18, 37, 20, and other wetlands west of the airfield between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	Except for much of Wetland 18, most of the wetlands are forested. In many places, the forest vegetation is not dense and may have been subjected to past management.
1948	New residences and driveways have been constructed in and near several wetlands. Additional areas of Wetland 18 have been cleared and are mowed or grazed. Selective logging has occurred in Wetland 37 and it may also be grazed. There are driveways and residences in and near Wetland 37 that fragment the south portion of the area.
1961	Much of Wetlands 18 and 36 continue to be farmed, but forest riparian areas are developing on abandoned farmland that is now associated with residential development. Most wetlands in this area contain forest and pasture vegetation.
1995	The wetland condition is generally similar to 1961, although a greater amount of uses occur along their perimeters. Portions of Wetland 18 and other wetlands located east of 12th Avenue South are located within the airport security fence. In these areas, residential and agricultural land uses have been displaced, and wetlands have revegetated with native vegetation.

This analysis shows that the pre-developed condition of most of these watersheds were various upland soil types. The pre-developed condition of most of the present airport site was also upland soil types. Various conclusions (see King County 1997) that the watersheds and Seattle-Tacoma International Airport contained large amounts of wetlands are not supported by the data presented by USDA (1952).

3.2 WETLAND IMPACTS

Nearly all of the larger wetlands present in 1936 are present today, but they have been impacted by development. Filling of several smaller wetlands (e.g., E, F, and K) has eliminated them. Some of the greatest impacts to the larger wetlands have occurred at Bow Lake, where wetland fill for commercial development has eliminated about 50 percent of the area mapped in 1936 as hydric soil. Other large wetlands have been variously impacted by excavation (Lora Lake and Lake Reba in the Vacca Farm area, and Northwest Ponds), and fill (in Wetlands 43 and 44 for SR 509, Wetland 28 for commercial development).

The examination of historical aerial photographs demonstrates that a variety of significant impacts have occurred to wetlands in the project area over the past 50 to 70 years. Major impacts to wetlands that have occurred include:

- **Clearing.** Land clearing occurred as a result of timber harvest, subsequent farming, or land development. Typical forest practices in the 1930s were to burn slash to promote reforestation, aid in agricultural development, or aid in urban development. Logging and burning were so extensive that not enough trees were left for satisfactory reseeding, and many areas became restocked with bracken fern, blackberry, alder, and vine maple (USDA 1952).

- **Agriculture.** Because wetland soils provide highly productive farmland when drained, wetland soils in the project area were selectively farmed. As a result, over 90 percent of "bottomland" soils[3] in King County were in agriculture by 1936 (USDA 1952). Wetland soils present in the STIA watersheds and their use in King County, as described by Poulson (USDA 1952), are:

  Bellingham silty clay: About 75 percent of this soil type was cleared and used for pasture or cultivated crops. All of it has been logged, and acreage was brought into cultivation as soon as it was cleared and drained.

  Carbondale muck: In populated areas, nearly all muck soils were drained and farmed with cultivated crops. In more remote areas, about 75 percent were farmed.

  Greenwood peat: This is a non-agricultural soil due to its acidity. Selling peat moss or development for cranberry production also provided some revenue from this soil type.

  Mukilteo peat: About 50 percent of these soils are farmed.

  Norma fine sandy loam: More than 80 percent of this soil type was used for crops or pasture, with additional areas being cleared and drained.

  Norma silty clay: This soil occurs in depressions unsuitable for agriculture. The soil survey notes these areas are suitable for reed canarygrass.

  Rifle peat: Peat soils are drained for cultivation (which can cause them to sink several feet through consolidation and oxidation). Over 70 percent of peat soils were farmed.

  In some cases, the abandonment of agricultural land use has allowed native vegetation to develop in previously farmed areas.

- **Fill.** Direct filling of wetlands became increasingly prevalent during and after the 1960s and 1970s as the area became increasingly urbanized. While some small wetlands were filled for airport and other commercial/industrial development in the 1940s, this analysis and review shows that most of the original STIA site was upland. At STIA, filling of portions of Wetland 28 occurred in about 1970, when the second runway and IWS Lagoon 3 were constructed.

  A considerable amount of wetland filling and fragmentation occurred as a result of road construction from the 1960s on. Filling of Wetland 43, Wetland 44, and Wetland C occurred when SR 509 was constructed in the late 1970s. Filling in the Vacca Farm, Lake Reba wetlands, and Wetland E occurred when SR 518 was constructed in the early 1970s. Widening of Highway 99, 1st Avenue South, and several other streets impacted small amounts of other scattered wetlands.

---

[3] Bottomland soils are typically hydric soils and were once wetland.

AR 050827

Fill of wetlands as part of land development was significant for many of the smaller wetlands that existed in 1952, and many of these wetlands have been largely eliminated as a result (i.e., Wetlands A, C, D, I, and J). Larger wetlands where significant fill for site development has occurred include the wetland perimeter of Bow Lake and the northwest portion of Wetland 28. In the third runway acquisition areas, wetland hydrology was not eliminated despite residential development, and many of these wetlands have persisted to the present (i.e., Wetlands A17, 18, 35, 37, 39, 41, and others).

- **Excavation.** Several wetland areas (Lora Lake, Lake Reba, Northwest Ponds, Tub Lake, and Arbor Lake) have been excavated, resulting in open water habitats. Lora Lake was excavated from peat soils in agricultural use to enhance residential development. Lake Reba was excavated from agricultural wetlands for stormwater management. Northwest Ponds, portions of the Tub Lake wetland, and Bow Lake were excavated to obtain horticultural peat. Northwest Ponds is also used for stormwater management. Arbor Lake was excavated for unknown reasons, likely to obtain peat or to enhance its appeal for residential development.
- **Buffer disturbance.** All wetlands have experienced clearing and disturbance of wetland buffers through forestry, farming, and/or urban development. In many cases, buffers have been wholly or partially developed. In some areas, when agricultural areas have been abandoned, native buffer vegetation has grown back.
- **Stormwater discharge.** Some wetlands have been used for stormwater management. Lake Reba and the Northwest Ponds are permitted stormwater facilities. Wetlands 4 through 10 are part of the Miller Creek detention facility. A portion of Wetland 52 was excavated for the Tyee Pond detention facility. Other stormwater treatment facilities were constructed in Wetland 43 to serve SR 509.
- **Sedimentation.** The types of land use changes that have occurred in the STIA area since 1936 typically result in increased sedimentation in wetlands. Farming results in large areas of plowed land that can generate sediments that may be transported to wetlands and streams. Forestry and burning to support reforestation or land clearing for agriculture also leave bare soils subject to erosion. Development of roads and associated drainage ditches increased the probability that sediments would be transported downstream to streams and wetlands. Early roads in the area would have generated a large amount of sediment runoff from their unpaved surfaces. Because of the prevalence of forestry, farming, and gravel road surfaces, sediment transport to creeks and wetlands was probably greater in the past (i.e., pre-1960) than under current conditions, where little soil disturbance occurs without extensive erosion control measures.

3.3 REGULATIONS PROTECTING WETLANDS

Prior to the mid-1980s, the small isolated wetlands located in the Miller, Des Moines, and Walker Creek watersheds had little if any land use protection, and were, where economically feasible, filled and drained to support agricultural or urban development. During the late 1980s and since, increasing land use protection levels have been placed on wetlands; now a variety of local, state, and federal laws are designed to prohibit nearly all activities in or near wetlands that would cause additional physical or ecological degradation. The most significant regulations protecting wetlands in the study area are:

- **Clean Water Act – Section 404.** Regulates fill placement in Waters of the U.S. Triggers Section 401 review by Ecology to protect water quality. Revisions to the Nationwide Permits in 2000 placed low thresholds on routine wetland fills and mitigation requirements generally require replacement of function and area. Individual Permits for more substantial wetland alterations require extensive mitigation to replace function and area. Mitigation ratios that require mitigation area in excess of the area of filling help ensure that cumulative losses do not occur over time.

- **Critical Areas Protection.** Critical area protection is included as part of the municipal code of each community in the watershed. These regulations protect, among other elements, wetlands, wetland buffers, streams, stream buffers, and fish and wildlife conservation areas.

  - **SeaTac** - Title 15, Chapter 15.30
  - **Burien** - Title 18, Chapter 18.60
  - **Des Moines** - Title 18, Chapter 18.86
  - **Normandy Park** - Title 13, Chapter 13.16

  The regulations provide specific standards and mitigation requirements for the modification of wetlands and their protective buffers. Local mitigation standards for wetland and buffer alterations require replacement of area and function. Mitigation ratios that require mitigation area in excess of the area of fill help ensure that cumulative losses do not occur over time.

- **Hydraulic Project Approval (HPA).** HPAs are required for projects that use, divert, obstruct, or change the natural flow or bed of any fresh water or saltwater of the state. HPA approvals generally require mitigation adequate to compensate for project impacts to wetlands and to streams that provide fish habitat. These approvals may also be required for projects not occurring in streams or wetlands, but that discharge stormwater runoff to them. Mitigation for these projects can require enhanced stormwater detention and water quality standards to preserve existing runoff patterns and water quality.

- **State and National Environmental Policy Acts (SEPA and NEPA).** SEPA and NEPA provide protection to wetlands by requiring analysis of project impacts to wetlands and for mitigation of adverse impacts.

- **Stormwater Management Standards.** Local stormwater management standards are designed to collect, detain, and treat stormwater runoff from urban areas and prevent degradation of streams.

4. STREAMS

The Seattle-Tacoma International Airport project area drains to several streams, including Miller Creek (and its Walker Creek tributary), Des Moines Creek, and the Green River via Gilliam Creek (see Figure 1). Baseline and historic watershed and fish habitat conditions in drainage areas affected by Master Plan Update improvement projects (Miller and Des Moines Creeks) are described in this section.

4.1 MILLER CREEK BASIN

The Miller Creek basin includes Miller Creek and Walker Creek. Walker Creek is a tributary to Miller Creek. The current condition and historical changes to the creeks are discussed here.

4.1.1 Historical Conditions and Changes Since 1936

Changes to Miller and Walker Creeks have been assessed over time using aerial photographs. These changes are summarized in Tables 25 and 26.

4.1.2 Current Conditions in Miller Creek

The Miller Creek watershed drains approximately 8 mi^2 of predominantly urban area, mostly within the cities of Burien and SeaTac. STIA facilities located in this basin include the north end of runways 16L and 16R and north air cargo facilities, an area of about 162 acres representing about 3 percent of the watershed. Flows in Miller Creek originate at Arbor, Burien, Tub, and Lora Lakes, Lake Reba, and from seeps located on the west side of STIA.

The uppermost reaches of Miller Creek (above approximately river mile [RM] 4.1) extend north of SR 518. The Hermes depression in the northwestern part of the basin is artificially drained and piped to a tributary to Arbor Lake. This portion of the watershed drains a gently rolling plateau between the Duwamish/Green River valley and Puget Sound. Although the watershed is generally highly developed, several small bogs, depressions, and wetland lakes remain in the upper basin; this area formerly had a more extensive network of headwater wetlands that buffered the stream from winter storms and provided recharge during summer dry periods (May 1996).

In reaches downstream of 1st Avenue South (RM 1.8), Miller Creek flows through a well-incised ravine and cuts through glacial material before entering Puget Sound via a small estuary. The outlet stream from Burien Lake enters the ravine reach at RM 1.2. A sewage treatment plant operates alongside Miller Creek at approximately RM 1.0. Walker Creek, an anadromous fish-bearing stream that originates in wetlands west of STIA and SR 509, enters Miller Creek approximately 300 ft upstream of its mouth, in a park just upstream of the Miller Creek estuary (Figure 11).

A waterfall, which drops over a hardpan lip at about RM 3.1, has been described as a complete barrier to upstream migrations of anadromous fish (Williams et al. 1975; Ames 1970). That assessment agrees with local historical anecdotes that make many references to salmon in Miller Creek up to about the waterfall location, but not beyond. Recent spawning surveys conducted by Trout Unlimited (Batcho 1999 personal communication) have also identified this waterfall as the upper limit to coho salmon (*Oncorhynchus kisutch*) distributions in Miller Creek.

Table 25. Changes in vegetation and land use near Miller Creek between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	A stream channel appears to originate in Wetland D. The channel is ditched from South 144th Street south to its confluence with other channels in the Vacca Farm area (Wetland A1, see Table 23). No riparian vegetation is present. South of Vacca Farm to South 154th Street, approximately half of the riparian area is in residential use with little riparian vegetation. The remaining area has a narrow forest or shrub buffer present on one or both sides. Between South 154th and South 160th, there are several natural meanders, with a fringe of riparian forest or shrub vegetation present. The stream flows through a residential neighborhood, where some of the land is cleared of natural vegetation to the edge of the stream. Between south of South 160th and Wetland 37, the area is mostly farmed and the riparian vegetation has been cleared. Farming activities extend to the edge of the stream. Forested riparian vegetation of Wetland 37 borders the stream within most of the wetland and south to 8th Place. West of 8th Place, there is a narrow riparian fringe through farmed fields, with areas lacking riparian vegetation. West of Des Moines Memorial Drive to Ambaum Boulevard, there is approximately 50% forest vegetation along the stream and 50% is farms, orchards, and homes. From Ambaum Boulevard to 1st Avenue South, the stream flows through a forested ravine. From 1st Avenue South to the estuary, the area has been logged in places, but forested cover is approximately 70%.
1948	From South 144th to South 154th, there has been little change since 1936. The stream is ditched within agricultural land and lacks riparian vegetation. From South 154th to South 160th, there has been additional residential development along the stream and subsequent loss of some riparian cover, though a narrow band is often present. There has been selective logging in some areas. South 160th has been constructed across the stream. From South 160th south to Des Moines Memorial Drive, small farms and residential land uses occur next to the stream. South of Wetlands 18 and 37, logging has occurred on both sides of the stream. New orchards and single-family residences have been constructed. From Des Moines Memorial Drive to Ambaum Boulevard, the area is similar to conditions in 1936, but approximately 75% of the area is forested and 25% is farms and residences. From Ambaum Boulevard to 1st Avenue South, the area has been completely cleared. Between 1st Avenue South and the estuary, there is some riparian vegetation along the stream with additional residential development in the basin. South and east of the stream, there is more logging and the forested riparian buffer has been reduced. There is dense riparian vegetation from 166th down to 175th Place, but the area is developed from 175th to the estuary.
1961	Considerable residential and commercial development has occurred. In several locations, particularly at Vacca Farm and near Wetlands 18 and 37, farming continues.
1995	South of South 144th, the stream flows through residential development. The area has been converted from agriculture to residential and commercial land uses. North of SR 518, the stream flows through a pasture area, with steep slopes on the west side and a narrow corridor of riparian vegetation. The stream flows under SR 518 through the Miller Creek detention facility, where abandoned farmland has reverted to riparian shrub and forested wetlands. Across the Vacca Farm area, there is little riparian vegetation present. South of Vacca Farm to South 160th, a narrow vegetated buffer is present in places, but the riparian area is largely dominated by residential land uses. The area between South 160th and Des Moines Memorial Drive has been converted from agricultural land uses to residential land uses. The undeveloped areas of Wetland 18 and Wetland 37 are becoming forested.

Table 25. Changes in vegetation and land use near Miller Creek between 1936 and 1995 (continued).

