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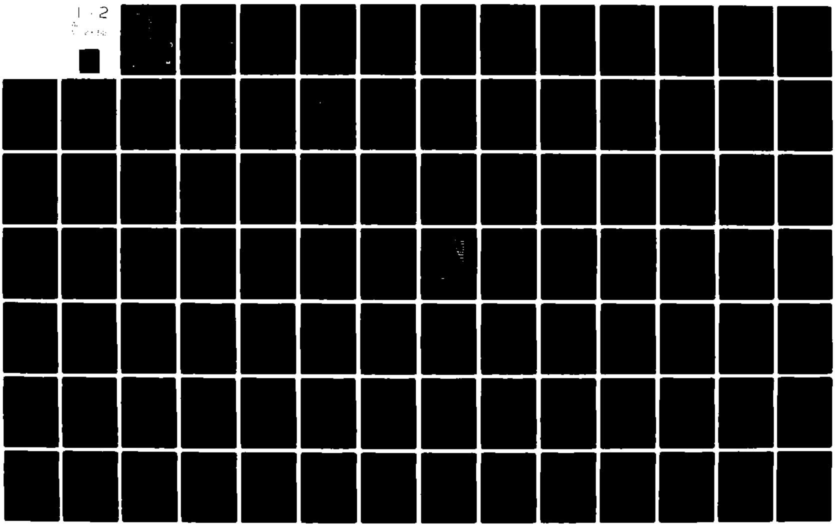

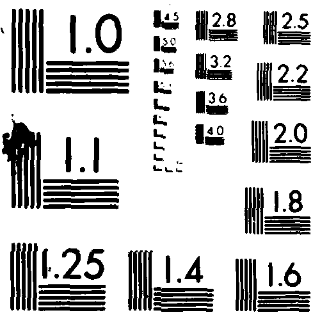

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COMMENCEMENT BAY STUDY

Sediments
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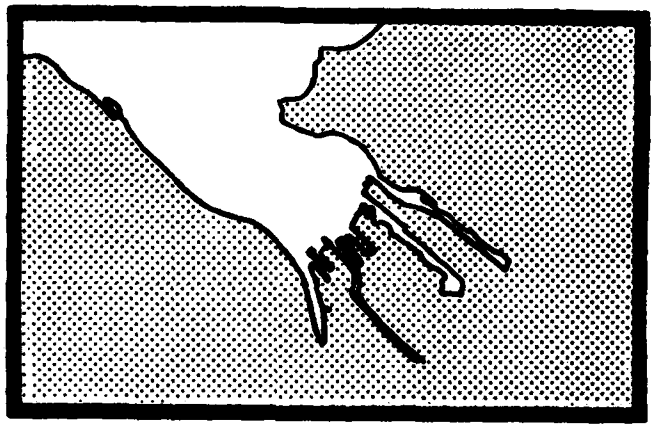
Birds



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Volume VII

December 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In the 20-month period ending December 1981, Dames & Moore (Seattle) assisted by four subcontractors completed a Phase I effort to collect baseline data and provide a detailed description of the natural and human systems of the Commencement Bay area in the southern Main Basin of Puget Sound in Washington State.

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COMMENCEMENT BAY STUDIES
TECHNICAL REPORT

VOLUME VII

- **SEDIMENTS**
- **NOISE**
- **CLIMATE AND AIR QUALITY**
- **AESTHETICS**
- **BIRDS**

for

U.S. Army Corps of Engineers
Seattle District

December 1981

TECHNICAL REPORT

SEDIMENTS

Author:
William J. Enkeboll, Dames & Moore

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1.0 INTRODUCTION

1.1 GENERAL

The objectives of the sediment studies, as defined by Section 3.7 of the U.S. Army Corps of Engineers' Statement of Work, for the Commencement Bay Studies (COBS) are to:

(a) Identify the existing sediment conditions in the bay and adjacent waterways.

(b) Determine the rate of sedimentation in the bay and adjacent waterways.

(c) Determine the growth trends of the Puyallup Delta.

(d) Evaluate the Corps of Engineers' maintenance dredging program with respect to dredging frequency, quantity of material removed, and other factors pertinent to maintenance of the waterways.

This technical report addresses the first three objectives, Sections 2.0, 3.0, and 4.0 respectively; the latter objective is addressed in detail in Section 1.5.2 of the COBS Land and Water Use Technical Report.

1.2 DATA COLLECTION

The data used for the identification of existing sediment conditions within the study area were developed during a field sampling and laboratory analysis program and by correlating available data from pertinent studies by other investigators. During the field sampling program 15 sediment samples were obtained from 13 general locations. Sediment stations are depicted on Figure 1. At Stations 3 and 8, samples were obtained from both the intertidal and subtidal zones; one sample was obtained at each of the other 11 stations. A listing of the stations and corresponding latitudes and longitudes is given in Table 1.