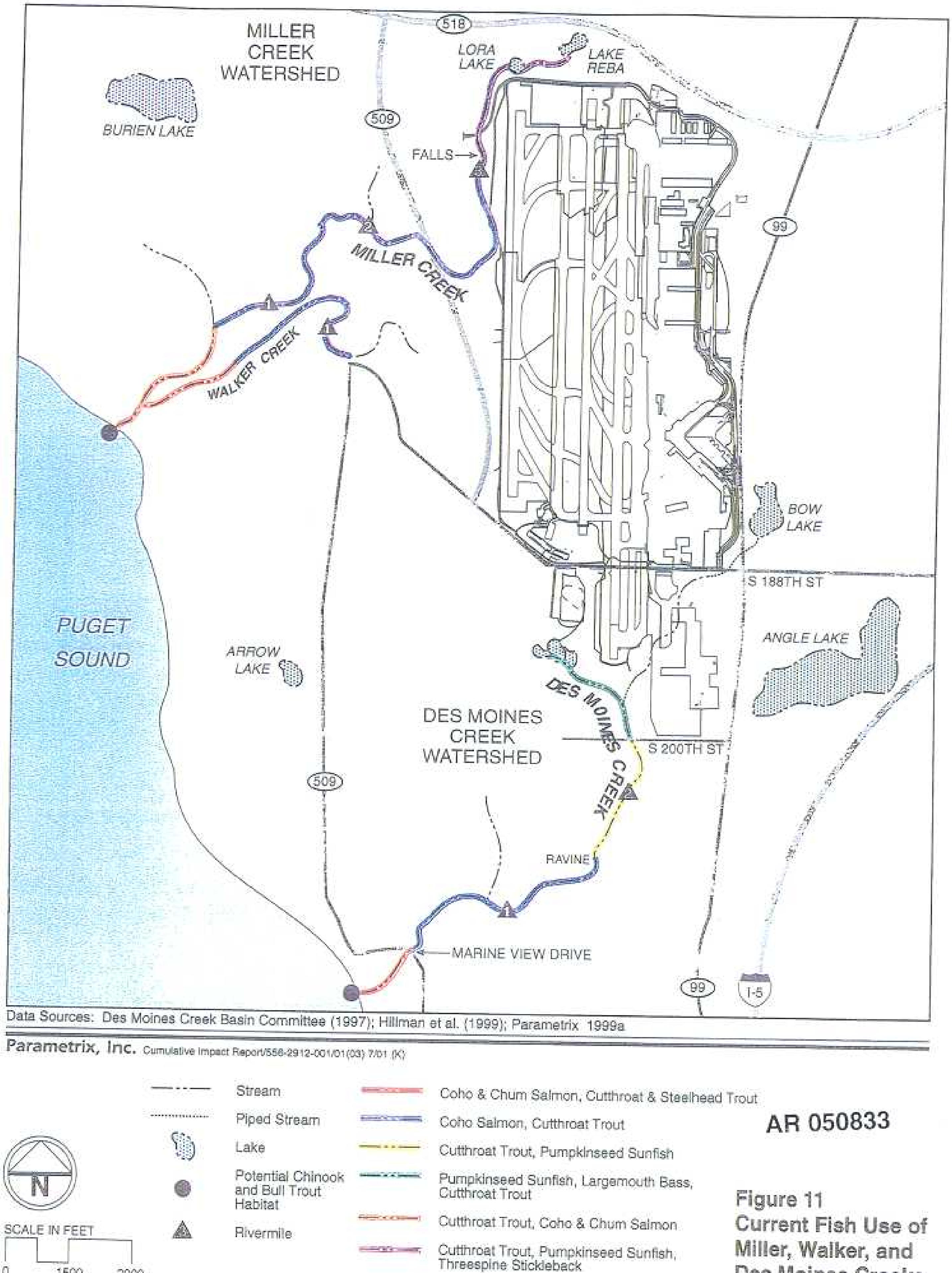
Year	Vegetation, condition, and land uses
	Between Des Moines Memorial Drive and Ambaum Boulevard, a narrow, forested riparian corridor is generally present, but in some places lawns abut the edge of the stream. Between Ambaum Boulevard and 1[st] Avenue South, the stream flows through an undeveloped forested area. South of 1[st] Avenue South to the confluence with Walker Creek, the riparian corridor is a forested ravine. Residences and other development generally border the ravine. South of the confluence with Walker Creek, the area is 90% built-out with single-family residences and supporting uses.

Table 26. Changes in vegetation and land use near Walker Creek between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	East of 1[st] Avenue South, Walker Creek can generally be identified by topography and vegetation along ditch lines. The riparian areas adjacent to the stream are largely developed as farmland. Wetland 43 (the origin of Walker Creek) is intensively farmed, and there is no evidence of a stream. West of 1[st] Avenue South to the estuary, the area has been logged in many places, but forested cover is approximately 70%.
1948	There is no evidence of Walker Creek east of Des Moines Memorial Drive. Between Des Moines Memorial Drive and 1st Avenue South, the stream flows through a mixture of farm and forestland. There is increased residential development, and in some places, farming has ceased. Between 1[st] Avenue South and the estuary, there is some riparian vegetation along the stream with additional residential development in the basin. South and east of the stream, additional logging has reduced the width of forested riparian buffers.
1961	Considerable residential and commercial development has occurred. Farming continues in most of Wetland 43, but activities have changed from row crops to pasture. Additional development has reduced riparian areas in some locations. In the undeveloped areas west of 1[st] Avenue South, forest vegetation is maturing.
1995	SR 509 bisects Wetland 43, and farming of the wetland has largely ceased. In many areas west of Des Moines Memorial Drive, riparian areas have matured compared to previous photographs. Some additional development in the watershed has occurred, and losses of riparian vegetation have occurred in limited areas.

Sampling has found threespine stickleback (*Gasterosteus aculeatus*), pumpkinseed sunfish (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), and cutthroat trout (*Oncorhynchus clarki*) in Miller Creek above these falls (see Figure 4-1 in Parametrix 2000b). The warmwater fish species are associated with Lora Lake and Lake Reba and the lower-velocity, fine-substrate reaches of upper Miller Creek. Only coho salmon and cutthroat trout were found rearing below the falls at RM 3.1 (Parametrix 2000b). However, chum salmon (*O. keta*) also spawn in lower Miller Creek (Hillman et al. 1999). During these surveys, no chinook salmon (*O. tshawytscha*) or bull trout (*Salvelinus confluentus*) were observed.

Downstream from the falls, culverts under 1[st] Avenue South and roads near RM 2.0 have been evaluated as impassable to fish (Williams et al. 1975; Ames 1970). However, adult coho salmon have been found upstream of the culverts (Batcho 1999 personal communication).



Data Sources: Des Moines Creek Basin Committee (1997); Hillman et al. (1999); Parametrix 1999a

Parametrix, Inc. Cumulative Impact Report/556-2912-001/01(03) 7/01 (K)

AR 050833

Figure 11
Current Fish Use of Miller, Walker, and Des Moines Creeks

The lower basin has benefited from instream habitat restoration conducted by Trout Unlimited. The goal is to increase the pool to riffle ratio of stream project segments from the original value of 13:87 calculated when work began in the 1980s, to a level approaching 50:50 (Batcho 1999 personal communication). The goal is also to improve pool quality for rearing juvenile salmonids and to increase habitat complexity. Coho salmon returning to the lower basin appear to have responded favorably; recent returns number about 300 adults per year. In fully restored habitat, the expectation is that Miller Creek would support between 700 and 1,200 adult coho salmon per year (Batcho 1999 personal communication).

Miller Creek enters Puget Sound through a private park in the City of Normandy Park. During low tide, the stream flows onto a low-gradient rocky beach composed of 3-inch-minus[4] coarse and fine gravel embedded with sand. To the north, for several hundred feet, the ordinary high water mark (OHWM) is defined by breakwater walls protecting residential property. To the south, for approximately 200 ft, the OHWM is defined by wrack[5] and large woody debris (LWD). The mouth of Miller Creek is affected by tidal activity, which alters stream morphology for approximately 150 ft upstream. Along this tidal channel, the stream is approximately 15 ft wide with overhanging salt marsh vegetation including Pacific silverweed (*Potentilla pacifica*), saltweed (*Atriplex patula*), and sedge (*Carex* sp.). This 15- x 150-ft (~ 0.05 acre) area comprises the estuarine area of Miller Creek[6] (see Section 4.2).

The confluence of Miller and Walker Creeks is approximately 300 ft upstream from the mouth of Miller Creek. Upstream from the confluence, Walker Creek has a diversion pipe that draws water into a small pond impounded by a control weir. Water leaving the pond enters Miller Creek approximately 10 ft upstream of the outfall to Puget Sound. The 3-ft-wide channel is incised approximately 1.5 ft and is tidally influenced from the confluence with Miller Creek to approximately 100 ft from the control weir. Salt marsh plants occur near its confluence with Miller Creek, and cattails (*Typha latifolia*) dominate the channel upstream near the control weir.

4.1.3 Current Condition of Fish Habitat in Miller Creek

The Washington Department of Fisheries (WDF) reported that Miller Creek had undergone extensive alteration and "total deterioration" due to heavy residential and commercial growth in the drainage in the early 1970s (Williams et al. 1975). Stream conditions necessary to adequately support spawning and rearing of salmonids "were virtually nonexistent" upstream of 1st Avenue South (RM 1.9) due to excessive amounts of sand and silts that comprised 70 to 100 percent of the bottom substrate (Ames 1970). King County's Surface Water Management (KCSWM 1987) evaluation of the Miller Creek basin noted that the high level of urbanization had degraded water quality, increased the volume and rate of stormflows, promoted erosion and mass wasting processes, and destroyed riparian habitat and vegetation.[7] These factors (Table 27) had greatly reduced the habitat quality of streams, which in turn affect fish populations.

---

[4] Indicating that 95 percent of the gravel present would pass through a 3-inch screen.
[5] Wrack is seaweed and other marine debris that is cast up on shore.
[6] This estuary may have been larger prior to development of a private park in the vicinity.
[7] Despite reported water quality degradation, Miller Creek is not on the 303(d) list of impaired waterbodies.

Table 27. Existing environmental conditions in Miller Creek, near Seattle-Tacoma International Airport.

Pathways Indicators	Environmental Baseline: Properly Functioning	At Risk	Not Properly Functioning	Explanation
Water Quality				
Temperature			X	Commercial, residential, and agricultural modifications to vegetation along the stream corridor have impacted ambient stream temperature. Causes of increased stream temperatures include the loss of riparian shading, impervious surfaces within the watershed, and the existing stormwater conveyance system. Daily fluctuations in water temperatures are greater in areas where riparian shading has been reduced. Stormwater systems and impervious surfaces have altered basin hydrology by conveying runoff rapidly to the stream. Runoff collected from impervious surfaces during summer may periodically contribute to temperature problems. Reduced infiltration may cause reductions in base flows, which may increase water temperatures during the summer low-flow periods.
Sediment			X	Urban developments within the watershed have altered native soils and vegetation, resulting in increased sedimentation in Miller Creek. Sedimentation from agricultural runoff as well as from channel alterations occurs at Vacca Farm. Several reaches with heavy sedimentation (highly embedded substrates) are apparent. Unmaintained culverts in low-gradient reaches tend to retain small substrates and reduce the capacity of the streambed to mobilize. Historic changes such as stream channelization and the removal of LWD have increased stream degradation and fine sediment input. Historic loss of wetlands further reduces the basin's capacity to buffer sediment inputs.
Chemical and Nutrient Contamination		X		Residential development has resulted in replacement of riparian vegetation with lawns. Agricultural runoff from urban development may contain fertilizers, herbicides, pesticides, metals, and oil and grease as pollutants that flow directly into the stream. Failed septic systems may also discharge nutrients and oxygen demand to the stream. The increase in nutrients could increase primary production and respiration, ultimately reducing dissolved oxygen (DO), especially during summer.
Habitat Access				
Physical Barriers			X	Several culverts may be barriers to migrations of resident and anadromous fishes at different times of the year, depending on flow conditions. The lack of LWD in the channel and alteration of stream hydrology may alter the ability of fish to pass a natural fall at approximately RM 3.0.
Habitat Elements				
Substrate			X	Gravel accumulations suitable for spawning by anadromous salmonids occur at several locations in the channel. Smaller accumulations suitable for resident salmonid spawning are more frequent; however, most spawning substrates are heavily embedded with silt and sand at levels greater than 30%.

Table 27. Existing environmental conditions in Miller Creek, near Seattle-Tacoma International Airport (continued).

Pathways Indicators	Environmental Baseline: Properly Functioning	At Risk	Not Properly Functioning	Explanation
Large Woody Debris			X	Historically, LWD has been cleared from the channel. The reduction or elimination of a native riparian area has impacted the recruitment of coniferous LWD. Loss of LWD has altered channel morphology resulting in reduced sinuosity, decreased pool to riffle ratio, and limited cover and habitat. Non-coniferous LWD recruitment occurs; however, it is routinely cleared from streams by homeowners.
Pool Frequency			X	Several deep pools exist. However, most are formed by modified channel features (e.g., below culverts, riprap, etc.) and lack quality habitat cover.
Off-Channel Habitat			X	Residential development has increased channelization and degradation, thereby eliminating opportunity for hydrologically connected seasonal habitats along stream margins. This has decreased side channel salmonid rearing habitat. Historic filling of riparian wetlands and armoring of streambanks may have decreased hydrologic connection to secondary channels.
Refugia			X	Channelization and reduction of instream structure decreases resting areas for fish. Loss of LWD and increased channel scouring reduces habitats available, especially low-velocity areas for juvenile fish. Riparian alterations, channelization, and lack of LWD result in few bank undercuts. Development to streambanks, channelization, and filling has resulted in loss of wetland and side channel habitat for rearing fish. Riparian impacts reduce overhead cover.
Channel Conditions and Dynamics				
Width to Depth Ratio			X	Width to depth ratios vary considerably along the length of Miller Creek, but are generally low in channelized reaches and more favorable in less-developed reaches.
Streambank Condition			X	Condition of streambanks in the basin is variable. The Vacca Farm reach is channelized; however, riparian vegetation tends to stabilize these reaches with minor undercuts. Several reaches through residential neighborhoods contain large non-coniferous trees that stabilize banks with undercuts. Other areas are armored with riprap or other artificial bank structures. Lower reaches contain areas with natural banks, but most associated vegetation is relatively small.
Floodplain Connectivity		X		Except for the Vacca Farm area, incised streams of this nature lack a significant floodplain. Some wetlands are hydrologically connected to the channel. In the mid-basin, many residential yards are modified to drain directly to the streambanks, and stormwater is conveyed directly back to the channel. Wetlands have been filled to enlarge developable areas. Impervious surfaces are extensive and may comprise up to 49% of the basin area.

AR 050836

Table 27. Existing environmental conditions in Miller Creek, near Seattle-Tacoma International Airport (continued).

	Environmental Baseline			
Pathways Indicators	**Properly Functioning**	**At Risk**	**Not Properly Functioning**	**Explanation**
Flow/Hydrology				
Peak/Base Flows			X	Negative effects of stormwater runoff in the upper basin have been moderated through regional and STIA detention ponds. Most runoff from residences and roads in the mid- and lower basin is conveyed directly to the channel, with little or no detention. Current conditions result in strong hydrographic peaks immediately following precipitation. Reduced infiltration and water withdrawals reduce summer base flows.
Drainage Network Increase			X	Impervious surfaces are extensive throughout the basin including the airport, roads, residences, and commercial development. Most runoff from impervious surfaces is conveyed through an extensive network of stormwater pipes and open drainage ditches. This increase in drainage network accentuates peak runoff rates.
Watershed Conditions				
Road Density and Location			X	Roads, parking lots, and other impervious surfaces are extensive throughout the basin.
Disturbance History			X	Human disturbances in the basin are extensive. Residential developments in the mid- and lower basin have maintained some riparian areas.
Riparian Reserves			X	Riparian areas have been extensively altered. The upper basin associated with the airport has little functioning riparian area. Riparian areas are extensively altered in agricultural areas. Limited functioning riparian areas exist in residential areas, but these are fragmented and have been invaded by exotic species that dominate many locations.

Trout Unlimited (1993), Luchessa (1995), Parametrix (2000b), and Hillman et al. (1999) have completed Miller Creek stream surveys. The 1995 survey by Luchessa was conducted as a Level I Stream Special Study using King County methodology (King County Building and Land Development 1991). Surveys agreed on Miller Creek's deteriorated habitat, particularly in the upper basin above RM 1.9. Factors contributing to loss of instream habitat included: degradation of water quality by pollutants, sediment, eutrophication of lakes and wetlands, and filling of wetlands; loss of protective streamside vegetation; and loss of instream large organic debris, natural meanders, and other diversity. In addition, high water temperatures in Miller Creek during the summer constitute a water quality concern, as do high fecal coliform counts, low dissolved oxygen (DO) levels, and residues of lawn and garden chemicals, especially in the upper reaches (Parametrix 2000b).

In Miller Creek, benthic macroinvertebrate sampling near the Master Plan Update projects found benthic index of biotic integrity (B-IBI)[8] scores of 10. These scores are similar to scores observed in other urban streams subjected to similar levels of hydrologic and habitat degradation (Kleindl 1995; Fore et al. 1996; Horner et al. 1996; Ecology 1999; May et al. 1997). Studies of Puget Sound lowland streams have demonstrated that the macroinvertebrate community, as evaluated through B-IBI analysis, correlates to fish use.

Specifically, coho salmon abundance diminishes in streams with B-IBI scores of 33 or lower; these degraded stream reaches were used by resident cutthroat trout and not by anadromous salmon (Ecology 1999; May et al. 1997). These findings are consistent with observations of fish use in Miller Creek and support surveys that suggest the portions of the stream adjacent to the Master Plan Projects do not currently provide high-quality habitat for coho salmon.

4.2 MILLER CREEK ESTUARY

4.2.1 Historical Conditions in Miller Creek Estuary

Historical conditions in the Miller Creek estuary are summarized in Table 28.

Table 28. Changes in vegetation and land use in the Miller Creek Estuary between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	A broad intertidal delta is located at the mouth of Miller Creek. A small road, separated from Puget Sound by a small berm, has modified the shoreline. East of the road, estuarine wetland is present, but portions have been filled for a house and parking area. East of the wetland, forested areas have been logged and contain small logging roads.
1948	Conditions are generally similar to those of 1936. A bridge was constructed and the road crosses the stream. Portions of the intertidal area have been bulldozed, and the shoreline area south of the estuary has been cleared and leveled. Forested areas east of the wetland now contain streets and a few houses.