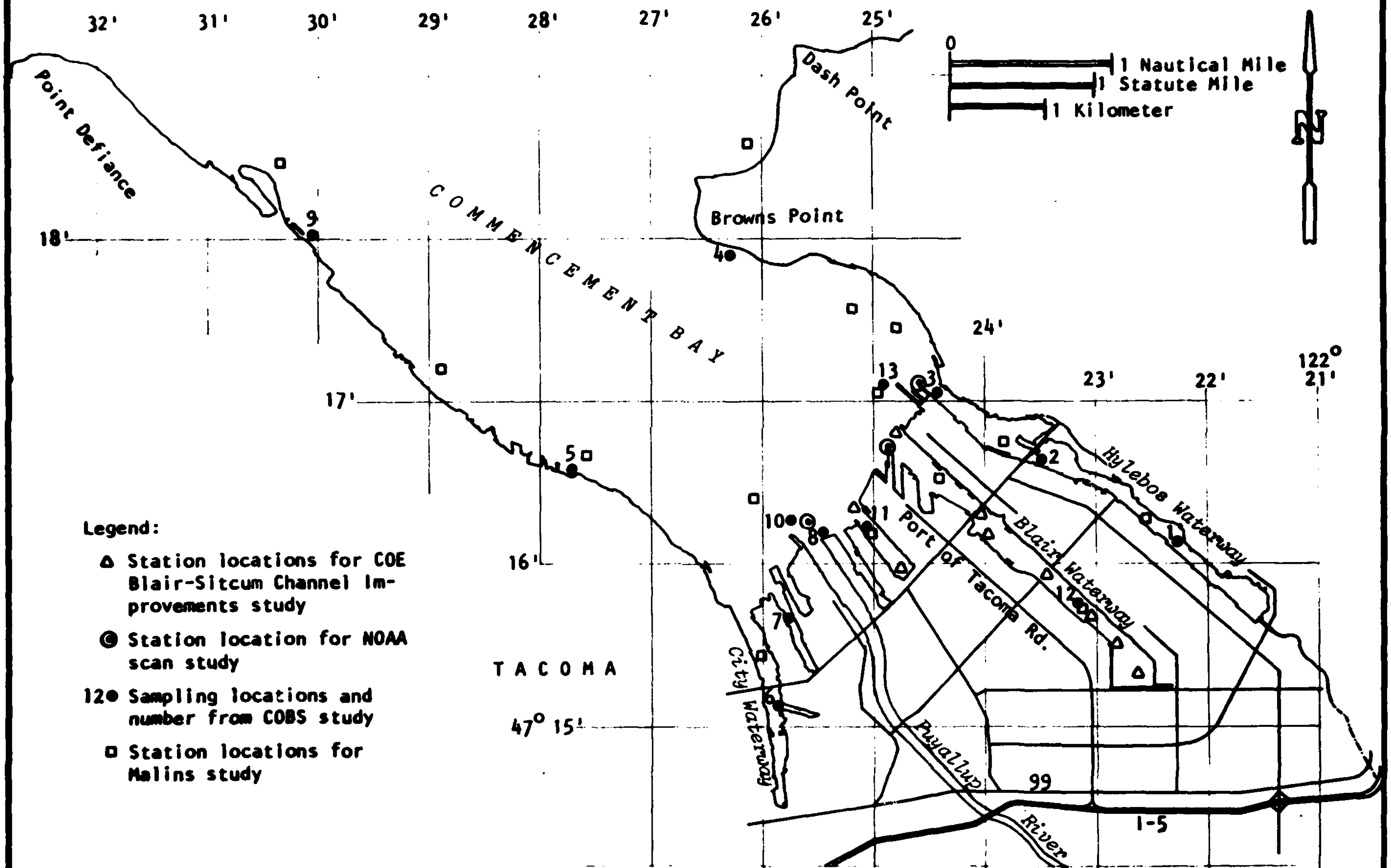


FIGURE 1
SEDIMENT SAMPLING STATIONS

TABLE 1

COBS SEDIMENT SAMPLING STATIONS AND LOCATIONS

Station Description	Latitude	Longitude
1 - Hylebos Waterway, lower turning basin	47°16'09"	122°22'15"
2 - Hylebos Waterway, East 11th Street Bridge	47°16'38"	122°23'30"
3 - Hylebos Waterway, mouth	47°17'04"	122°24'28"
4 - Browns Point, south side	47°17'04"	122°26'17"
5 - Old Tacoma, off Starr Avenue	47°16'34"	122°27'43"
6 - City Waterway, at mouth of Wheeler-Osgood	47°15'07"	122°26'17"
7 - Middle Waterway, 0.4 mile northwest of 11th Street	47°15'39"	122°25'45"
8 - Between Puyallup and Milwaukee Waterways	47°16'13"	122°25'27"
9 - ASARCO, 300 feet east of the southeast end of dock	47°18'02"	122°30'05"
10 - Puyallup River mouth	47°16'15"	122°25'48"
11 - Sitcum Waterway, 0.5 mile northwest of 11th Street	47°16'14"	122°25'03"
12 - Blair Waterway, 1/4 mile southeast of Lincoln Street	47°15'46"	122°23'10"
13 - Between Blair and Hylebos Waterways, off Pier No. 23	47°17'09"	122°24'54"

The sediment sampling was conducted between April 14 and 16, 1980 in conjunction with the first benthic invertebrate sampling effort. Each of the samples was obtained by divers from approximately the upper 1 foot of sediments. A total of approximately 1-1/2 liters of sediment were retained for each sample. The portion of the sample for polychlorinated biphenyl (PCB) analysis (see SAMPLE ANALYSIS below) was collected in a glass container and capped with a screw-type cap placed over aluminum foil. The remainder of the sample was obtained in three plastic tubes (2-1/2 inches in diameter by 6 inches in length) and capped with press-on type plastic caps. A sample of near-bottom water was also obtained in a glass container at each station for use as background water in the elutriate testing. Each of the several containers comprising the samples from each sampling location was placed on ice and refrigerated until delivered to the testing laboratory.

2.0 EXISTING SEDIMENT CONDITIONS

2.1 GENERAL

Both physical and chemical analyses were conducted on each of the samples to determine existing sediment conditions in the study area. The physical analyses consisted of grain size determinations by both sieving and hydrometer analysis; these were performed by Dames & Moore. The chemical characteristics of the sediments were analyzed by AM TEST, Inc. of Seattle.

Both bulk sediment and elutriate testing were performed for the chemical analyses. The parameters and constituents analyzed were selected by the Corps of Engineers prior to the initiation of our services. The parameters analyzed were:

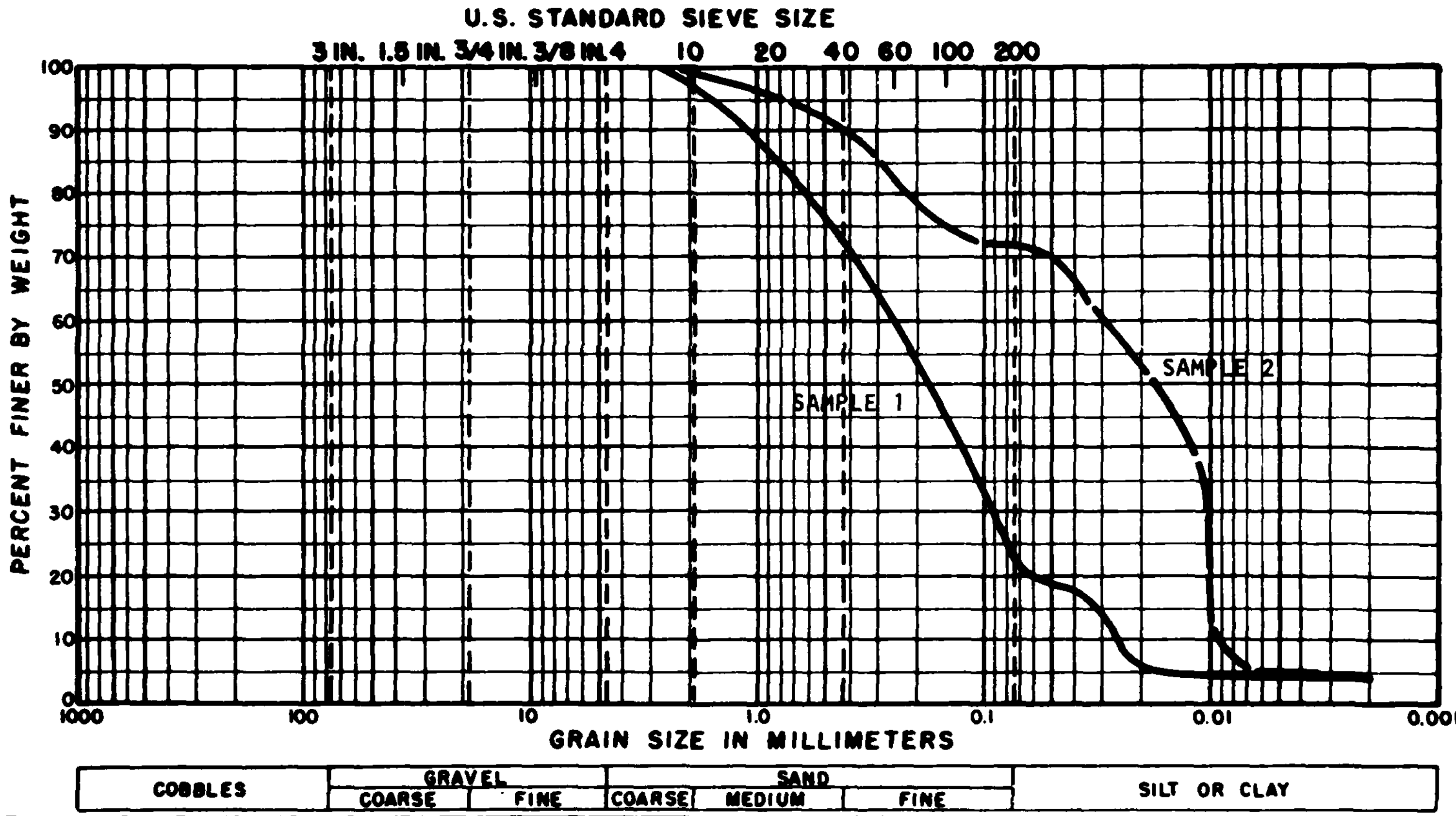
Bulk Sediment Samples	Elutriate Analyses	
chemical oxygen demand (COD)	arsenic	lead
volatile solids	cadmium	zinc
sulfides	chromium	
oil-grease	copper	
polychlorinated biphenyls (PCB)		

The sections below describe the specific results of the physical and chemical sediment analyses.

2.2 PHYSICAL CHARACTERISTICS

Physical characteristics of the sediments within the study area were examined by performing gradation analyses on each of the sediment samples obtained and by correlating information from nautical charts and visual observations. The results of the gradation analyses are presented in the form of the gradation curves presented on Figures 2 through 9. The sample numbers on those figuers correspond to the station numbers described previously.