[8] B-IBI for Puget Sound lowland streams (Kleindl 1995) quantifies the overall biotic condition of a stream based on measurements of benthic macroinvertebrate diversity, abundance, and species composition. B-IBI scores for streams in the Puget Sound lowlands correlate with levels of urbanization (Fore et al. 1996; Horner et al. 1996) and fish use (Ecology 1999; May et al. 1997).

Table 28. Changes in vegetation and land use in the Miller Creek Estuary between 1936 and 1995 (continued).

Year	Vegetation, condition, and land uses
1961	Portions of emergent wetland have been excavated to create a pond. The Miller Creek channel has been relocated. A building and parking areas have been constructed in the riparian zone.
1995	The stream channel has been relocated to the north side of the wetland. Wetland fill near the south end has occurred to construct a parking area, and the road crossing the estuary has been abandoned. A pond has been excavated on the south side of the estuary. The area now includes a mowed lawn, which occurs on fill in the central portion of the area.

4.2.2 Current Conditions in Miller Creek Estuary

A small estuary occurs where Miller Creek enters Puget Sound. Analysis of baseline conditions in the estuary (see Table 28) indicates significant modification of this area by park development. As Miller Creek approaches the beach, there is a private park to the south and several houses border the north side. The park is mainly a grassy area with deciduous trees growing near the streambank. The stream enters the beach about 75 ft downstream of a small footbridge and an adjacent house.

The shoreline adjacent to Miller Creek is predominantly gravel and sand, with driftwood marking the high tide mark. This shoreline type continues for several hundred feet north and south of the stream, where houses and cement bulkheads have been built at the high tide mark. The slope of the upper intertidal beach is moderate, dropping approximately 5 ft over a distance of 30 ft, then gently into the water, dropping approximately 4 ft over 150 yards to mean lower low water (MLLW).

The intertidal zone at the mouth of Miller Creek is predominantly of mixed gravel and sand substrate. Some cobble, boulders, and sandy areas are also present. The stream channel in the upper intertidal zone contains more cobble than adjacent areas.

The channel is vegetated with green algae (*Enteromorpha intestinalis*). The substrate has some attached barnacles, mussels, and snails. Upper intertidal areas adjacent to the stream have very little algae or other attached marine life; however, amphipods and isopods are abundant under rocks and in the sand. In the middle intertidal zone, *E. intestinalis* becomes less abundant in the stream channel, while barnacles and mussels become the dominant species adjacent to the stream. In the lower intertidal zone, the stream channel is poorly defined and the substrate within and adjacent to the stream channel is a mixture of gravel and sand. Barnacles and mussels are present, but less dense than found in the middle intertidal zone. Additionally, species of brown, red, and green algae are all sporadically present, and bivalve siphons can be observed in the sandy areas.

4.2.3 Current Conditions in Walker Creek

Walker Creek drains an approximately 2.5-mi^2 subbasin of the Miller Creek watershed. The stream originates in a 30-acre wetland (Wetland 43) located between Des Moines Memorial Drive and SR 509. The stream flows through both residential and commercial development before its confluence with Miller Creek approximately 300 ft upstream from Puget Sound. Much of the riparian areas adjacent to the stream have been eliminated or altered by adjacent development.

Walker Creek parallels Miller Creek for roughly one-half its length, and they share similar effects from urbanization. King County Surface Water Management (KCSWM 1987) reports several problems in the Miller/Walker Creek watershed created by urbanization; these include excessive runoff from streets, parking lots, and commercial areas that has increased the volume and rate of stormflows. These increased flows have lead to mass-wasting and stream erosion, flooding, and loss of habitat. Runoff from this development has also reduced water quality and impaired fish usage.

Even though coho salmon occur in the lower reaches of Walker Creek (Batcho 1999 personal communication), the absolute upstream limit of coho salmon use has not been documented. Coho salmon use in Walker Creek is approximated in Figure 11. Hillman et al. (1999) conducted spawning surveys in Walker Creek from October 1998 to March 1999, and tallied 66 coho salmon redds in the lower 3.6 km (2.3 miles). They also found seven chum salmon redds up to RM 1.35, and one potential cutthroat trout redd in the lower 1500 ft of the stream. During these surveys, chinook salmon and bull trout were not observed.

While a small portion of the Walker Creek watershed (approximately 5.2 acres) will be developed for the third runway project, the project will not remove or directly alter fish habitat in Walker Creek. The runway project would fill about 0.26 acre of Wetland 44 (upslope of the defined Walker Creek channel and fish habitat). Potential indirect impacts to the stream could occur as a result of changes in water quality and hydrology.

4.3 DES MOINES CREEK

Des Moines Creek originates in Bow Lake (east branch) east of STIA and Northwest Ponds (west branch) southwest of STIA. Current and historical conditions in the stream are discussed in this section.

4.3.1 Historical Conditions in Des Moines Creek

Changes to Des Moines Creek have been assessed over time using aerial photographs. These changes are summarized in Table 29 and see Table 20.

Table 29. Changes in vegetation, land use, and riparian conditions in Des Moines Creek near Des Moines Creek Park between 1936 and 1995.

Year	Vegetation, condition, and land uses
1936	The riparian corridor associated with Des Moines Creek and within Des Moines Creek Park is densely forested. Vegetation cover becomes increasingly patchy towards South 200th Street. There is evidence of logging within the corridor. Wetlands 29, 30, B5, B6, and B7 are generally forested. Wetlands in Borrow Area 1 are forested or farmed. Wetland 51 is forested.
1948	Riparian forested cover is present along most of the stream. Agricultural uses are also present in the riparian area. North of South 200th Street, land use is mixed and includes more residential development and logging. Wetland conditions are generally similar to those of 1936.
1961	Wetlands are generally farmed and surrounded by residential development. Wetlands 29 and 30 are generally forest- and shrub-dominated, but portions appear to be pasture. Wetland 51 remains forested.
1995	The majority of the area is forested, with an open field on the west side of the stream. The riparian buffer is approximately 100 ft wide (minimum) and continuous. Surrounding land uses include high-density residential and small areas of pasture to the south. Wetlands in Borrow Area 3 are forested, while those in Borrow Area 1 are generally shrub-dominated.

4.3.2 Current Conditions in Des Moines Creek

The Des Moines Creek watershed covers about 5.8 mi^2 of predominantly residential, commercial, and industrial area lying within the cities of SeaTac and Des Moines; it also includes a small area of unincorporated King County (Des Moines Creek Basin Committee 1997). STIA occupies 23 percent of the upper Des Moines Creek watershed. Baseline environmental conditions in the stream (Table 30) are highly modified from natural conditions by a variety of development and land use practices.

The headwaters of the east branch (considered the main stem by most locals) originate at Bow Lake, 3.7 RM from Puget Sound. The upper half-mile of the east branch, from Bow Lake downstream to about RM 3, is conveyed through underground pipes. The west branch originates from the Northwest Ponds stormwater detention complex located at the western edge of the Tyee Valley Golf Course and joins the east branch at approximately RM 2.4. Downstream of South 200th Street (RM 2.2), the stream flows through Des Moines Creek Park, a forested riparian wetland. The park includes an incised ravine at about RM 1.8. The ravine is a high-gradient reach in which the stream has cut to hardpan for most of the length, providing little quality fish habitat. The stream is paralleled within this ravine by a paved trail and/or service road and sewer line protected in places by rock bank armoring.

Documentation of fish use in Des Moines Creek is provided in a Des Moines Creek Basin Committee report (1997) and Hillman et al. (1999), and is mapped in Figure 11. A variety of native salmonids use the lower 0.4 mile (below Marine View Drive), and include chum salmon and coho salmon, as well as cutthroat and steelhead (*O. mykiss*) trout. Only steelhead, cutthroat trout, and coho salmon are known to pass the partial migratory blockage under Marine View Drive. Coho salmon use extends to approximately RM 1.5. The upper plateau reach supports a mixture of cutthroat trout and non-native warmwater fish species, particularly pumpkinseed sunfish. Largemouth bass (*Micropterus salmoides*) are found in lower numbers than pumpkinseed sunfish in the upper stream. Warmwater fish found in the stream mainstem are presumed to originate from larger populations in Bow Lake and the Northwest Ponds. Chinook salmon and bull trout have not been observed in Des Moines Creek.

A cascade at RM 1.5 in the ravine reach was mapped as impassible to upstream-migrating fish (Williams et al. 1975). However, recent surveys have not identified this cascade as a fish barrier (Resource Planning Associates et al. 1994). The Midway Sewage Treatment Plant is located at RM 1.1 where the ravine widens. The channel in this reach contains several aging weirs originally intended to be fish-passage structures; in their present state they may act as impediments to fish passage. Just below the treatment plant, the gradient decreases and the stream develops a floodplain that allows a more meandering channel, better habitat conditions, and well-developed riparian vegetation.

Table 30. Existing environmental conditions in Des Moines Creek, near Seattle-Tacoma International Airport.

Pathways Indicators	Environmental Baseline: Properly Functioning	At Risk	Not Properly Functioning	Explanation
Water Quality				
Temperature			X	Commercial and residential development in the stream corridor have impacted riparian conditions, affecting stream temperature. Daily fluctuations in water temperatures are greater in areas where riparian shading has been reduced, such as the Tyee Valley Golf Course. Stormwater systems and impervious surfaces have altered basin hydrology by conveying runoff rapidly to the stream. Runoff collected from impervious surfaces during summer may periodically contribute to temperature problems. Reduced infiltration may cause reductions in base flows, which may increase water temperatures during summer low-flow periods.
Sediment			X	Urban development within the watershed has resulted in alteration of native soils and vegetation, resulting in increases in the sediment discharge and transportation in Des Moines Creek. Several reaches with heavy sedimentation (highly embedded substrates) are apparent. Historic changes such as stream channelization and removal of LWD have increased stream incision and fine sediment input. Historic loss of wetlands may reduce capacity of basin to buffer sediment inputs.
Chemical and Nutrient Contamination		X		The Tyee Valley Golf Course may be a source of fertilizer and chemical runoff. Increases in nutrients increase biological activity in the stream, ultimately reducing DO, especially during summer. Residential and commercial development near Bow Lake or parking lots south of the runway has likely increased loading of fertilizers, pesticides, metals, and organic hydrocarbons (oil and grease) to the stream.
Habitat Access				
Physical Barriers			X	Several weirs on the Tyee Valley Golf Course and culverts on Marine View Drive or South 200th Street may be barriers to resident and anadromous fish at different times of the year, depending on flow conditions.
Habitat Elements				
Substrate			X	Gravel accumulations suitable for spawning by anadromous salmonids occur at several locations in the lower reaches of the channel. Smaller accumulations suitable for resident cutthroat trout spawning are more frequent. Most spawning substrates are heavily embedded with silt and sands.

Table 30. Existing environmental conditions in Des Moines Creek, near Seattle-Tacoma International Airport (continued).

Pathways Indicators	Environmental Baseline: Properly Functioning	At Risk	Not Properly Functioning	Explanation
Large Woody Debris			X	LWD has been cleared from the channel. The reduction or elimination of a native riparian area has impacted the recruitment of coniferous LWD. Loss of LWD has altered channel morphology resulting in reduced sinuosity, decreased pool to riffle ratio, and limited cover and habitat. Coniferous and non-coniferous LWD recruitment occur below South 200th Street on the east bank of the stream (Parametrix 1997).
Pool Frequency			X	Des Moines Creek streambed does not meet optimal pool frequency conditions in the Tyee Valley Golf Course. Channelization, increased sediment input, alterations to the hydrography, removal of LWD, and riparian alterations have decreased pool frequency and may have impacted the development of future pools. A high pool frequency occurs below South 200th Street where the stream grade increases to a step/pool system formed mainly by boulders.
Pool Quality			X	The stream is channelized within the Tyee Valley Golf Course where a few deeper pools exist, especially below weirs. Quality habitat features do not exist within these pools. Boulders and some LWD form several deep pools below South 200th Street.
Off-Channel Habitat			X	Channelization through the Tyee Valley Golf Course has eliminated opportunities for hydrologically connected habitat along stream margins, resulting in a decrease in side channel rearing habitat. Below South 200th Street, the steep slope of the stream confines the channel, offering little off-channel habitat.
Refugia			X	Channelization and reduction of instream structure decreases hydraulic heterogeneity resulting in the loss of resting areas for fish. Loss of LWD and increased channel scouring reduces habitats available, especially low-velocity areas for juvenile fish. Riparian alterations, channelization, and lack of LWD result in few bank undercuts. Channelization and filling have resulted in loss of wetland and side channel habitat for rearing fish. Riparian impacts also reduce overhead cover. Within the ravine south of South 200th Street, the steep slopes offer some overhanging vegetation and LWD.
Channel Condition & Dynamics				
Width to Depth Ratio			X	Width to depth ratios vary considerably along the length of Des Moines Creek, but are generally low in channelized reaches and more favorable in less developed reaches.
Streambank Condition			X	Condition of streambanks in the basin is variable. The upper portion of the stream is largely culverted or channelized through parking lots, streets, and a golf course. Stream width is narrow, with portions of the banks containing riprap. Lower reaches of the stream (below South 200th Street) contain areas with natural banks and forested riparian vegetation.
Floodplain Connectivity		X		Large wetlands connected to the channel occur on the Tyee Valley Golf Course. Some stormwater detention exists in the upper basin associated with STIA. Wetlands have been filled to enlarge developable areas.

Table 30. Existing environmental conditions in Des Moines Creek, near Seattle-Tacoma International Airport (continued).

Pathways Indicators	Environmental Baseline: Properly Functioning	At Risk	Not Properly Functioning	Explanation
Flow/Hydrology				
Peak/Base Flows			X	Impervious surfaces are extensive and may comprise up to 49% of the basin area. Little of this area receives adequate stormwater management. Return of stormwater in the upper basin has been moderated through detention ponds associated with airport runoff. Most runoff from residences and roads in the mid- and lower basin is conveyed directly back to the channel, with little or no detention. Current conditions likely result in strong hydrographic peaks immediately following precipitation.
Drainage Network Increase			X	Impervious surfaces are extensive throughout the basin and include the roads, residences, commercial development, and airport facilities. Most runoff from impervious surfaces is conveyed through ditches and pipe systems to the stream without adequate stormwater management.
Watershed Conditions				
Road Density and Location			X	Roads are extensive throughout the basin.
Disturbance History			X	Basin disturbances are extensive; however, parkland or residential development in the mid- and lower basin have maintained some riparian areas.
Riparian Reserves			X	Riparian areas have been extensively altered in the upper reaches. The riparian areas upstream of South 200th Street are extensively altered by golf course and other development. Lower reaches contain a relatively continuous riparian corridor. The width of the corridor is variable and frequently limited by residential uses and exotic species.

AR 050844

At Marine View Drive (RM 0.4), a 225-ft-long box culvert conveys the stream under the roadway, but acts as an impediment to migrating salmon and trout because of its high velocities (greater than 7 ft per second) and length (Des Moines Creek Basin Committee 1997). Below Marine View Drive, the stream reach through Des Moines Beach Park provides some of the most accessible and more heavily spawned fish habitat in the system. Hillman et al. (1999) found coho and chum salmon redd densities of 26.3 and 20.0 redds/mi, respectively, during studies in this reach in 1998-1999.

4.3.2.1 Condition of Fish Habitat in Des Moines Creek

King County has estimated that the Des Moines Creek basin is 32 percent impervious surface, based on digitized land use data and GIS (Parametrix 2000b). May (1996) reported a value of 49.1 percent, based on aerial photo analysis. Previous stream studies and habitat inventories dating back to 1974 (Des Moines Creek Basin Committee 1997) established that Des Moines Creek has been severely degraded by urbanization. Little usable salmonid habitat exists in the system upstream of South 200th Street. Downstream of South 200th Street, where the stream flows through a forested wetland area, a short reach harbors resident trout and pumpkinseed sunfish. Better native fish habitat exists in meanders below the Midway Treatment Plant; however, the culvert under Marine View Drive restricts migrating salmon and trout from reaching this habitat. The stream reach through Des Moines Beach Park provides the most fish use, with coho salmon, chum salmon, cutthroat trout, and steelhead observed in this reach.

Des Moines Creek is on the Washington State 303(d) list of impaired water bodies for exceeding standards for fecal coliform levels at both stormflows and base flows (Parametrix 2000b; Ecology 1998a; Des Moines Creek Basin Committee 1997). High water temperatures in summer have also been identified as a water quality concern (Parametrix 2000b; Des Moines Creek Basin Committee 1997).

Des Moines Creek enters Puget Sound through Des Moines Park Beach located in the City of Des Moines. During low tide, the stream flows onto a low-gradient rocky beach composed of 3-inch-minus coarse and fine gravel embedded with sands. To the north for several hundred feet, the OHWM is defined by wrack (accumulations of debris at the high-tide line). To the south for approximately 50 ft, the OHWM is defined by breakwater walls protecting residential property. Beyond the house to the south, the beach is composed of riprap protecting the Des Moines Marina.

4.4 DES MOINES CREEK ESTUARY

4.4.1 Historical Conditions in Des Moines Creek Estuary

Changes to Des Moines Creek estuary are summarized in Table 31.

Table 31. **Changes in vegetation and land use near the Des Moines Creek estuary between 1936 and 1995.**

Year	Vegetation, condition, and land uses
1936	The mouth of Des Moines Creek and estuary are largely developed. At the mouth of the stream, a building is constructed on piers over the stream channel and the upper intertidal area. A road crosses the stream mouth and appears to be located on an earthen seawall. Adjacent to the stream channel is a meadow, small roads, and small cabins. Des Moines Memorial Drive crosses the stream ravine on fill. North of the road crossing, a forested corridor (up to 800 ft wide) is present, which continues to the northeast in a relatively wide riparian corridor (greater than 100 ft).
1948	The area is similar to the 1936 condition. The small meadow is now a parking area, and portions of the slopes of the ravine are less thickly forested.
1961	The area is similar to the 1948 condition.
1995	The area has been developed into a park. Buildings have been removed from intertidal and some riparian areas.

4.4.2 Current Conditions in Des Moines Creek Estuary

A small estuary is present where Des Moines Creek enters Puget Sound. Baseline environmental conditions in this estuary have been highly modified by park development. Before entering the beach, Des Moines Creek runs through Des Moines Beach Park, which consists of lawn, roads, parking areas, etc. Two bridges cross the stream, and the streambank is stabilized with riprap.

The marine shoreline is stabilized with riprap for about 200 ft north of Des Moines Creek before a vegetated bluff starts and continues north. Approximately 400 ft north of Des Moines Creek, some houses are protected by cement bulkheads located near the high tide mark. Immediately south of the stream, a riprap wall runs south and west across the beach to a fishing pier and the Des Moines Marina. Within the marina, the shoreline continues as riprap. The beach at the stream mouth and north of the stream has a gentle slope, dropping approximately 5 ft over 100 yards. South of the stream mouth, the riprap wall drops steeply from the high tide mark to the lower intertidal zone over a span of 25 to 30 ft.

The intertidal zone at the mouth of Des Moines Creek is composed of gravel and sand with some cobble and boulders. This substrate type is fairly uniform throughout the intertidal zone north of the stream. South of the stream, starting at the fishing pier, riprap covers the entire intertidal zone. *Enteromorpha intestinalis* is the dominant algae in the upper intertidal zone, covering cobble and boulders about 75 ft into the Des Moines Creek channel. Lesser amounts of *E. intestinalis* are attached to rocks adjacent to the stream with barnacles sporadically present. Barnacles and mussels dominate the middle intertidal zone, except in the stream channel, where *E. intestinalis* dominates most cobble with some presence of barnacles. The lower intertidal zone continues to have abundant numbers of barnacles and mussels with green, brown, and red algae being common. Isopods, shore crabs, and snails were more readily found in this zone, and bivalve siphons were periodically observed in sandy areas. The riprap south of the stream hosts an intertidal community very different from the gradual beach to the north of the stream. Barnacles, mussels, and the red algae *Mastocarpus papillatus* densely occupy the majority of the intertidal zone. *Littorina* snails and limpets are also abundant throughout this area.

4.5 STREAM IMPACTS

Environmental impacts to streams that have occurred in the STIA watersheds over the past 50 to 70 years are similar to those that are found in small urban streams throughout the region. They include the following:

- **Channelization and confinement of stream channels.** This impact has occurred in several reaches of Miller, Walker, and Des Moines Creeks. These impacts reduce channel complexity, increase velocities, eliminate pools for holding and rearing, eliminate spawning gravel, fill side channels, reduce wood recruitment, and reduce connectivity with floodplain and riparian zones.
- **Loss of riparian vegetation.** Riparian vegetation has been removed as a result of urbanization, forestry, and agriculture. As a result, overhanging vegetation, stream shade, and cover are reduced. Resulting increased solar radiation can elevate water temperatures. Vegetation loss reduces LWD recruitment, terrestrial insect influx, and leaf litter influx, thus altering the energy cycle.
- **Loss of forested areas.** Urbanization, forestry, and agriculture have reduced forest cover, which alters the runoff cycle affecting the timing and magnitude of flows. This can increase erosion and change channel morphology.
- **Loss of wetlands.** Loss of riparian wetlands can reduce detrital input and energy cycles.
- **Creation of impervious surfaces.** Urbanization alters the runoff cycle, affecting the timing and magnitude of flows. This can increase erosion, degrade water quality, increase stormwater runoff, and change channel morphology. Stormwater runoff introduces pollutants to aquatic habitats.
- **Culverts, pipes, and ditches.** The creeks contain numerous culverted and ditched reaches. These obstruct fish passage, reduce movement of gravel, and can strand fish in ditches. Ditch networks increase runoff rates and connect the stream system to impervious surfaces and other high-runoff areas.
- **Loss of estuarine and nearshore habitats.** Much of the freshwater to saltwater transition habitats of Miller and Des Moines Creeks have been altered or filled. Habitat, including cover and food production for smolts and adults, is limited.
- **Erosion and sedimentation.** Increased turbidity from stormwater runoff, inputs of fine sediment from construction sites, and channel erosion from high streamflows can reduce water and sediment quality. The transition from agricultural and forestry land uses to urban land uses has probably reduced the amount of land disturbance and sedimentation rates.
- **Fertilizer and pesticide use.** Degraded water quality and increased toxicity may result in biological degradation. A change from agricultural to urban land uses has likely shifted the spectrum of nutrient and chemical use in the watersheds. Agricultural use included application of barnyard manure, fertilizers, and pesticides. These applications were frequently in farmed wetlands with direct connections to streams through drainage ditches. Quantitatively, use of these chemicals may be lower than in the recent past. However, new land uses result in pollutants from stormwater and risks of accidental spillage from a wide variety of commercial chemicals.

4.5.1 Current Regulatory Protection for Streams and Aquatic Habitats

Many of the regulations that protect wetlands also protect Miller, Walker, and Des Moines Creeks from the potential adverse impacts of nearby development. These are briefly described below. Additional information and requirements are found in Ecology (1998b).

- **Clean Water Act – Section 404.** Regulates fill placement in Waters of the U.S., and triggers Section 401 review by Ecology to protect water quality. Mitigation ratios that require mitigation area in excess of the area of fill help ensure that cumulative losses do not occur over time.
- **Critical Areas Protection.** Critical area protection is included as part of the municipal code of each community in the watershed. These regulations protect, among other elements, wetlands, wetland buffers, streams, stream buffers, and fish and wildlife conservation areas.
  - **SeaTac** - Title 15, Chapter 15.30
  - **Burien** - Title 18, Chapter 18.60
  - **Des Moines** - Title 18, Chapter 18.86
  - **Normandy Park** - Title 13, Chapter 13.16

  The regulations provide specific standards and mitigation requirements for the modification of streams and their protective buffers. Local mitigation standards for stream and buffer alterations require replacement of area and function.

- **Hydraulics Project Approval.** HPAs are required for projects that use, divert, obstruct, or change the natural flow or bed of any fresh water or saltwater of the state. HPA approvals generally require mitigation adequate to compensate for project impacts to streams. These approvals may also be required for projects not occurring in streams or wetlands, but that discharge stormwater runoff to them. Mitigation for these projects can require enhanced stormwater detention and water quality standards to preserve existing runoff patterns and water quality.
- **State and National Environmental Policy Acts.** SEPA and NEPA provide stream protection by requiring analysis of project impacts to streams and by requiring mitigation of adverse impacts.
- **Stormwater Management Standards.** Local stormwater management standards are designed to collect, detain, and treat stormwater runoff from urban areas and prevent degradation of streams.
- **Endangered Species Act.** The listing of chinook salmon and bull trout under the Endangered Species Act (ESA) provides additional protection to the streams. Review of development projects or other watershed activities under the ESA is often necessary to ensure that habitat or water quality impacts are avoided in the estuarine mouths (where the listed species could occur).

The above permits and other related environmental approvals (Ecology 1998b) help prevent cumulative impacts to streams, water quality, and aquatic habitat.

5. WILDLIFE HABITATS

Wildlife habitat is defined as an area with an adequate combination of resources (e.g., food, cover, water) and environmental conditions (climate, suitable levels of predators or competitors, etc.) that support use (i.e., survival and reproduction) by individuals of a given species. The types of habitat resources and features that meet a species' biological needs identifies the habitat niche a species occupies. A species habitat niche is used to predict species responses to past, present, and future land uses of an area.

5.1 WILDLIFE HABITAT TYPES

In the Miller and Des Moines Creek watersheds, a number of wildlife habitat types are present. The present and past (since 1936) habitats (as defined by Brown [1985] and Johnson and O'Neil [2001]) occurring in the STIA watersheds are briefly described below. Current habitats are mapped in Figure 7.

5.1.1 Upland Successional

Upland successional habitats in the area (listed below) are various, due to the wide variety of human disturbances that have occurred in the watersheds.

- **Grass/forb stage.** Generally this area consists of abandoned pastures and recently cleared land. Shrub communities consisting of blackberry (*Rubus discolor*) or Scots broom (*Cytisus scoparius*) quickly replace it.
- **Lowland shrub.** Abandoned pastures, lawn areas, and other disturbed sites generally become dominated by introduced blackberry and Scots broom shrubs. This stage can persist for many years.
- **Coniferous.** All coniferous forests in the area are in early- to mid-stages of succession. The larger tracts of this community type occur in the stream ravines or relatively steep slopes bordering the Puget Sound shoreline. Some areas north and south of STIA that were formerly developed neighborhoods have an open overstory of native and non-native conifer trees and an understory of blackberry and ornamental shrubs. Since 1936, large amounts of this habitat have been replaced by development.
- **Deciduous.** Deciduous and mixed coniferous and deciduous forests occur scattered throughout the area. They typically occur on steeper slopes, bordering wetland areas. Since 1936, large amounts of this habitat have been developed.

5.1.2 Agricultural Habitats

Agricultural habitats have been essentially abandoned, and agricultural lands have generally been developed. Smaller areas have reverted to wetland or upland successional communities. In 1936, plant communities in large portions of the watershed had been altered, and included the following habitat types:

- **Herbaceous cropland**
- **Orchard**
- **Unmowed, stable** (i.e., pasture)
- **Mowed, stable** (i.e., hayfields)

5.1.3 Urban Habitats

Urban habitats in the watersheds have increased dramatically since 1936, when urban areas were almost absent.

- **Mostly vegetated.** This habitat consists of low-density residential areas where, in addition to home sites, larger yards, landscaped areas, and small areas of undeveloped land provide habitat.
- **Moderately vegetated.** This habitat type consists of medium-density residential development.
- **Poorly vegetated.** This habitat type consists of high-density residential development, commercial/retail development, etc.

5.1.4 Wetland and Aquatic Habitat

A variety of commonly recognized wetland habitats are found in the watersheds.

- **Freshwater lake/pond.** These habitats occurred in several locations. In the Des Moines Creek watershed, they are limited to the Northwest Pond (Wetland 28) area and Bow Lake. In the Miller Creek watershed, they occur at Lake Burien, Arbor Lake, Tub Lake, Lake Reba, and Lora Lake. The area of open water habitat appears to have increased since 1936.
- **Salt marsh.** There is no salt marsh habitat present in either watershed. Small amounts of salt marsh habitat may have once occurred at the mouths of both Miller and Des Moines Creeks.
- **Shrub wetland.** Many of the wetlands contain shrub wetland habitat. In the Miller Creek basin, the largest areas occur in the Tub Lake area, the Lake Reba area, and in Wetland 43. In the Des Moines Creek Basin, the largest area of this habitat type occurs in the Northwest Ponds and Bow Lake areas. The amount of shrub wetland habitat appears to have increased since 1936.
- **Freshwater marsh.** Little freshwater marsh was historically present, and little is present today. Fringes of this habitat border the Northwest Pond area, Lake Reba and associated wetlands, and ditches on the Vacca Farm site.
- **Bog.** Tub Lake remains as a high-quality bog system. Peat mining has removed some bog vegetation. Other wetland areas that may have once contained bog communities are Bow Lake, Vacca Farm, and the Northwest Pond areas.
- **Wet meadow.** All wet meadow habitats in the watersheds are artificial. Seasonally saturated areas of the Tyee Valley Golf Course, portions of the Vacca Farm area, Wetland 22

on the airfield, and several small wetlands in lawn or pasture within the acquisition area are wet meadow habitats.

- **Forested wetland.** Historically, most vegetated wetland habitats were likely forested wetlands. The larger areas of this habitat occur in the Lake Reba wetland complex, Wetland 43, and Wetland 44 in the Miller Creek Watershed. In the Des Moines Creek watershed, the largest areas occur in Wetland 28 and Wetland 51. The area of this habitat type has increased since 1936.

5.2 HISTORICAL CONDITIONS AND CHANGES IN HABITAT TYPES AND AREA SINCE 1936

To provide ACOE with information on the watersheds as a whole, and on changes to wildlife habitat that have occurred over time, additional data has been reviewed and organized.

Available information on historical habitat conditions in the watersheds can be estimated from Shapiro and Associates (1994) (see Table 1 and Figures 2 through 6), which evaluated historical land use in a 27,650-acre area (2.5 miles wide and 13 miles long) rectangle centered on STIA. The study area is generally between 1st Avenue South and 51st Avenue South and between Alaska Street and 304th Street South. While this analysis is not specific to the watersheds of concern, it includes the entire Des Moines Creek watershed and a portion of the Miller Creek watershed. Coupled with review of historical aerial photographs, it provides a basis for estimating habitat conditions in the watersheds prior to and immediately following STIA development.

In 1948, over 67 percent of the area was in open space. Evaluation of 1936 and 1948 aerial photographs indicate the open space consists of agricultural lands, early successional forestland, and farmed wetlands. Throughout the mosaic of habitat types, scattered farms and homes are present, as are a number of golf courses. Urban land uses present in the study area near STIA were generally low- to medium-density residential areas (about 24 percent of the study area).

The impact of Master Plan Update development projects on vegetation and wildlife habitat was evaluated in the Final Environmental Impact Statement (FEIS) (FAA 1996) for the project. This analysis included classifying and mapping wildlife habitats in the construction areas and vicinity (totaling about 6,600 acres of land) (Table 32).

The areas impacted by the project do not provide high-quality wildlife habitat for many wildlife species (FAA 1996, 1997). Approximately 300 of the roughly 700 acres are managed grasslands associated with the airport operations area and a golf course, with relatively low habitat value for most native wildlife communities. Approximately 80 acres are lower-quality shrub habitat typically consisting of non-native Himalayan blackberry that provides limited habitat value to a small number of animal species. The remaining areas of impact (early successional deciduous and coniferous forest) typically occur in former residential neighborhoods. In these areas, development has eliminated native understory shrub and herbaceous vegetation, snags, downed logs, or other habitat features that reduces their suitability to wildlife. The forest understory is typically colonized by non-native plants (both the shrub and herbaceous layers) and is fragmented by streets or more highly developed areas that further reduce their habitat suitability.

Table 32. Impacts to vegetation and wildlife habitat (from FEIS data [FAA 1996 and Parametrix 2001a]).

Vegetation Class	Existing Area (Acres)	Alternative 3 Impact Area (Acres)[a]
Managed Grassland	900	283
Grassland	142	57
Shrubland	253	83
Deciduous Forest	723	244
Coniferous Forest	112	14
Wetlands[b]		
Forest	54	8.17
Shrub	54	2.98
Emergent	42	7.22
Urban (density varies)	4, 320	

[a] Values overestimate habitat impacts due to avoidance of wetlands in Borrow Areas 1 and 3. and do not reflect changes that occur as a result of mitigation.

[b] Wetland values are from Parametrix (2001a).

5.3 WILDLIFE USE

Patterns of wildlife use in the study area are expected to change with the changes in habitat types available to them, as shown by King County (1987), Raedeke (1988), and Penland (1984).

5.3.1 Amphibians and Reptiles

In western Washington, most amphibian and reptile species inhabit wetland and forested habitats, with few, if any, species found in agricultural or urban habitat types. In 1936 and 1948, considerable forestland had been converted to agricultural use, and most wetlands were largely in agricultural land uses. These areas (including the Vacca Farm, Lake Reba, Wetland 28, Wetlands 43 and 44 and Bow Lake wetland complexes) are largely in agricultural uses, and therefore, little amphibian use would be expected.