Study area sediments generally are classified as sandy silts and silty sands. Sandy sediment samples were obtained from Hylebos Waterway, Browns Point, along Ruston Way in the Old Tacoma area, City Waterway,



SAMPLE	DEPTH (m)		CLASSIFICATION
1	- 8		SILTY FINE TO MEDIUM SAND
2	-10		SILT WITH FINE TO MEDIUM SAND

FIGURE 2
GRADATION CURVE - SAMPLING STATIONS 1, 2

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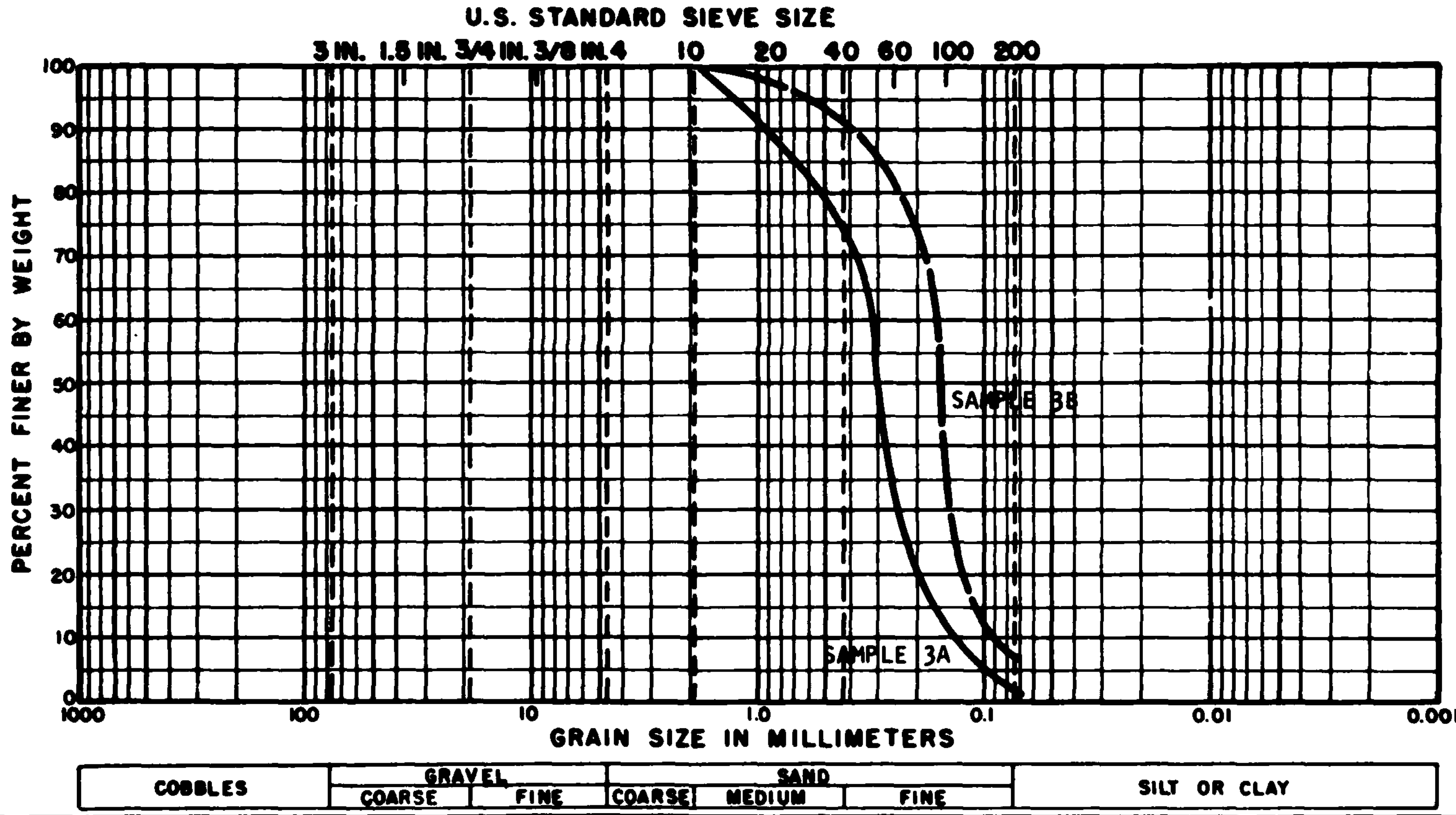
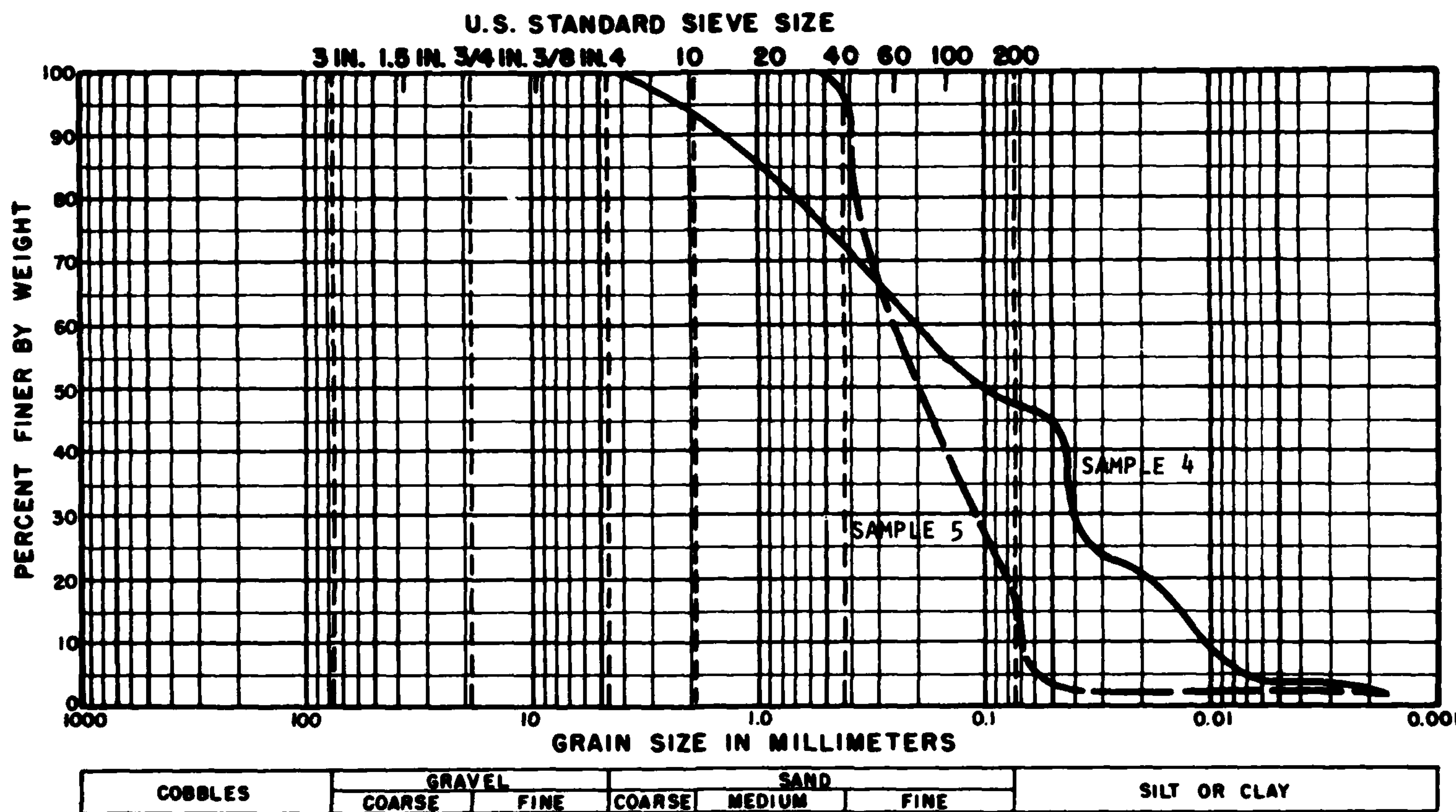