During later years, some of these agricultural uses were abandoned. Portions of wetlands were filled (wetlands surrounding Bow Lake) or converted to other uses (portions of Wetland 28 were filled or converted to golf course uses) and do not provide significant amphibian habitat. However, in other areas where agricultural uses have been abandoned, portions of the Vacca Farm/Lake Reba wetlands and most of Wetlands 43 and 44 have reverted to wetland plant communities and provide improved habitat for amphibians compared to their 1936 condition.

5.3.2 Small Mammals

In 1936 and 1948, considerable forestland had been converted to agricultural use, and most wetlands were largely in agricultural land uses. These areas (including the Vacca Farm, Lake Reba, Wetland 28, Wetlands 43 and 44, and Bow Lake wetland complexes) are largely in agricultural uses, and therefore, little small mammal use would be expected.

During later years, some of these agricultural uses were abandoned. Portions of wetlands were filled (wetlands surrounding Bow Lake) or converted to other uses (portions of Wetland 28 were filled or converted to golf course uses) and do not provide significant small mammal habitat. However, in other areas where agricultural uses have been abandoned, portions of the Vacca Farm/Lake Reba wetlands and most of Wetlands 43 and 44 have reverted to wetland plant communities and provide improved habitat for small mammals compared to their 1936 condition.

In western Washington, many small mammal species inhabit wetland and forested habitats. Agricultural and urban habitats contain fewer species than are found in natural habitats. Thus, as timber harvest, farming, and urban development have occurred, the habitat for many species of small mammals has decreased or been eliminated.

In addition to habitat loss, mobility of small mammals is decreased by fragmentation of habitats. In the Miller and Des Moines Creek watersheds, fragmentation has occurred through commercial and residential development, and by highway development. Development has isolated wetland habitats from other natural areas, which could reduce the overall habitat value and species diversity. Likewise, highways crossing wetlands (i.e., SR 509 crossing Wetlands 44 and 43 and SR 518 separating Vacca Farm and Lake Reba from other undeveloped areas to the north [including Tub Lake]) fragments a larger system, which reduces the overall habitat value for some small mammal species.

A number of small mammals in Washington prefer freshwater wetland and aquatic habitats. Historically, in the Miller, Walker, and Des Moines Creek watersheds, these could have included Northern water shrew, beaver, Richardson's vole, muskrat, mink, and river otter. Miller, Walker, and Des Moines Creeks and several associated wetlands provide potential habitat for beaver and muskrat.

5.3.3 Large Mammals

Prior to settlement, large mammals expected to occur in the area would have included coyote, red fox, mountain lion, bobcat, elk, mule deer, and black bear. By 1936, given the extent of agriculture in the area, the extent of deforestation, distance from the foothills of the Cascades, and past and on-going hunting pressure, mountain lion, elk, and black bear could have been extirpated from the area. In the present condition, these species would not be expected to occur in the watersheds, and habitat for other species would be much reduced. Only coyote and red fox would be expected to occur in the less-developed urban habitats.

5.3.4 Birds

Bird life in the Miller and Des Moines Creek watersheds is expected to be diverse (Table 33), and to reflect the variety of wetland, upland, and shoreline habitats present. Because of their mobility, even in highly urbanized or fragmented watersheds, the habitat areas available to bird populations using the watershed also extends beyond watershed boundaries.

Bird use of urban Puget Sound environments (including wetlands) is documented by Gavareski (1976), King County (1987), Milligan (1985), Norman (1998), Penland (1984), and Richter and Azous (2001). Many migratory (and resident) birds disperse widely and use urban habitat for

Table 33. Bird species reported near Seattle-Tacoma International Airport (FAA 1996), in wildlife surveys at Dumas Bay (Norman 1998), and in the Kent Christmas Bird Count area (Audubon Society 2001).

Common Name	STIA MPU* EIS	Dumas Bay	Christmas Bird Count
Red-throated loon	No	Yes	Yes
Pacific loon	No	Yes	Yes
Common loon	No	Yes	Yes
Pied-billed grebe	Yes	Yes	Yes
Horned grebe	No	Yes	Yes
Red-necked grebe	No	Yes	Yes
Eared grebe	No	Yes	Yes
Western grebe	No	Yes	Yes
Double-crested cormorant	No	Yes	Yes
Brandt's cormorant	No	Yes	Yes
Pelagic cormorant	No	Yes	Yes
American bittern	No	No	No
Great blue heron	Yes	Yes	Yes
Green heron	No	Yes	Yes
Trumpeter swan	No	No	Yes
Great white-fronted goose	No	No	Yes
Snow goose	No	Yes	Yes
Black brant	No	Yes	Yes
Canada goose	Yes	Yes	Yes
Wood duck	Yes	No	Yes
Green-winged teal	Yes	Yes	Yes
Mallard	Yes	Yes	Yes
Northern pintail	No	Yes	Yes
Cinnamon teal	No	Yes	Yes
Northern shoveler	No	Yes	Yes
Gadwall	Yes	Yes	Yes
Eurasian wigeon	No	Yes	Yes
American wigeon	Yes	Yes	Yes
Canvasback	No	Yes	Yes
Redhead	No	No	Yes
Ring-necked duck	No	No	Yes
Greater scaup	No	Yes	Yes
Lesser scaup	No	Yes	Yes
Harlequin duck	No	No	Yes
Black scoter	No	Yes	Yes
Surf scoter	No	Yes	Yes
White-winged scoter	No	Yes	Yes
Common goldeneye	No	Yes	Yes

Table 33. Bird species reported near Seattle-Tacoma International Airport (FAA 1996), in wildlife surveys at Dumas Bay (Norman 1998), and in the Kent Christmas Bird Count area (Audubon Society 2001) (continued).

Common Name	STIA MPU* EIS	Dumas Bay	Christmas Bird Count
Barrow's goldeneye	Yes	Yes	Yes
Bufflehead	No	Yes	Yes
Hooded merganser	No	Yes	Yes
Common merganser	Yes	Yes	Yes
Red-breasted merganser	No	Yes	Yes
Ruddy duck	No	Yes	Yes
Osprey	No	Yes	Yes
Bald eagle	Yes	Yes	Yes
Northern harrier	Yes	No	Yes
Sharp-shinned hawk	Yes	Yes	Yes
Cooper's hawk	Yes	Yes	Yes
Northern goshawk	No	No	Yes
Red-tailed hawk	Yes	Yes	Yes
Rough-legged hawk	No	Yes	Yes
Swainson's hawk	No[a]	No	No
American kestrel	No	Historic	Yes
Merlin	No	Yes	Yes
Peregrine falcon	No	Yes	Yes
Ring-necked pheasant	No	Historic	Yes
Ruffed grouse	No	Historic	Yes
California quail	No	Yes	Yes
Virginia rail	No	Historic	Yes
Sora	No	Historic	Yes
American coot	No	Yes	Yes
Black-bellied plover	No	Yes	Yes
Semipalmated plover	No	Yes	No
Killdeer	Yes	Yes	Yes
Greater yellowlegs	No	Yes	Yes
Lesser yellowlegs	No	No (Expected)	No
Spotted sandpiper	No	Yes	Yes
Black turnstone	No	No (Expected)	Yes
Western sandpiper	No	Yes	Yes
Least sandpiper	No	Yes	Yes
Dunlin	No	Yes	Yes
Sanderling	No	Yes	No
Long-billed dowitcher	No	No (Expected)	Yes
Short-billed dowitcher	No	Yes	No
Common snipe	No	Yes	Yes
Whimbrel	No	No	No

Table 33. Bird species reported near Seattle-Tacoma International Airport (FAA 1996), in wildlife surveys at Dumas Bay (Norman 1998), and in the Kent Christmas Bird Count area (Audubon Society 2001) (continued).

Common Name	STIA MPU* EIS	Dumas Bay	Christmas Bird Count
Parasitic jaegar	No	Yes	No
Mew gull	No	Yes	Yes
Ring-billed gull	No	Yes	Yes
California gull	No	Yes	Yes
Herring gull	No	Yes	Yes
Thayer's gull	No	Yes	Yes
Western gull	No	Yes	Yes
Glaucous-winged gull	Yes	Yes	Yes
Glaucous x western gull	No	Yes	Yes
Gull sp.	No	Yes	Yes
Heerman's gull	No	Yes	Yes
Caspian tern	No	Yes	No
Common tern	No	Yes	No
Common murre	No	Yes	Yes
Pigeon guillemot	No	Yes	Yes
Marbled murrelet	No	Yes	Yes
Rhinoceros auklet	No	Yes	Yes
Band-tailed pigeon	Yes	Yes	Yes
Rock dove	Yes	Yes	Yes
Mourning dove	No	Historic	Yes
Common barn-owl	No	Yes	Yes
Western screech-owl	No	Yes	Yes
Great horned owl	Yes	Yes	Yes
Northern pygmy-owl	No	No	Yes
Snowy owl	No[a]	No	No
Short-eared owl	No	No	Yes
Northern saw-whet owl	No	Yes	Yes
Anna's hummingbird	No	Yes	Yes
Rufous hummingbird	No	Yes	No
Black swift	No[a]	No	No
Common nighthawk	No[a]	No	No
Belted kingfisher	Yes	Yes	Yes
Downy woodpecker	Yes	Yes	Yes
Hairy woodpecker	Yes	Yes	Yes
Northern flicker	Yes	Yes	Yes
Pileated woodpecker	Yes	Yes	Yes
Red-breasted sapsucker	No	Yes	Yes
Willow flycatcher	No	Yes	No
Pacific-slope flycatcher	No	Yes	No

Table 33. Bird species reported near Seattle-Tacoma International Airport (FAA 1996), in wildlife surveys at Dumas Bay (Norman 1998), and in the Kent Christmas Bird Count area (Audubon Society 2001) (continued).

Common Name	STIA MPU* EIS	Dumas Bay	Christmas Bird Count
Olive-sided flycatcher	Yes	Yes	No
Tree swallow	Yes	Yes	No
Violet-green swallow	No	Yes	No
Purple martin	No	Yes	No
Northern rough-winged swallow	No	Yes	No
Barn swallow	Yes	Yes	No
Cliff swallow	No	Yes	No
Bank swallow	No[a]	No	No
Horned lark	No[a]	No	No
Steller's jay	Yes	Yes	Yes
Common raven	No	Yes	Yes
Black-capped chickadee	Yes	Yes	Yes
Mountain chickadee	No	Yes	Yes
Chestnut-backed chickadee	No	Yes	Yes
Bushtit	Yes	Yes	Yes
Red-breasted nuthatch	Yes	Yes	Yes
White-breasted nuthatch	No	Historic	No
Brown creeper	Yes	Yes	Yes
Bewick's wren	Yes	Yes	Yes
Winter wren	Yes	Yes	Yes
Marsh wren	No	Yes	Yes
American dipper	No	Yes	Yes
Golden-crowned kinglet	No	Yes	Yes
Ruby-crowned kinglet	No	Yes	Yes
Hermit thrush	No	Yes	Yes
American robin	Yes	Yes	Yes
Varied thrush	No	Yes	Yes
Swainson's thrush	No	Yes	No
Townsend's solitaire	No	Yes	No
American pipit	No	Yes	Yes
Cedar waxwing	No	Yes	Yes
Northern shrike	No	Yes	Yes
European starling	Yes	Yes	Yes
Western warbling-vireo	No	Yes	No
Solitary vireo	No	Historic	No
Hutton's vireo	No	Yes	Yes
Orange-crowned warbler	Yes	Yes	Yes
Nashville warbler	No	Yes	No
Yellow warbler	Yes	Yes	No

Table 33. Bird species reported near Seattle-Tacoma International Airport (FAA 1996), in wildlife surveys at Dumas Bay (Norman 1998), and in the Kent Christmas Bird Count area (Audubon Society 2001) (continued).

Common Name	STIA MPU* EIS	Dumas Bay	Christmas Bird Count
Black-throated gray warbler	No	Yes	No
Common yellowthroat	No	Yes	Yes
Townsend's warbler	No	Yes	Yes
Audubon's warbler	No	Yes	Yes
MacGillivray's warbler	No	Yes	No
Wilson's warbler	No	Yes	No
Black-headed grosbeak	No	Yes	No
Western tanager	No	Yes	No
Rufous-sided towhee	Yes	Yes	Yes
Rustic bunting	No	No	Yes
Vesper sparrow	No	No	Yes
American tree sparrow	No	No	Yes
Savannah sparrow	No	Historic	Yes
Fox sparrow	No	Yes	Yes
Song sparrow	Yes	Yes	Yes
Lincoln's sparrow	No	No (Expected)	Yes
Swamp sparrow	No	No	Yes
White-throated sparrow	No	No	Yes
Golden-crowned sparrow	No	Yes	Yes
White-crowned sparrow	Yes	Yes	Yes
Harris' sparrow	No	No	Yes
Dark eyed junco	Yes	Yes	Yes
Red-winged blackbird	No	Yes	Yes
Western meadowlark	No	No	Yes
Brewer's blackbird	No	No	Yes
Brown-headed cowbird	No	Yes	Yes
Purple finch	No	Yes	Yes
House finch	No	Yes	Yes
Red crossbill	No	Yes	Yes
Pine siskin	No	Yes	Yes
American goldfinch	Yes	Yes	Yes
Evening grosbeak	No	Yes	Yes
House sparrow	Yes	Yes	Yes

[a] This species has been reported as salvaged on the STIA airfield.

* MPU = Master Plan Update.

breeding, foraging, and as migration corridors. The large amounts of marginal urban habitat suitable for use by migrating birds will remain following Master Plan Update project development. Since urban habitats similar to those being eliminated are common in Puget Sound and the STIA vicinity, significant impacts on the regional populations of birds are unlikely. The area of habitat available to bird life near STIA includes, *at a minimum*, that habitat occurring within the Miller and Des Moines Creek watersheds, as well as nearby areas such as the adjacent Puget Sound subwatersheds of WRIA 9 (Table 34).

Table 34. Current land uses in the WRIA 9 Puget Sound sub-watersheds.

Land Cover Description	Area (MI^2)	Area (Acres)	% Watershed
Industrial & Commercial	5.97	3818.13	6.29
Bare Rock/Concrete	0.24	156.41	0.26
City Center, Industrial	3.21	2054.80	3.38
Recently Cleared	0.33	208.52	0.34
High-Density Residential	19.52	12493.81	20.57
Subtotal	*29.27*	*18731.67*	*30.84*
Low/Medium Density Residential	**11.18**	**7,154.25**	**11.78**
Conifer - Early	**0.05**	**32.05**	**0.05**
Conifer - Mature	**0.00**	**0.00**	**0.00**
Conifer - Middle	**0.02**	**15.30**	**0.03**
Deciduous Forest	**3.77**	**2412.09**	**3.97**
Mixed Forest	**1.28**	**817.56**	**1.35**
Shrub	**0.45**	**285.07**	**0.47**
Grass - Brown	**1.20**	**765.24**	**1.26**
Grass - Green	**0.48**	**307.03**	**0.51**
Open Water	**0.34**	**215.56**	**0.35**
Subtotal	*18.77*	*12,004.15*	*19.77*
TOTAL	48.025	30,735.82	100

Note: Land uses listed in bold are land uses that are considered to provide low (residential and grass) to moderate or high (remaining types) habitat value to wildlife.

Detailed information regarding bird species of concern (Norman 2001) that use upland habitats are discussed below and in FAA (1997). All species would be expected to use the wetland, upland, and riparian habitat protected in both the on- and off-site mitigation areas.

- **Band-tailed pigeon.** Although the band-tailed pigeon is in decline, the main threat to the species appears to be habitat loss and direct human-caused mortality in Central America (Audubon Society 2001). In urban parks and gardens in western Washington, the species is actually becoming more common (Audubon Society 2001). Consequently, loss of habitat due to the proposed action is not expected to significantly affect the species populations.