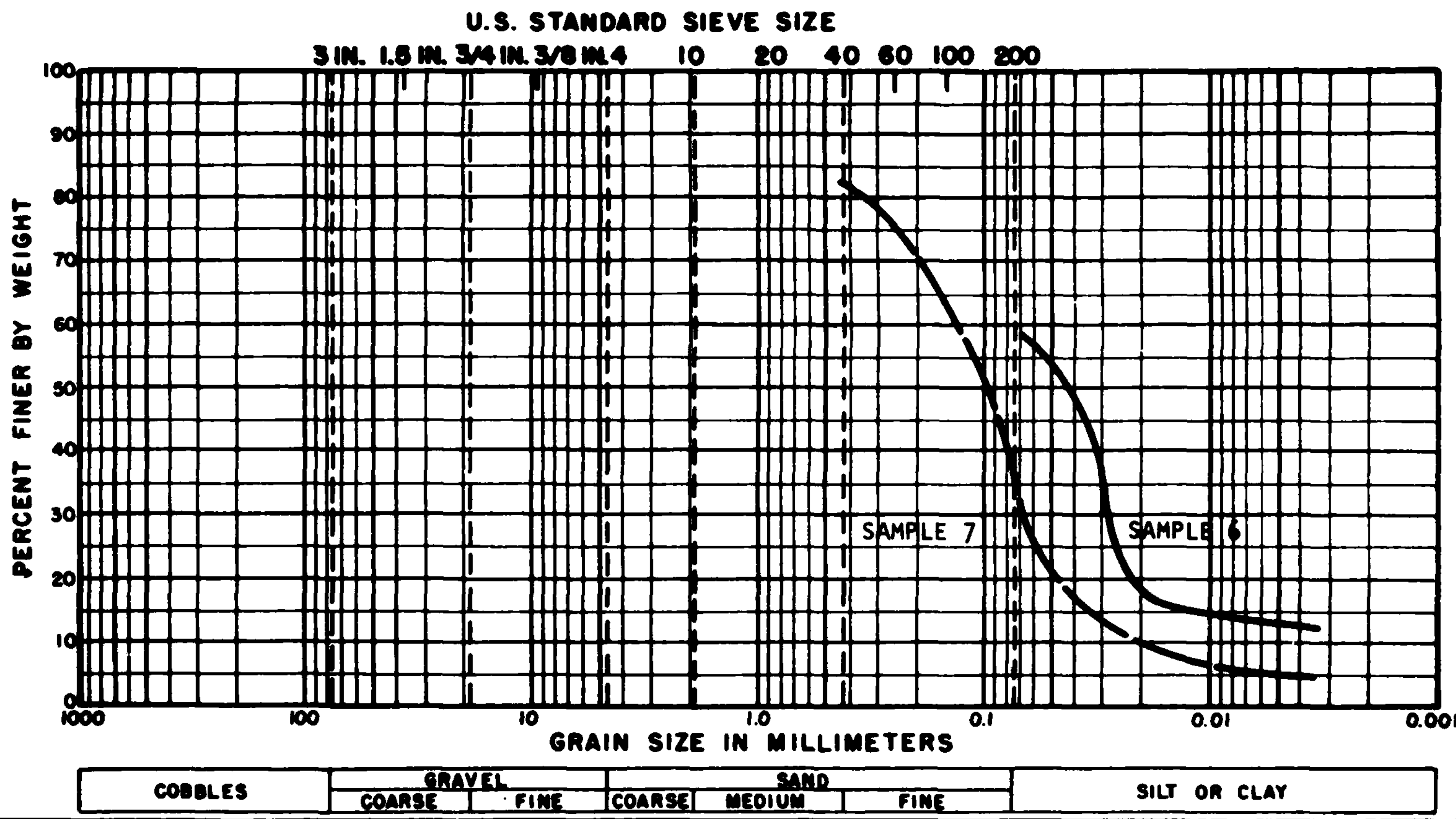
SAMPLE	DEPTH (m)	CLASSIFICATION
3A	+ .9	FINE TO MEDIUM SAND
3B	-2.5	FINE TO MEDIUM SAND

FIGURE 3
GRADATION CURVE – SAMPLING STATION 3



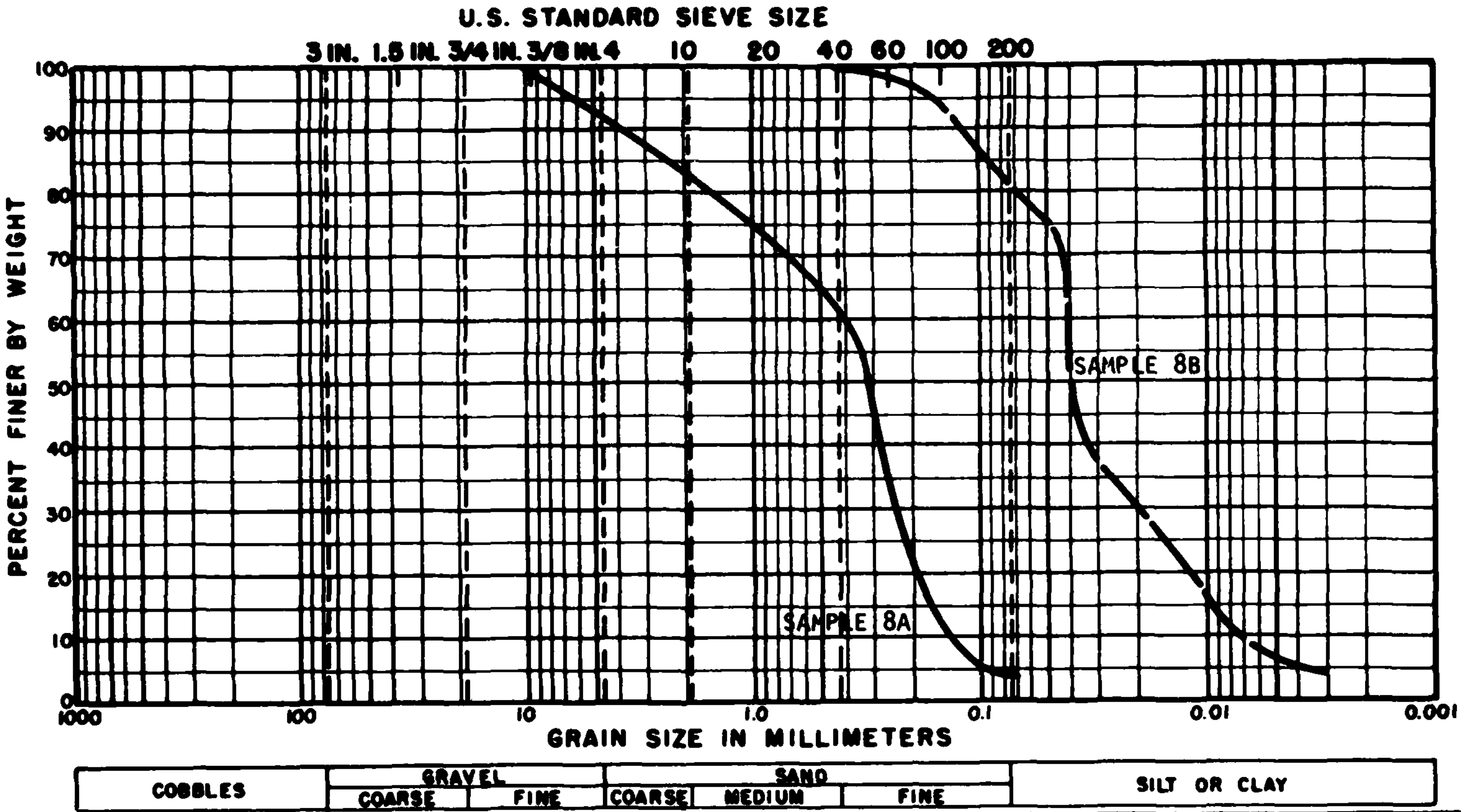
SAMPLE	DEPTH (m)	CLASSIFICATION	
4	-2.5		SILTY FINE TO COARSE SAND
5	-2.5		SILTY FINE SAND