- **Belted kingfisher.** Belted kingfishers use wetland habitats with open water components. Wetlands that will be impacted by the Master Plan Update improvements do not provide suitable kingfisher habitat. Mitigation at Lora Lake and in Auburn could improve habitat for this species.
- **Pileated woodpecker.** As stated in Appendix M of the FEIS (FAA 1996), pileated woodpeckers have been observed in the approximately 187-acre deciduous forest in the central portion of the south borrow areas. Under the proposed action, some of this forested area would be removed. Loss of this acreage will not have a significant effect on pileated woodpeckers regionally, as large tracts of their preferred habitat, mature coniferous forests, will be unaffected.
- **Barn swallow, tree swallow, cliff swallow, willow flycatcher, black-capped chickadee, bushtit, orange-crowned warbler, song sparrow, white-crowned sparrow, black-headed grosbeak, Wilson's warbler, American goldfinch.** These species are all common in suburban environments. Abundant habitat outside of the project area will remain for these species following construction of Master Plan Update projects, because the birds are widely distributed in urban and non-urban areas throughout Puget Sound.
- **Swainson's thrush.** This species occurs in coniferous and mixed forests with dense undergrowth. The majority of the acreage impacted by the proposed action does not contain adequate cover to provide habitat for the species. Habitat in the project area that will be impacted contains marginal nesting habitat for this species, and these areas are most likely used for foraging habitat during migration. Remaining habitat in nearby areas outside of the project area will provide foraging habitat. Suitable Swainson's thrush nesting habitat in the low-elevation coniferous forests of western Washington will be unaffected.
- **Hutton's vireo.** This species is a resident of mixed forests with evergreens and oaks, with moderate to dense canopy cover (Davis 1995). Most of the habitat impacted by the Master Plan Update projects does not contain adequate canopy cover to provide habitat for the species. Because only a small amount of marginal Hutton's vireo habitat will be impacted by the proposed action, the project will not have a significant affect on the species.
- **Sharp-shinned hawk and Cooper's hawk.** Loss of forest represents loss of habitat for these species. However, forest types impacted under the proposed action (i.e., young, deciduous forest) are relatively common in the Puget Sound region, and adequate habitat outside the project area will remain for these species.
- **Northern harrier, American kestrel, and western meadowlark.** Harriers, kestrels, and meadowlarks prefer open habitats. Approximately two-thirds of the existing unmanaged grassland habitat will remain upon completion of the proposed action. Although some existing managed grassland will be impacted, the total acreage of managed grasslands will increase overall (due to creation of new managed grassland areas).
- **Common nighthawk.** This species nests in open areas and forages in a wide variety of habitats (Csuti et al. 1997). By increasing the amount of open habitat, the project will increase the amount of nighthawk nesting habitat. Some loss of foraging habitat will occur where areas are paved and similarly developed. However, given the wide variety of foraging habitat that this species will use, foraging habitat is not expected to be a limiting factor for this species, and other habitat in surrounding areas will remain as foraging areas.

- **Vaux's swift.** This species uses a wide variety of habitats where suitable cavities (i.e., dead trees, chimneys) are available (Smith et al. 1997). Removal of trees and abandoned houses (with chimneys) will reduce available cavities for this species, although remaining trees within and near the project site will continue to provide cavities for the species.
- **Streaked horned lark.** This species has been extirpated from most of the Puget Trough, and no breeding records for the species are present in the project vicinity (Smith et al. 1997). Use of the project area is likely limited to occasional fly-overs and stop-overs during migration.

Richter and Azous (2001) report on bird use in a variety of urban, suburban, and rural wetlands in King County, Washington. They report 90 species of birds as occurring in the wetlands. With the exception of water birds, the avifauna was generally found to be an extension of the adjacent upland fauna.

The potential for wetland fill to impact birds is most significant for those species with narrow habitat requirements, particularly for those species restricted to wetland habitat types. Using the versatility rating[9], the potential for the Master Plan Update projects to impact birds adapted to specialized wetland habitats was considered. Species with versatility ratings of less than 15 are listed in Table 35. Also listed are the potential habitats for these species in wetlands located near STIA, and for the mitigation site in Auburn. While fill of several wetlands will impact habitat used by several species of these birds, replacement habitat will be constructed in Auburn. With the exception of waterfowl, on-site wetland mitigation would also provide habitat suitable for use by most species.

---

[9] Versatility rating is an indicator of the sensitivity of wildlife species to habitat loss or change. The rating is based on the sum of primary and secondary habitats that a species uses for feeding or breeding. Species with versatility ratings of 15 or less are considered to have low versatility rating, ratings between 16 and 28 are moderate, and ratings greater than 29 are high.

Table 35. Potential use of wetlands near Seattle-Tacoma International Airport by bird species with low habitat versatility ratings[a].

Bird Species[b]	Versatility Rating	Potential Habitat in STIA Wetlands[c]	Habitat in Auburn
Marsh wren	8	**A1[d], 28, 43**	Emergent
Common yellowthroat	8	**A1, 28, 43**	Emergent
Red-winged blackbird	11	**A1, 28, 43**	Emergent
Great blue heron	14	**A1, 28, 43, 18, and 37**	Emergent/Open Water
Mallard	10	**A1, 28, 43, 18, and 37, Farmed Wetlands**	Emergent Open Water
Belted kingfisher	–	**A1, 28, 43, 18, and 37**	Open Water
Virginia rail	10	**A1, 28, 43**	Emergent
Pied-billed grebe	–	**Lora Lake, 28**	Open Water
House sparrow	–	**Various**	Not Present
Killdeer	4	**Farmed Wetlands**	Emergent
Gadwall	10	A1, 28, 43	Open Water
Canada geese	8	**A1, 28, 43, Farmed Wetlands**	Emergent/Open Water
Hooded merganser	12	Not present	Open Water
Green heron	6	43	Emergent
Sora	10	43	Emergent
Glaucous-winged gull	–	A1, 28	Open Water
Red-eyed vireo	10	**18, 37, 28, 43, 44**	Forested/Shrub/Buffer
Blue-winged teal	10	A1, 28, 43	Open Water
Caspian tern	–	Not Present	Not Present
American coot	10	A1, 28	Open Water

[a] Versatility ratings refer to the sum of the number of plant communities or stand conditions used for breeding and feeding by a species (Brown 1985). A low versatility rating (less than 15) indicates a more specialized species that may require special habitat or management actions to maintain it in an area. Other species found in King County wetlands are adapted to a wide variety of wetland and non-wetland habitats. A " – " means the species was not assigned a rating by Brown (1985).

[b] Species listed are those species with low versatility ratings (Brown 1985) that occur in one or more of 19 wetlands studied in King County (Richter and Azous 2001). Wetlands in this study averaged 10.29 acres in size and were located in urban, suburban, and rural land use areas.

[c] **Bold lettering** indicates that project impacts to specific areas of suitable habitat for these species may occur through construction of Master Plan Update improvements or mitigation.

[d] Impacts to emergent habitat in Wetland A1 occur from project fill, stream relocation, and mitigation.

6. SUMMARY

This analysis has documented changes to land use, wetlands, streams, and wildlife habitats in the Miller and Des Moines Creek watersheds for the purpose of determining cumulative effects. The findings are summarized in Table 36.

While large changes in land use have occurred in the watersheds that have impacted streams, wetlands, and wildlife habitat, it appears that the most substantial changes have occurred prior to airport development. These changes included clearing old-growth forest and development of agriculture lands at the time of settlement (late 1800s and early 1900s). More recently, the development of forest and agricultural lands for residential, commercial, and transportation (roads and airport uses) facilities has continued to impact stream, wetland, and wildlife habitats in the watersheds. Most of this development occurred without environmental mitigation and has contributed to cumulative losses of wetland, stream, and habitat resources.

The development of STIA has contributed to wetland, stream, and habitat impacts at levels that appear proportionate to other development that has occurred in the watershed. While the large footprint associated with the development of airport facilities (primarily between 1946 and 1972) resulted in wetland loss and stream modifications, such losses were also common to many of the private- and public-sector development projects that occurred prior to the establishment of environmental regulations. The need for large buffers as part of noise remedy programs near STIA has resulted in purchase of wetlands associated with agricultural and residential land uses by the Port. The removal of these land uses has resulted in the revegetation and preservation of several wetland areas.

The historical impacts to wetlands, streams, and wildlife habitat are typical for urban areas in King County (Azous and Horner 2001). Clearing of forestland to accommodate agricultural uses has occurred throughout the Puget Sound region. As has occurred in the Miller, Walker, and Des Moines Creek watersheds, the development of agriculture in the region routinely included the modification of wetlands, soil drainage, and stream channel conditions to improve land for crop production. Conversion of forest and agricultural lands to urban uses has occurred throughout the Seattle-Tacoma metropolitan areas. These conversions have included wetland filling, stream channel modification, watershed hydrology modification, and wildlife habitat loss. In the Miller, Walker, and Des Moines Creek watersheds, these impacts have been similar to other localities. The impacts in these watersheds have been less severe than in many areas (i.e., wetland and tideland filling at the mouths of the Puyallup, Duwamish, and Snohomish Rivers, or wetland fill and stream channelization for commercial development in the lower Green River Valley).

Current and future development (including the STIA Master Plan Update actions) must comply with a variety of environmental regulations affecting wetlands, streams, and habitat. These regulations and substantial mitigation requirements reduce the potential that additional cumulative impacts would occur. For the Master Plan Update projects, wetland, stream, and hydrologic mitigation improves wetland and stream functions by enhancing wetlands and streams, and by retrofitting previous development lacking stormwater quality and quantity controls to meet current standards.

Table 36. Cumulative effects analysis of wetlands, streams, and other aquatic resources in the Des Moines, Miller, and Walker Creek basins.

Resource	Past Actions	Proposed Action[a]			Other
		Construction	Operation	Mitigation	Present and Future Actions[b]
Wetland Area	Losses have occurred as a result of farming, commercial, residential, and airport development.	Loss of 18.37 acres would occur.	None.	Designation of over 134 acres of mitigation (67 acres on-site and over 65 acres in Auburn).	No net loss. Federal state and local regulations are increasingly protective of wetlands. Section 404 Nationwide Permits (NWPs) and Individual Permits require mitigation, typically exceeding area impacts.
Biological Wetland Functions	Losses to biological functions have occurred. In addition to filling and draining wetlands, past development and land uses have reduced the natural vegetation in and near wetlands and affected wildlife habitats. Development has affected the rates and quality of runoff, which has impacted aquatic habitat in some wetlands.	Construction will eliminate the biological functions of 18.37 acres of wetland. Without mitigation, wetland loss and buffer impacts would cause losses of biotic functions.	Without mitigation, operation impacts to wetland habitat could include habitat disturbance, wildlife management activities, and runoff impacts.	No net loss. Wetland restoration and enhancement coupled with buffer protection and enhancement will increase in-basin biotic function and connectivity of remaining wetlands. Out-of -basin mitigation creates 65 acres of high quality wetland and buffer habitats. Long-term protection and preservation of greater amounts of higher-quality wetlands balance temporal losses of habitat.	No net loss. Federal state and local regulations are increasingly protective of wetlands. Section 404 NWPs and Individual Permits require mitigation, typically exceeding area impacts. Mitigation planning increasingly focuses on replacing and enhancing functions, and local regulations protect wetland buffers.
Physical Wetland Functions	Filling of wetlands has eliminated the flood storage, water quality, and groundwater exchange functions they provide from several areas. Past development and land uses have reduced the vegetation in and near remaining wetlands, which	Construction will eliminate the physical functions of 18.37 acres of wetland. Without mitigation, wetland loss and buffer impacts would cause losses of physical functions.	Without mitigation, operation impacts to physical wetlands functions could include decreased water quality, groundwater exchange, and stormwater storage functions.	No net loss. Wetland restoration and enhancement coupled with buffer protection and enhancement will increase in-basin biotic function and connectivity of remaining wetlands. Out-of-basin mitigation creates 65 acres of high-quality	No net loss. See above.

Table 36. Cumulative effects analysis of wetlands, streams, and other aquatic resources in the Des Moines, Miller, and Walker Creek basins (continued).

Resource	Past Actions	Proposed Action[a]			Other
		Construction	Operation	Mitigation	Present and Future Actions[b]
	may reduce water quality and other functions they provide.			wetland and buffer habitats. Long-term protection and preservation of greater amounts of higher-quality wetlands balance temporal losses of habitat.	
Instream Habitat	Impacts to instream habitat have occurred from forestry, farming, and urban development. These activities have eliminated high quality in-stream habitats.	Fill of a portion of the Miller Creek stream channel would occur. Without mitigation, the loss of degraded habitat would occur.	Without mitigation, increased runoff could further degrade instream habitat.	Beneficial. Relocation and enhancement of Miller Creek, instream habitat projects, buffer enhancement, and wetland restoration improve instream habitat.	Beneficial. Sensitive areas regulations protecting streams and buffers, coupled with restoration and enhancement projects, including the planned Des Moines Creek regional detention facility, should improve habitat conditions for fish and aquatic life.
Stream Hydrology - Low Flow	Impacts to stream hydrology have occurred from forestry, farming, and urban development. Land clearing from forestry and farming activities could have increased recharge and low flows. Urban development and pavement would have decreased groundwater recharge and reduced low flows.	Construction of new impervious surfaces, without mitigation, would reduce groundwater recharge and reduce low flow.	None.	Maintain. Low flow conditions are maintained by infiltration and stormwater storage.	Degrade. Current municipal stormwater regulations do not address low flow impacts, nor require mitigation. For projects undergoing state or federal permitting, low flow mitigation may be required.
Stream Hydrology - Peak Flow	Impacts to stream hydrology have occurred from forestry, farming, and urban development. Land clearing from forestry and farming activities would have	Constructions of new impervious surface, without mitigation, would increase peak flows and degrade aquatic habitat.	None.	Beneficial. Stormwater detention facilities for new and past development will mitigate peak runoff rates and retrofit for past development.	Beneficial. Stormwater detention facilities for new and past development will mitigate peak runoff rates. Some projects (i.e. transportation projects funded

Table 36. Cumulative effects analysis of wetlands, streams, and other aquatic resources in the Des Moines, Miller, and Walker Creek basins (continued).

Resource	Past Actions	Proposed Action[a]			Other
		Construction	Operation	Mitigation	Present and Future Actions[b]
	increased runoff rates and peak flows. Urban development and pavement constructed without stormwater management facilities would have increased peak flows significantly.				by Washington State Department of Transportation [WSDOT]) may provide detention facilities for past development. The Des Moines Creek regional detention facility should improve Des Moines Creek peak flows above the baseline level.
Floodplains	Land development and loss of flood storage has occurred in some floodplains.	Fill of floodplain and loss of flood storage would occur.	None.	Maintain. Floodplain fill will be balanced by floodplain mitigation.	Maintain. Local regulations adequately protect floodplain areas.
Water Quality	Impacts to water quality have resulted from past forestry, farming, and urban development in the watersheds. Land clearing from forestry and farming activities would have increased sediment runoff rates. Runoff from fertilizers and agricultural chemicals would have degraded water quality. Urban development has resulted in untreated stormwater runoff, which degrades water quality.	Without mitigation, sediment runoff could degrade water quality.	Without mitigation, new impervious surface could generate contaminated runoff and degrade water quality.	Maintain. New stormwater quality best management practices (BMPs) will treat runoff from new and existing impervious surfaces.	Maintain. Stormwater treatment facilities for new development will prevent significant degradation of water quality. Some projects (i.e., WSDOT-funded transportation projects) may provide treatment facilities for past development.

[a] Effects of the proposed actions on wetlands and streams are discussed in the *Natural Resources Mitigation Plan* (Parametrix 2001b), the *Wetland Impact and Functional Analysis Report* (Parametrix 2001a), the *Biological Assessment* (Parametrix 2000b), the *FEIS* (FAA 1996), the *FSEIS* (FAA 1997), and the *Comprehensive Stormwater Management Plan* (Parametrix 2000a).

[b] Evaluated with mitigation that would be required to meet federal, state, and local regulations.

AR 050866

7. REFERENCES

Ames, J. 1970. Miller Creek: present status and potential for salmon production. Washington Department of Fisheries, report to file. Olympia, Washington.

ACOE (U.S. Army Corps of Engineers). 2001. Request for information: Natural Resources Mitigation Plan (issued to Port of Seattle, March 22, 2001)

Audubon Society. 2001. Christmas bird count data for Kent, Washington. Available at: http://birdsource.tc.cornell.edu/CBCOutput/review.html?speciesByState=false&yr=101&circle=S724562.

Azous, A. and R. Horner. 2001. Wetlands and urbanization: implications for the future. Lewis Publishers, New York, New York.

Batcho, A. 1999. Personal communication of October 1999. Trout Unlimited.

Brown, E.R. 1985. Management of wildlife and fish habitats in forests of western Oregon and Washington, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. Portland, Oregon.

Council on Environmental Quality. 1997. Considering cumulative effects under the National Environmental Policy Act. Washington D.C.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service, U.S. Department of Interior. Washington, D.C.

Csuti, B., A.J. Kimerling, T.A. O'Neil, M.M. Shaughnessy, E.P. Gaines, and M.M.P. Huso. 1997. Atlas of Oregon wildlife: distribution, habitat, and natural history. Oregon State University Press, Corvallis, Oregon.

Davis, J.N. 1995. Hutton's vireo. *In* A. Poole and F. Gill, eds., Birds of North America, No. 189:1-20. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

Des Moines Creek Basin Committee. 1997. Des Moines Creek basin plan. Des Moines Creek Basin Committee (City of SeaTac, City of Des Moines, Port of Seattle, and King County Surface Water Management). Seattle, Washington.

Draper, M. 1975. Timber, tides and tales: a history of the Des Moines area. Des Moines, Washington, privately published by the author.

Ecology (Washington State Department of Ecology). 1998a. The Washington State 1998 Clean Water Act Section 303(d) candidate list submitted to EPA. Washington Department of Ecology, Olympia, Washington.

AR 050867

Ecology (Washington State Department of Ecology). 1998b. Permit handbook: commonly required environmental permits for Washington State. Pub No. 90-29. Washington Department of Ecology, Olympia, Washington.