FIGURE 4
GRADATION CURVE - SAMPLING STATIONS 4,5



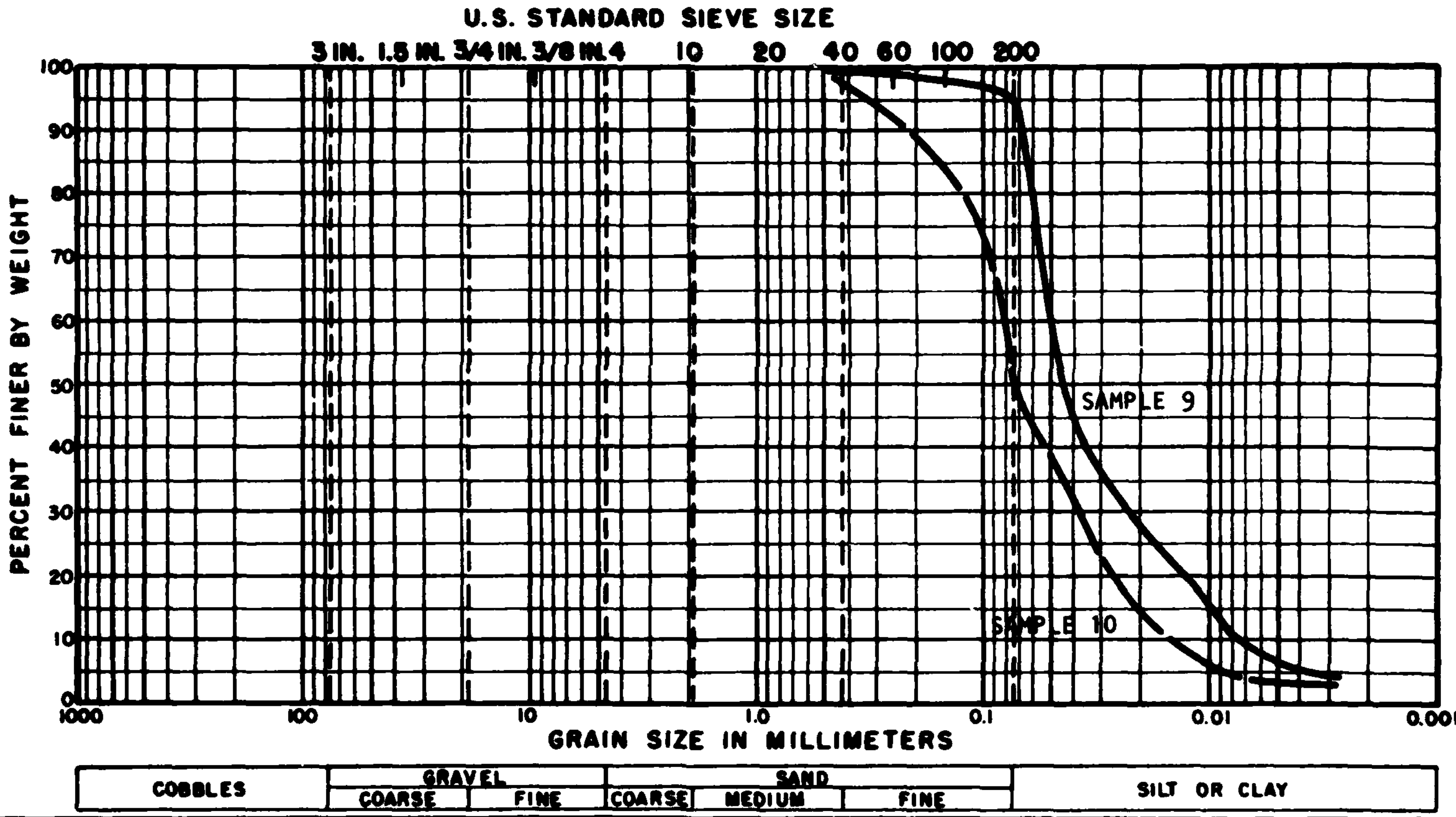
SAMPLE	DEPTH (m)	CLASSIFICATION	
6	-2.5		SILT WITH FINE SAND
7	-2.5		SILTY FINE TO MEDIUM SAND

FIGURE 5
GRADATION CURVE - SAMPLING STATIONS 6, 7



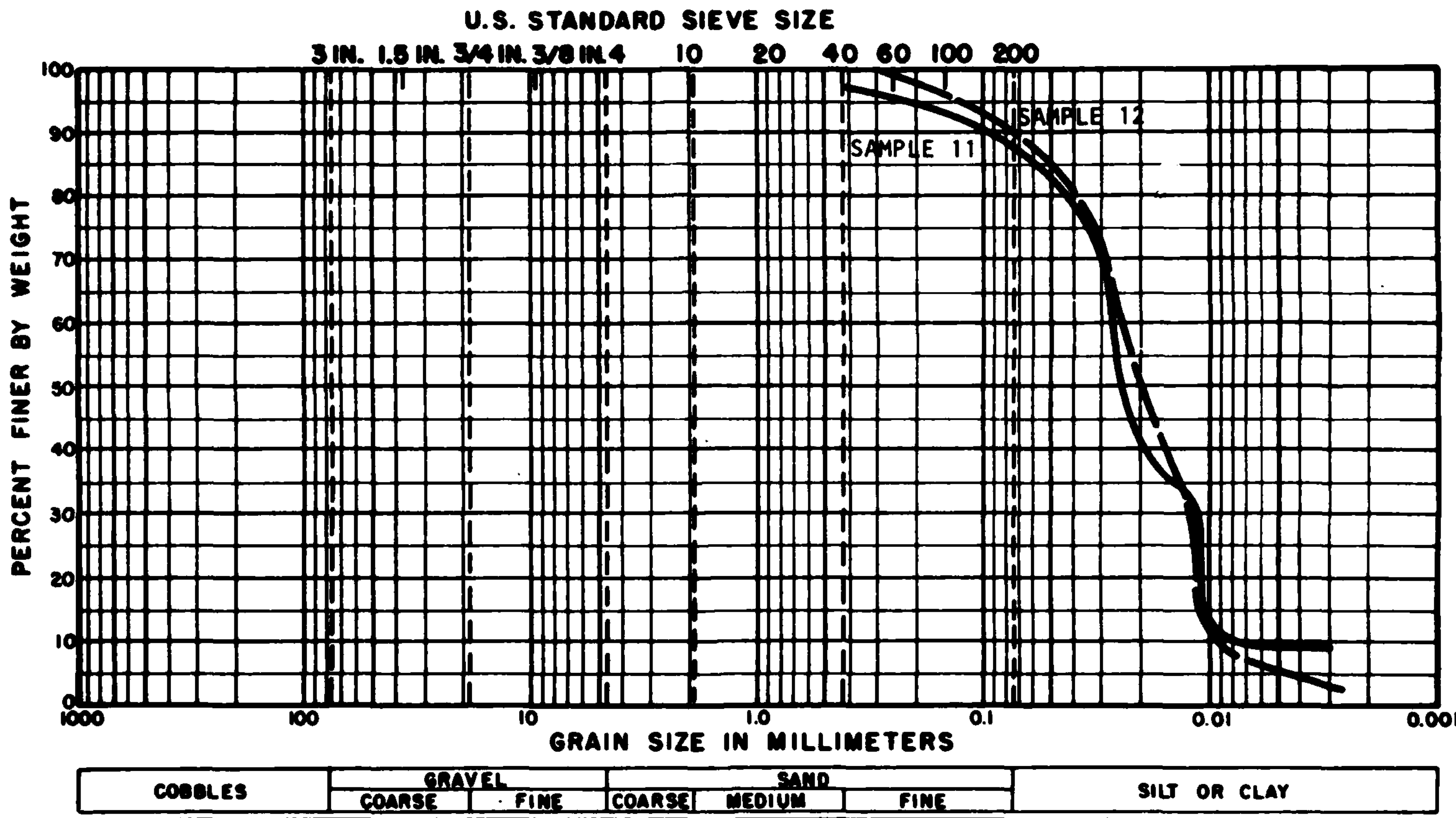
SAMPLE	DEPTH (m)	CLASSIFICATION
8A	+ .9	FINE TO COARSE SAND
8B	-10	SILT WITH FINE SAND