Ecology (Washington State Department of Ecology). 1999. The relationship between stream macroinvertebrates and salmon in the Quilceda/Allen drainages. Washington Department of Ecology, Olympia Washington. Publication Number 99-311.

Eyler, M. and E. Yeager. 1972. The many roads to Highline. Published by the Highline Publishing Company, Seattle, Washington.

FAA (Federal Aviation Administration). 1996. Final environmental impact statement for proposed Master Plan Update development actions at Seattle-Tacoma International Airport. Prepared for the Port of Seattle, SeaTac, Washington.

FAA (Federal Aviation Administration). 1997. Final supplemental environmental impact statement for the proposed master plan update at Seattle Tacoma International Airport. Port of Seattle. Seattle, Washington.

Fore, L.S., J.R. Karr, and R. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. Journal of the North American Benthological Society 15(2):212-231.

Gavareski, C. 1976. Relation of park size and vegetation to urban bird populations in Seattle, Washington. *In:* The Condor 78:375-382.

Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996. Watershed determinants of ecosystem functioning. Proceedings of an Engineering Foundation Conference. American Society of Civil Engineers, Snowbird, Utah.

Hillman, T.W., J.R. Stevenson, and D.J. Snyder. 1999. Assessment of spawning and habitat in three Puget Sound streams, Washington. Report to Airport Communities Coalition. BioAnalysts, Inc. 33 pp.

Johnson, D. and T. O'Neil. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

KCSWM (King County Surface Water Management). 1987. Basin reconnaissance program summary. Reconnaissance Report No. 12, Miller Creek basin. Natural Resources and Parks Division and Surface Water Management Division, King County, Washington.

Kennedy, R.T. and G.F. Schmidt, eds. 1989. One hundred years of the "Waterland" community: a history of Des Moines, Washington. Published by the City of Des Moines, Washington.

King County. 1987. Wildlife habitat profile. King County Open Space Program, King County, Washington.

King County and the Washington State Conservation Commission. 2000. Habitat limiting factors and reconnaissance assessment report: Green/Duwamish and Central Puget Sound Watersheds (Water Resource Inventory Area 9 and Vashon Island). King County, Washington.

King County Building and Land Development Division. 1991. Stream survey report criteria, Department of Parks, Planning and Resources, Bellevue, Washington.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound lowland streams, Washington, USA. M.S. Thesis, University of Washington. Seattle, Washington.

Lillesand, T. and R. Kiefer. 1979. Remote sensing and image interpretation. John Wiley & Sons, New York, New York.

Luchessa, S. 1995. Stream survey report for Miller Creek. Appendix F *in*: Natural resource mitigation plan for the proposed Master Plan Update improvements at Seattle-Tacoma International Airport. Seattle, Washington.

May, C. 1996. Assessment of cumulative effects of urbanization on small streams in the Puget Sound lowland ecoregion. Dissertation, University of Washington, Seattle, Washington.

May, C.W., E.B. White, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Sound lowland streams. Water Resources Series Technical Report No. 154. Department of Ecology, Olympia, Washington. Publication Number 98-04.

Milligan, D. 1985. The ecology of avian use of urban freshwater wetlands in King County, Washington. University of Washington, Seattle, Washington.

National Transportation Research Board. 1998. Guidance for estimating the indirect effects of proposed transportation projects. Report 403. National Academy Press, Washington, D.C.

NRCS (Natural Resources Conservation Service). 2000. Hydric soils list, King County area, Washington: Detailed soil map legend. Available at: http://www.wa.nrcs.usda.gov/FOTG/SECTION2/hydric_lists/wa633hyd.doc. Updated November 13, 2000.

Norman, D. 1998. Report to Greg Fewins, City of Federal Way, Department of Community Development: 1997 Dumas Bay Centre monitoring and final recommendations. Norman Wildlife Consulting, Shoreline, Washington.

Norman, D. 2001. Comment letter to Jonathan Freedman (U.S. Army Corps of Engineers) and Ann Kenny (Washington State Department of Ecology) regarding Reference # 1996-4-02325 Port of Seattle 404/401 Application to Construct Third Runway at Seattle-Tacoma International Airport. Dated February 16, 2001.

Parametrix. 1997. Channel survey of Des Moines Creek, Northwest Ponds to S. 200th St., Parametrix, Inc., Kirkland, Washington.

Parametrix. 2000a. Comprehensive stormwater management plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix. 2000b. Biological assessment for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix. 2000c. Wetland delineation report for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix. 2001a. Wetland functional assessment and impact analysis for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix. 2001b. Final natural resources mitigation plan, Master Plan Update improvements, Seattle-Tacoma International Airport. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Penland, S. 1984. Avian responses to a gradient of urbanization in Seattle, Washington. University of Washington, Seattle, Washington.

Port of Seattle. 2000. Joint Aquatic Resource Permit Application (JARPA) for Corps of Engineers Projects. No. 96-4-023 25. Seattle, Washington.

Raedeke, K. 1988. Forest management and wildlife in the Pacific Northwest. *In:* The Northwest Environmental Journal, 4:263-278. University of Washington, Seattle, Washington.

Resource Planning Associates, Aquatic Resource Consultants, and Caldwell Associates. 1994. A fish habitat survey of Des Moines Creek. Report prepared for the Port of Seattle. Seattle, Washington.

Richter, R. and A. Azous. 2001. Bird communities in relation to watershed development. *In:* A. Azous and R. Horner. 2001. Wetlands and urbanization: Implications for the future. Lewis Publishers, New York, New York.

Rigg, G.B. 1958. Peat resources of Washington. Prepared for the State of Washington, Department of Conservation Division of Mines and Geology. Olympia, Washington.

Shapiro and Associates, Inc. 1994. Sea-Tac Airport vicinity land use inventory project. Prepared for Port of Seattle Aviation Planning Division. Seattle, Washington.

Smith, M.R., P.W. Mattocks, Jr., and K.M. Cassidy. 1997. Breeding birds of Washington State. Volume 4 *in* K.M. Cassidy, C.E. Grue, M.R. Smith and K.M. Dvornich, eds. Washington State Gap Analysis – Final Report. Seattle Audubon Society Publications in Zoology No. 1, Seattle.

Trout Unlimited. 1993. 1993 Trout Unlimited Miller Creek stream survey results. Reported as Appendix A *in* Lucchessa, S. 1995. Sea-Tac Airport Master Plan Update Final EIS. Stream Survey Report for Miller Creek. Shapiro and Associates, Inc., 1201 Third Avenue, Suite 1700, Seattle, Washington 98101.

USDA (U.S. Department of Agriculture). 1952. Soil survey, King County, Washington. Series 38, No. 31. In cooperation with the Washington Agricultural Experiment Station and the Washington State Planning Council.

USDA SCS (U.S. Department of Agriculture Soil Conservation Service). 1973. Soil survey, King County area, Washington. In cooperation with Washington Agricultural Experimental Station. United States Government Printing Office, Washington, D.C. 100 pp.

USFWS (U.S. Fish and Wildlife Service). 1987. National wetlands inventory. Des Moines, Washington.

U.S. Geological Survey. 1900. Tacoma, Washington. 1:125,000 scale topographic map.

U.S. Geological Survey. 1949. Des Moines, Washington 1:24,000 scale topographic map.

U.S. Geological Survey. 1983. Burien, Washington 1:25,000 scale topographic-bathymetric map. Denver, Colorado.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1, Puget Sound region. Washington Department of Fisheries, Olympia, Washington.

APPENDIX A

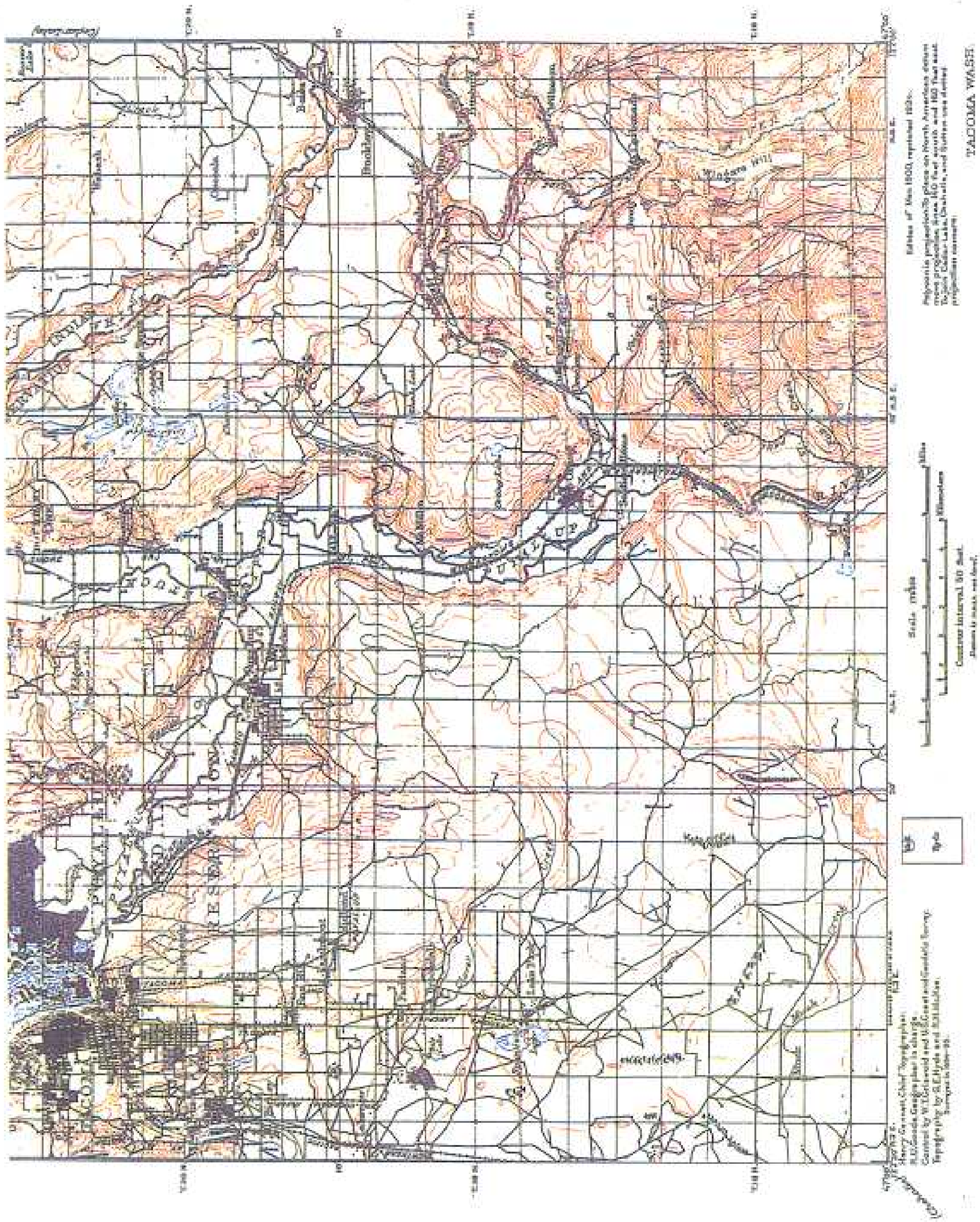
KING COUNTY SOIL SURVEY - 1952

Soil classification map key.

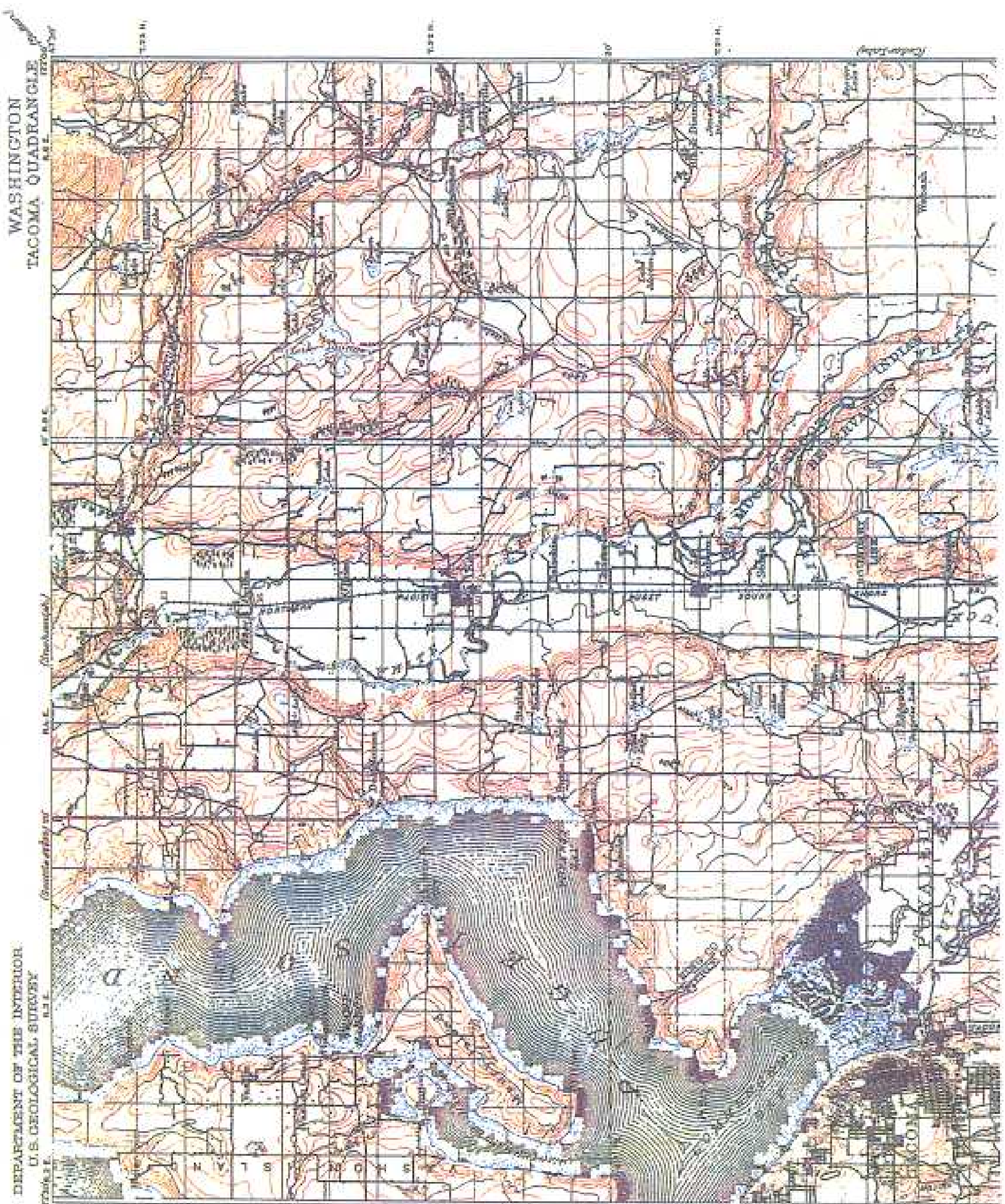
Soil	Map Symbol
Alderwood gravelly loam	
Gently undulating	Aa
Rolling	Ab
Alderwood gravelly sandy loam	
Hilly	Ad
Rolling	Ae
Bellingham silty clay	Bf
Carbondale muck	Ca
Shallow	Cb
Cathcart loam	
Hilly	Ce
Rolling	Cf
Coastal beach	Cg
Everett gravelly loamy sand, rolling	Ef
Everett gravelly sandy loam	
Gently undulating	Eh
Hilly	Eg
Rolling	Ek
Greenwood peat	Gb
Indianola fine sandy loam	
Hilly	Ia
Rolling	Ib
Indianola loamy fine sand, rolling	Ic
Kitsap silt loam	
Hilly	Ka
Undulating	Kb
Lynden loamy sand	La
Made land	Ma
Mukilteo peat	Md
Norma fine sandy loam	Nb
Norma silty clay	Nc
Puget silty clay	Pc
Puget silty clay loam	Pd
Puyallup fine sandy loam	Pf
High bottom	Pg
Puyallup silt loam	Pk
Low bottom	Pl
Puyallup very fine sandy loam	Pm
Rifle peat	Rd
Rough broken and stony land	Rh
Snohomish silt loam	Sd
Sultan silt loam	Sn
High bottom	So
Woodinville silt loam	Wa