FIGURE 6
GRADATION CURVE - SAMPLING STATION 8



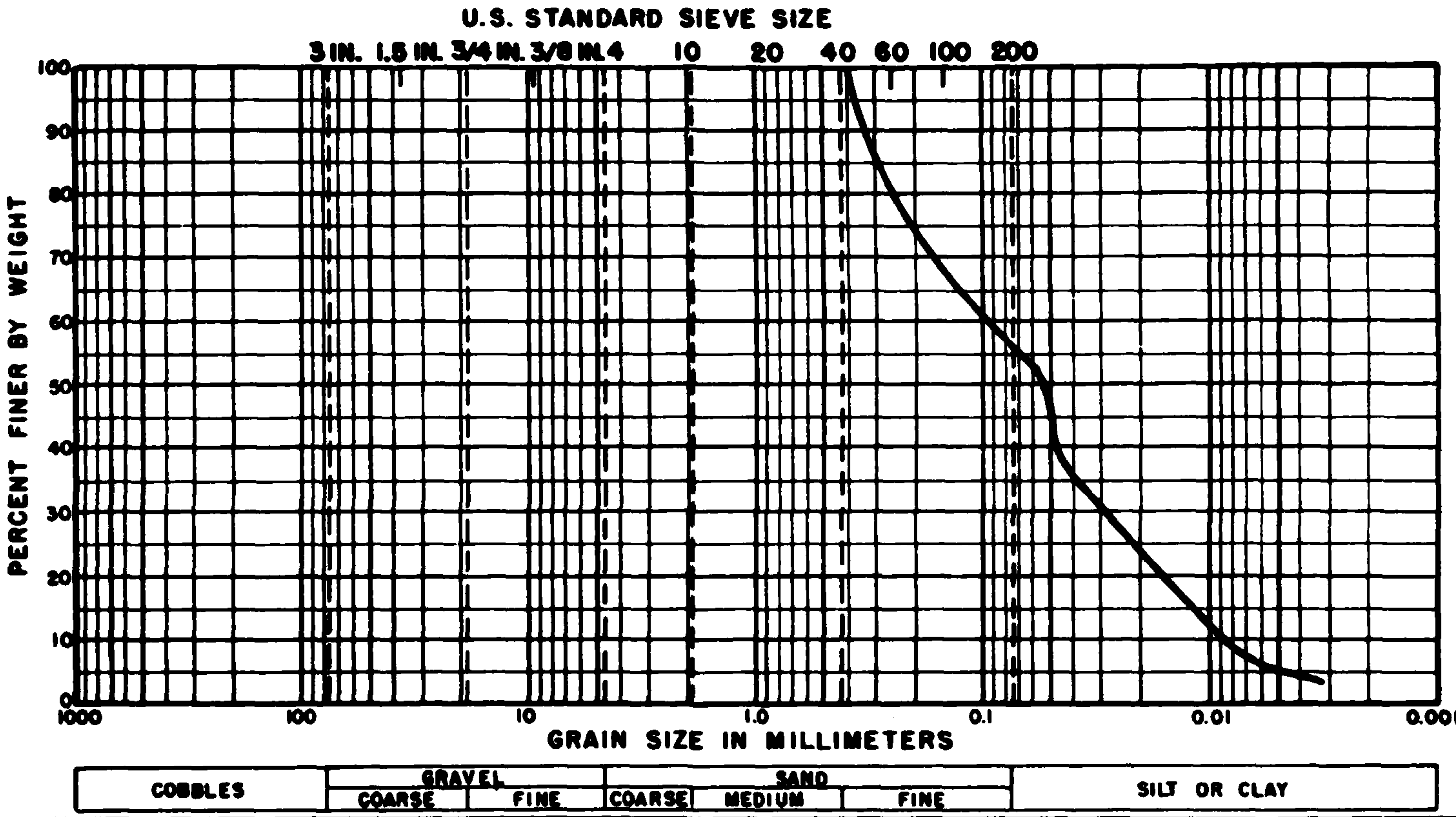
SAMPLE	DEPTH (m)	CLASSIFICATION	
9	-18		SILT WITH FINE SAND
10	- 2.5		SILT WITH FINE SAND

FIGURE 7
GRADATION CURVE - SAMPLING STATIONS 9, 10



SAMPLE	DEPTH (m)		CLASSIFICATION
11	-11		SILT WITH A TRACE OF FINE SAND
12	-14		SILT WITH A TRACE OF FINE SAND

FIGURE 8
GRADATION CURVE - SAMPLING STATIONS 11, 12



SAMPLE	DEPTH (m)	CLASSIFICATION	
13	-18		SILT WITH FINE SAND

FIGURE 9
GRADATION CURVE – SAMPLING STATION 13

Middle Waterway, and off Pier 1 between Puyallup and Milwaukee Waterways. Silty sediments were encountered at the other sampling locations. These results indicate that relatively sandy sediments can be expected to be encountered in the waterways which receive occasional maintenance dredging. The sediments in the Puyallup River mouth can be expected to consist of both silt and sand located randomly, depending on localized erosion and deposition patterns resulting from the river currents. In addition to the Puyallup River, Hylebos and Wapato Creeks, surface runoff from the port industrialized area, and the resuspension of fine sediment material by wave action also contribute significant sources of silty sediment material.

Nautical charts indicate that nearly all of the bottom of the main body of Commencement Bay is of muddy composition, probably silty material. Although the dredged waterways typically exhibit sandy bottoms, thin layers of silt can be expected to accumulate between dredging episodes.

Gravelly sediments generally occur along the north and south shore as beach deposits within the intertidal zone. These gravels result primarily from erosion of the bluffs adjacent to Commencement Bay. Sand and silt particles of sloughed material are removed and redistributed by wave action, leaving the gravel. Transport of the gravel by wave and current action can be expected to occur only to a minor degree. Because the source of gravel is from the localized sloughing of bluff material, roads adjacent to the bay, riprap banks, or any other development or structures that eliminate or minimize the potential for shoreline erosion effectively reduce the sources of gravel along the bay's edge.

The most significant source of sandy sediments in the Commencement Bay area is the Puyallup River. Some additional sandy material originates from erosion of the surrounding bluffs.

2.3 CHEMICAL CHARACTERISTICS

The chemical conditions of Commencement Bay sediments were investigated by performing chemical analyses on sediment samples and researching the results of studies by other investigators. Chemical analyses were performed on each of the sediment samples obtained as a part of the study. The results of these analyses are presented in Tables 2 and 3.

TABLE 2

BULK SEDIMENT TEST RESULTS

Station (depth)	Chemical Oxygen Demand (COD)	Volatile Solids	Sulfide	Oil-Grease	PCB (ppb)
	(percent dry weight)				
1 (-8m)	7.9	4.15	0.006[a]	0.037	536[c]
2 (-10m)	9.9	5.03	0.009	0.026	<10[d]
3 (-2.5m)	1.3	1.63	0.002	0.005	<10
3 (+0.9m)	1.0	1.82[a]	0.0003	0.005	<10
4 (-2.5m)	3.8	4.58	0.006	0.009	<10
5 (-2.5m)	9.0	6.75	0.009	0.083	103[c]
6 (-2.5m)	40.4[a]	15.03	0.028	0.190[a]	<10
7 (-2.5m)	9.6	3.52	0.010	0.048	<10
8 (-10m)	6.0	4.49	0.013	0.010	<10
8 (+0.9m)	9.5	5.09	0.007	0.009	<10
9 (-18m)	2.0	2.54	0.004	0.007	<10
10 (-2.5m)	17.4	16.32	0.103	0.034	<10
11 (-11m)	9.4 8.1[b]	8.20 5.9[b]	0.017 0.024[b]	0.021 0.13[b]	<10
12 (-14m)	6.6 3.9[b] 5.5[b]	4.25 4.3[b] 5.4[b]	0.001 0.005[b] <0.001[b]	0.019 0.09[b] 0.08[b]	<10
13 (-18m)	5.4	2.69	0.004	0.004	26[c]

(a) Replicate analyses performed on these samples as a routine testing procedure--the higher of the values is shown.
(b) Data from: U.S. Army Corps of Engineers, Seattle District (1979).
(c) All PCBs detected are Arochlor 1254.
(d) Values preceded by the less-than notation (<) indicate: (1) the detection limit for the analysis, and (2) that the concentration of the parameter, if present, was less than the detection limit.