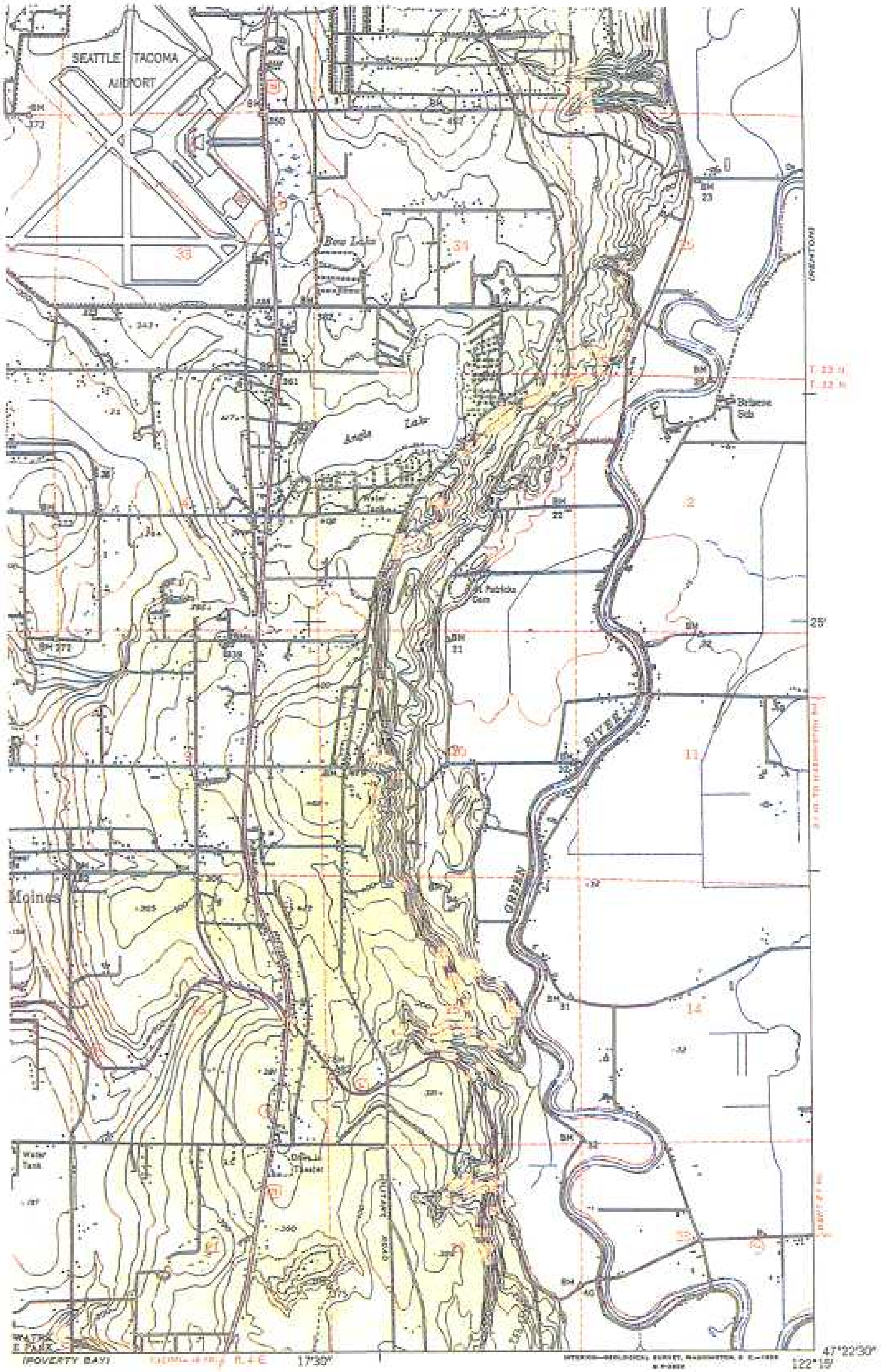

COUNTRY CLUB
Southern Heights School
Burien
Highline High School
Sunnydale High School
Bow Lake
Angle Lake School
Angle Lake
Des Moines School

4411330 1



AR 050875


WASHINGTON
TACOMA QUADRANGLE
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



SCALE 1:24 000

0 1 MILE

000 3000 4000 5000 6000 7000 FEET

0 1 KILOMETER

OUR INTERVAL 25 FEET
TUM IS MEAN SEA LEVEL

SENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
ANGE OF TIDE IS APPROXIMATELY 13 FEET

WITH NATIONAL MAP ACCURACY STANDARDS
DERAL CENTER, DENVER, COLORADO OR WASHINGTON 25, D. C.
APHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION

Heavy-duty ..... Light-duty .....
Medium-duty ..... Unimproved dirt .....
U. S. Route State Route

WASHINGTON
QUADRANGLE LOCATION

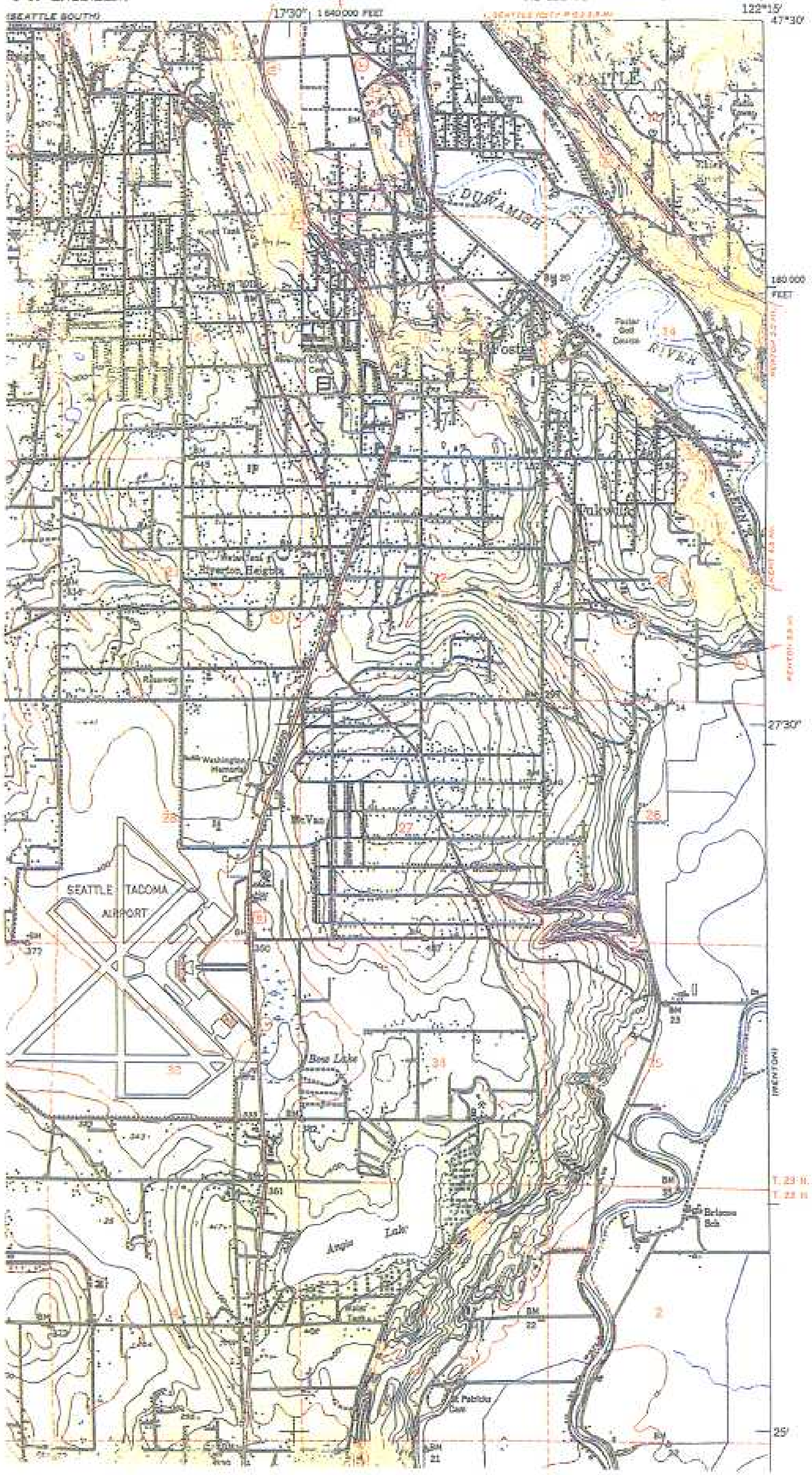
DES MOINES, WASH.
N4722.5—W12215/7.5

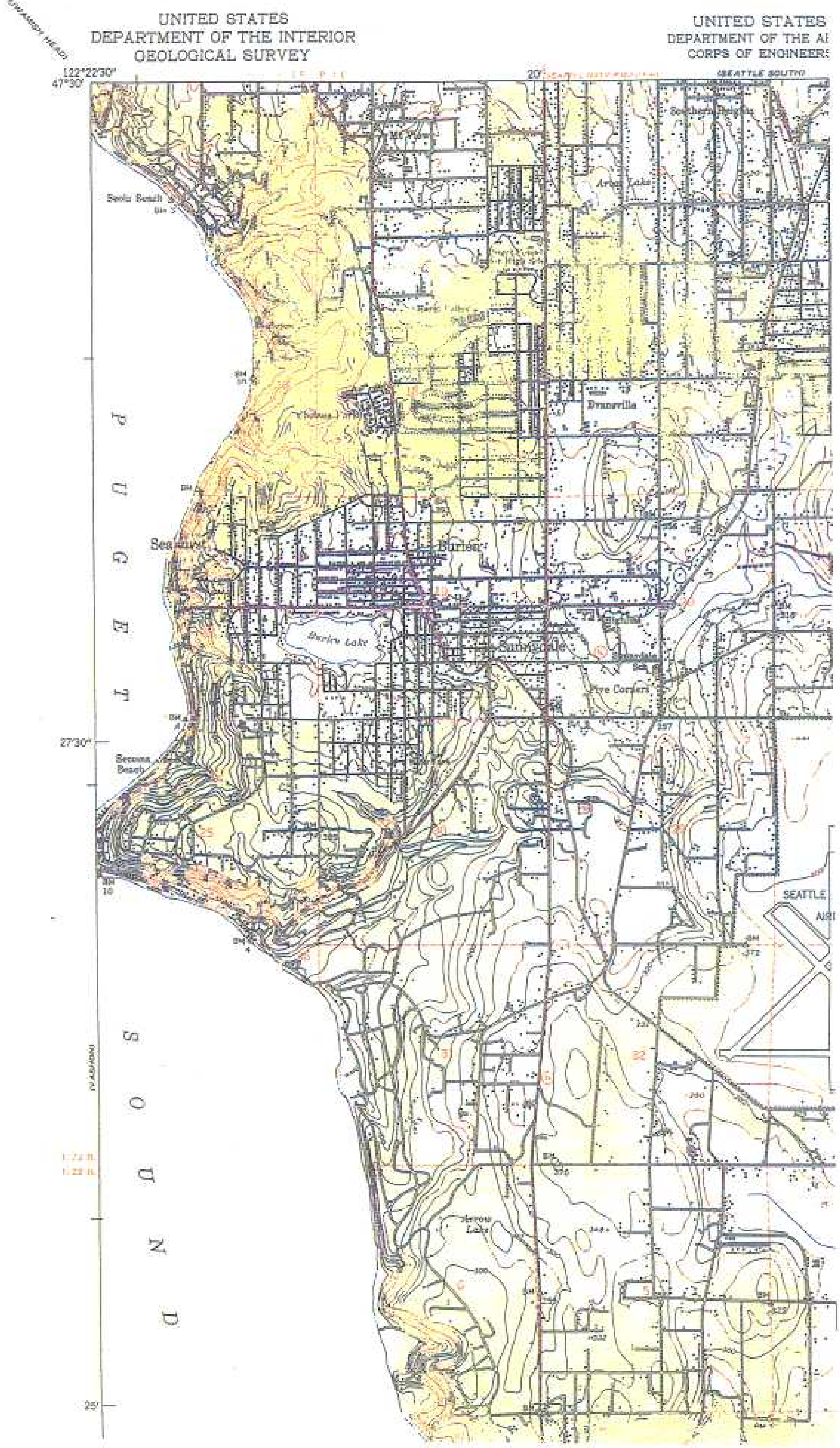
1949

AR 050877

ITED STATES
MENT OF THE ARMY
PS OF ENGINEERS

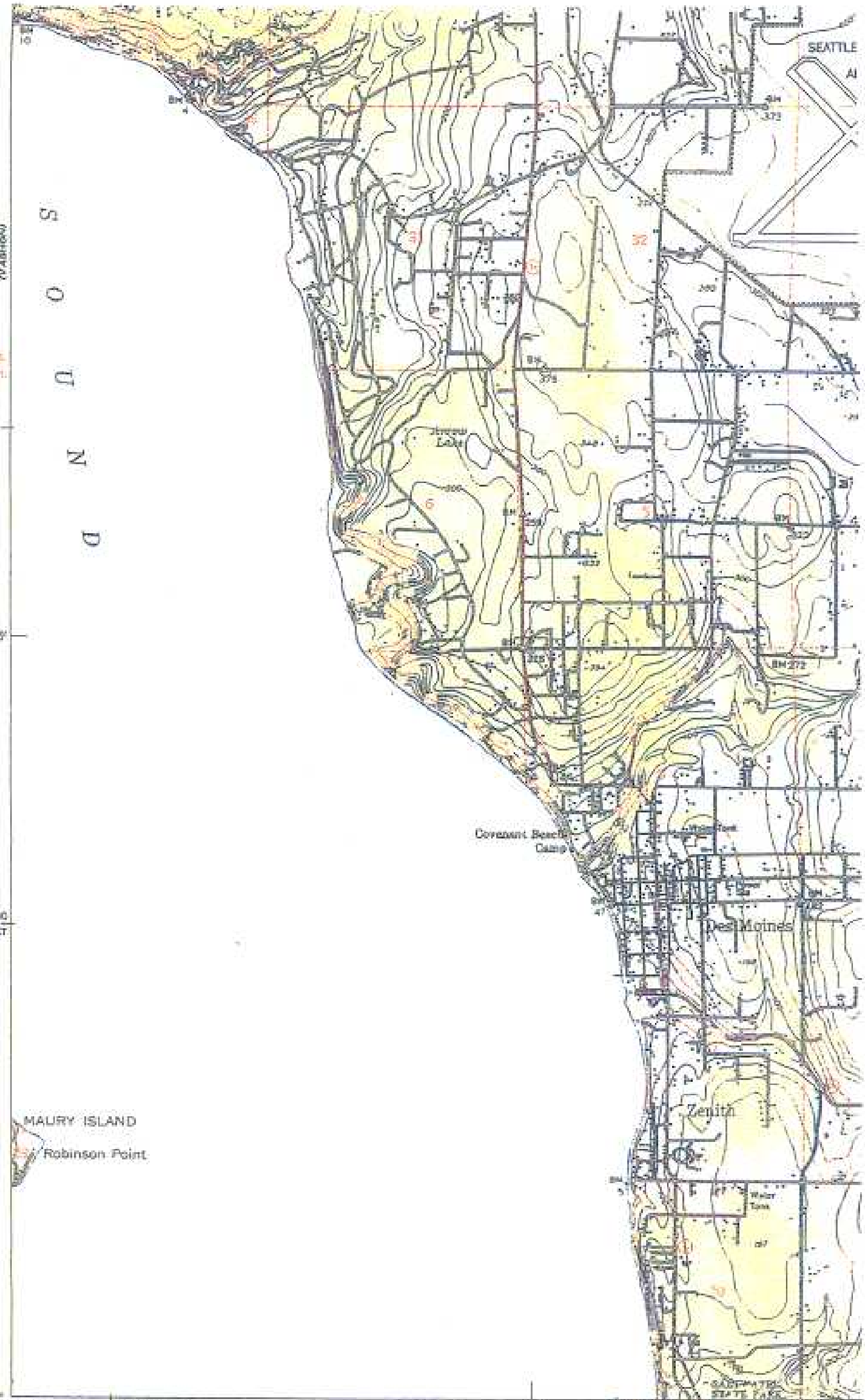
DES MOINES QUADRANGLE
WASHINGTON—KING CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)





UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
UNITED STATES
CORPS OF ENGINEERS
122°22'30"
47°30'
20'
27'30"
25'
P U G E T S O U N D
Seahurst
Burien
Burien Lake
Evansville
Sunnydale
Five Corners
Arrow Lake
SEATTLE

AR 050879



Mapped by the Army Map Service
Published for civil use by the Geological Survey

Control by USC&GS and King County Engineer Office

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1943. Field check 1949

Polyconic projection. 1927 North American datum
10,000-foot grid based on Washington coordinate system, north zone

No distinction is made between dwellings, barns, commercial and industrial buildings

Unchecked elevations are shown in brown

Dashed land lines indicate approximate locations

TRUE NORTH
MAGNETIC NORTH
22°
APPROXIMATE MEAN DECLINATION, 1949

SCALE 1:24 000

CONTOUR INTERVAL 25 F
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACC
FOR SALE BY U. S. GEOLOGICAL SURVEY, FEDERAL CENTER, DEN
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBO

APPENDIX B

HISTORICAL TOPOGRAPHIC MAPS