TABLE 3

ELUTRIATE TEST RESULTS

Station (deptn)	Arsenic (As)		Cadmium (Cd)		Chromium (Cr)		Copper (Cu)		Lead (Pb)		Zinc (Zn)		PCB (ppb)
	(parts per million)												
1 (-8m)	<0.03[a]		<0.002		<0.005		0.005		<0.002		0.010		
2 (-10m)	<0.03		<0.002		<0.005		0.004		<0.002		0.007		
3 (-2.5m)	<0.03		0.003		<0.005		0.005		<0.002		0.020		
3 (+0.9m)	<0.03		<0.002		<0.005		0.010		<0.002		0.011		
4 (-2.5m)	<0.03		<0.002		<0.005		0.004		<0.002		<0.002		
5 (-2.5m)	<0.03*		<0.002		<0.005		0.005		0.01		0.102		
6 (-2.5m)	<0.03		<0.002		<0.005		0.005		<0.002		0.017		
7 (-2.5m)	<0.03		<0.002		<0.005		0.005		0.01		0.017		
8 (-10m)	<0.03*		<0.002		<0.005		0.004		<0.002		0.011		
8 (+0.9m)	<0.03		<0.002		<0.005		0.004		<0.002		0.011		
9 (-18m)	<0.03[b]		<0.002[b]		<0.005[b]		0.020[b]		<0.002[b]		0.082[b]		
10 (-2.5m)	<0.03		<0.002		<0.005		0.004		<0.002		<0.002		
11 (-11m)	<0.03	0.016[c]	<0.002	0.008[c]	<0.005	0.003[c]	0.004	0.009[c]	<0.002	0.030[c]	0.007	0.009[c]	<0.005[c]
12 (-14m)	<0.03	0.009[c]	<0.002	0.001[c]	<0.005	<0.001[c]	0.007	0.004[c]	<0.002	0.007[c]	0.006	0.001[c]	<0.005[c]
		0.018[c]		0.003[c]		<0.001[c]		0.006[c]		0.019[c]		0.001[c]	<0.005[c]
13 (-18m)	<0.03		<0.002		<0.005		0.004		<0.002		0.006		
Back-ground	<0.03		<0.002		<0.005		0.005		<0.002		0.027		

(a) Values preceded by the less-than notation (<) indicate: (1) the detection limit for the analysis, and (2) that the concentration of the parameter, if present, was less than the detection limit, except that asterisked (*) values indicate a detectable trace below the limit of quantification.

(b) Replicate analyses performed on these samples as a routine testing procedure--the higher of the values is shown if the parameter was present in quantifiable amounts.

(c) Data from: U.S. Army Corps of Engineers, Seattle District (1979).

By examining the sediments in bulk sediment and elutriate analyses, the results are readily adaptable to an evaluation of their suitability for disposal as a dredged material. This is normally accomplished by the Environmental Protection Agency (EPA) as part of the Section 404b permit review process for a specific project. Criteria for such an evaluation generally include an examination of the chemical quality of sediments as indicated by the bulk sediment and elutriate analyses and a consideration of dilution characteristics at the proposed dredged material disposal site. It is expected that the information developed during this study (see Tables 2 and 3) will be used as a basis for comparison for future dredging/disposal projects. However, additional chemical/biological testing may be required in the future to meet 404b guidelines (Kasselbaum 1981).

Elutriate analyses are generally intended to simulate the agitation of a sediment mass during dredging, transport, and disposal. As such, the elutriate analysis results refer to the chemical constituents released by agitation rather than by acid leaching techniques used by most other investigators. While the results of the two different types of analyses are not directly comparable, the general relationships and trends of the data can be examined.

The results of the bulk chemical analyses performed on the sediment samples collected during this study indicate that relatively high levels of chemical oxygen demand, volatile solids, sulfides, and oil-grease, occur in four locations in Commencement Bay: (1) in City Waterway (Station 6), (2) near the Puyallup River mouth (Station 10), (3) along Ruston Way off Old Tacoma (Station 5), and (4) in the Sitcum Waterway (Station 11). Polychlorinated biphenyls (PCB) were found in the sediments at only three sampling locations: (1) the Hylebos Waterway lower turning basin (Station 1), (2) Ruston Way off Old Tacoma (Station 5), and (3) off Pier 23 between the Blair and Hylebos Waterways (Station 13). The PCB concentration in the sediment at the Hylebos lower turning basin was five times greater than at the Old Tacoma station, which had the second highest concentration of PCB in the study samples.

It was originally intended that the PCB analysis be performed during the elutriate test. However, it was inadvertently performed on the sediment itself during the bulk sediment analysis. As indicated by the bulk sediment test results in Table 2, the PCB concentration, if any, in 12 of the 15 samples was below the detection limit for that analysis. Because the elutriate analysis examines concentrations of "releasable" materials, the PCB concentration in the elutriate for those 12 samples would be expected to be lower than the concentrations measured on a "total" or bulk basis in an analysis. However, such concentrations could possibly be quantified if the detection limit in the elutriate analysis is lower than that in the bulk sediment analysis. The concentrations of PCB in the other three samples in which measurable amounts were observed would be expected to be less in the elutriate analyses for the same reason.

On the basis of the chemical indicators of chemical oxygen demand, volatile solids, sulfide, and oil-grease, the best sediment conditions in the Commencement Bay area occurred at sampling stations located outside of individual waterways. On the basis of the chemical indicators of chemical oxygen demand, volatile solids, sulfide, and oil-grease, the best sediment conditions in the Commencement Bay area occurred at sampling stations located outside of individual waterways.

Results of the elutriate analyses performed on the samples obtained for this study indicate normally insignificant releases of metals into the water during agitation, except for: (1) copper in the sediments near Hylebos Waterway mouth (Station 3) and near the ASARCO smelter (Station 9), (2) lead at the Old Tacoma station off Ruston Way (Station 5) and in the Middle Waterway (Station 7); and (3) zinc at the Old Tacoma station off Ruston Way (Station 5), near the ASARCO smelter (Station 9), and at the mouth of the Hylebos Waterway (Station 3). The sources of these metals are not specifically known but probably result primarily from fills, concentrated dischar s to Commencement Bay through outfalls, and areal or non-point discharges from surface runoff.

Of other studies of Commencement Bay sediments, only the results of the Corps of Engineers' study on potential channel improvements for Blair and Sitcum Waterways (USACOE 1979 and Riley et al. 1982) are directly comparable to the results of the chemical analyses performed on samples obtained during the COBS study. Although only Blair and Sitcum Waterways were examined in USACOE 1979, the concentrated effort allowed the sampling and analysis of sediments in those two waterways at considerably more stations than the COBS studies. Specifically, the Corps of Engineers' Blair and Sitcum Waterways studies examined seven locations in Blair and two in Sitcum, compared to one location each in the COBS studies. Riley et al. (1982) examined organic contaminants at several locations in Hylebos and Blair Waterways. The results of their PCB analyses correlated well with those of the COBS study.

On the basis of the chemical indicators listed previously, the sediment in Sitcum Waterway is generally of lower quality than in the Blair Waterway. The dredged material disposal site designated by the Department of Natural Resources (DNR) (see Figure 14 in the Land and Water Use Technical Report) was also investigated by the Corps of Engineers in the channel improvement study (U.S. Army Corps of Engineers 1979); the sediments are indicated to be of generally lower quality than in Blair Waterway but of better quality than in Sitcum Waterway.

The Corps of Engineers (1979) elutriate analyses indicated that sediments at the DNR disposal site release higher concentrations of lead and zinc during agitation than do the sediments in Sitcum or Blair Waterways. However, the Corps sampling showed that sediments in both Sitcum and Blair Waterways have a generally higher concentration of arsenic and lead than other waterways. The COBS sampling does not confirm these elevated levels. This may be due to non-uniform concentrations of some heavy metals in sediments or to different sampling techniques and sensitivities of laboratory analyses.

A recent study published by the National Oceanic and Atmospheric Administration (NOAA) (Malins et al. 1980) addresses biological abnormalities in central and southern Puget Sound and chemical contaminants in sediments. Although the results of this study relate to total sediment concentrations of contaminants and are therefore not directly comparable to the data described above, the trends and indications of the data are useful for a general comparison of sediment quality at various locations within Commencement Bay.

Malins et al. (1980) indicate that sediments in Sitcum Waterway contain high concentrations of arsenic, cadmium, chromium, copper, lead, zinc, and certain organic compounds. In fact, chromium, copper, lead, and zinc were found in higher concentrations in Sitcum Waterway than at any other location examined in the study. The Hylebos Waterway was found to be relatively high in cadmium, chromium, copper, lead, zinc, and organic compounds. A station near Old Tacoma off Ruston Way was found to be high in concentrations of copper, lead, zinc, and certain organic compounds. Zinc was also found in high concentrations in sediments near the ASARCO smelter. Malins continued this study into 1981; the summary of the additional data is being reviewed by the NOAA/MESA Puget Sound Project Office and was unavailable for review at the time of this report. However, Long (1981a) indicates the additional year's data confirm that reported in Malins et al. (1980).

While only the results of the Corps of Engineers study for potential channel improvements in Blair and Sitcum Waterways (USACOE 1979) are comparable to the COBS results with respect to sediment analysis, the NOAA study (Malins et al. 1980) contains sufficient sampling points and analyses to provide the basis for an approximate comparison of sediment quality at various locations within Commencement Bay. Several of the sampling locations for each of these three studies are located near sampling locations used in the other studies. For the purposes of this study, compatible stations were selected (by design) to facilitate comparison of data.* The sampling locations of these various studies (and of one other described below) are shown in Figure 1.

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*The reader is referred to the respective studies for detailed information regarding sampling methodologies, analytical techniques, and a detailed discussion of the results.

A 1974 study of City Waterway (City of Tacoma 1974) had one sediment station, C-2, at about the same location as COBS Station 6. The 1974 sediment analysis technique was similar to that used in the COBS study. In elutriate/supernatant comparisons, the 1974 City of Tacoma lead value was 53 ppb compared to a non-detectable COBS lead level in 1980. City of Tacoma 1974 zinc levels were below detection limits (5 ppb); COBS yielded a zinc value of 17 ppb in 1980. In 1974, Chemical Oxygen Demand (COD) was 2.8 percent compared to 40.4 percent in 1980 sampling (both on a dry weight basis). In 1974, volatile matter was 2.8 percent while in 1980 volatile solids was 15.03 percent (both on a dry weight basis). How much of these differences are real or the result of varying techniques and laboratories is not known. It is interesting to note that in the 1974 City of Tacoma study, the supernatant levels of lead were higher (160 and 392 ppb) at the two stations (Stations C-6 and C-7) at the landward end of City Waterway. No COBS sediment sampling stations were located a comparable distance into City Waterway.

Other studies containing information on Commencement Bay sediment characteristics are available, but generally consist of comparisons of Commencement Bay sediments with sediments of other areas within Puget Sound. One of these, a NOAA study that examined sediments from the mouth of the Puyallup River, Hylebos Waterway, and Blair Waterway (Brown 1978), also examined sediments in the industrial marine environments at Elliott Bay (Seattle) and Sinclair Inlet (Bremerton). Overall, sediment quality in Commencement Bay is generally comparable to both Elliott Bay and Sinclair Inlet. Samples from the Hylebos Waterway mouth, Elliott Bay, and Sinclair Inlet contained high concentrations of extractable materials and aromatic hydrocarbons. However, a sample obtained near the mouth of the Puyallup River was of generally good quality. This is contrary to the previously described results of the COBS sediment analysis. However, it is expected that such variables as localized sampling position, time of year, and constituents analyzed account for much of this difference.

The NOAA study and other studies (Crecelius et al. 1975, Carpenter et al. 1978), in addition to indicating that sediment quality in Commencement Bay is generally similar to other industrialized areas of Puget

Sound, indicate that specific locations within Commencement Bay contain sediments of lower overall quality than other Puget Sound sample areas. Although very high values of arsenic have been found in sediments in the vicinity of the ASARCO smelter, high concentrations of arsenic and other metals in sediments have also been found in the vicinity of Vashon Island (Carpenter et al. 1978). While the arsenic found in sediments near the smelter is almost entirely contained in slag (bulk and particles) and is relatively unavailable to the saltwater environment, the arsenic in sediments near Vashon Island is generally available. Arsenic in these sediments may be attributable to emissions from the ASARCO stack. A recent DOE investigation of log sort yards (Washington Department of Ecology, unpublished) indicates slag in a freshwater, low pH environment does leach both arsenic and other selected heavy metals. See the EIS documents for the proposed ASARCO variance (PSAPCA 1981a).

Despite these high levels of arsenic found near the smelter and in the vicinity of Vashon Island, generally low levels of arsenic are found within Commencement Bay itself and in Puget Sound between Point Defiance and Vashon Island. The flushing action of the Puyallup River and the tidal currents within Puget Sound are thought to prevent the buildup of arsenic in these generally open bodies of water. Similar logic can be applied to other chemical contaminants from other sources and at other locations. Accumulations of chemical contaminants could be expected in areas where flushing is somewhat limited and where inputs of chemical contaminants are historically known to occur, such as in the waterways of Commencement Bay. In fact, COBS results discussed previously indicate that sediment quality in the waterways is generally lower than that in other sediment sampling locations within Commencement Bay.

Two other studies in progress by NOAA/PMEL (Long 1981b) may contain additional information about sediment conditions in Commencement Bay. However, the results of these studies were not available for review at the time of this report.

To this point, sediment quality has been discussed in relative terms because no regulations or guidelines exist which define acceptable or unacceptable sediment quality. However, guidelines do exist for levels of certain contaminants in water. Because elutriate analyses examine the concentrations of chemical constituents in water after agitation of a sediment sample, the results of the elutriate analyses may be compared with the water quality guidelines.

New water quality regulations/guidelines have recently been published by the Environmental Protection Agency (EPA) (45 Fed. Reg. 79,318). These guidelines are based on the results of numerous studies by several investigators, and represent a consensus of criteria for various chemical constituents. The guidelines update and supersede older EPA regulations which have been in effect since the early 1970s. While the older guidelines contain "minimum risk" and "hazardous levels" for the various chemical constituents, the new regulations describe the criteria in terms of "acute," "chronic," "24-hour average," and "any-given-time" levels. In many instances, the new guidelines are less stringent than the older guidelines.

None of the chemical constituents analyzed in the elutriate analyses conducted for this study are found in concentrations greater than the acute, chronic, or any-given-time levels. However, zinc concentrations were greater than the 24-hour average level criterion (0.058 ppm) at both the Old Tacoma sampling station off Ruston Way and at the ASARCO station. The levels of copper are found to be greater than or equal to the 24-hour average (0.004 ppm) level at each of the COBS sampling stations. The levels of copper were significantly greater than (2-1/2 to 5 times) the 24-hour average level in sediments obtained from the mouth of the Hylebos Waterway and near the ASARCO smelter. However, the water quality studies indicate that the concentration of copper was slightly greater than the 24-hour average level criterion in the background water as well (see Table 3).

3.0 EXISTING SEDIMENTATION RATES

Sedimentation rates within Commencement Bay are quite low except in the vicinity of the bay's primary sediment source, the Puyallup River. An examination of historic nautical charts indicates that water depths throughout the majority of the bay have changed very little within the last 100 years. Although some sedimentation undoubtedly occurs, the net accumulation of sediments and resulting decrease in water depth appear to be minimal. Exceptions to this general pattern occur in the vicinity of the mouth of the Puyallup River, in the vicinity of the mouths of Blair and Sitcum Waterways, and in the designated DNR open-water dredge material disposal site in Commencement Bay (see Figure 15 of the Land and Water Use Technical Report). At various times, three DNR-designated open-water disposal sites have existed in Commencement Bay. One of these disposal sites is still used. Two others, one located adjacent to the existing disposal site and one located near the mouth of the Puyallup River, have not been used since the mid-1970s. Deposition of mechanically transported dredge material is the principal cause of sediment accumulation and the resultant decrease in water depth in the disposal areas.

Nautical charts indicate a net accumulation of approximately 4.25 meters of sediment between Blair and Sitcum Waterways between 1923 and 1974. The overall apparent average sedimentation rate at this location is therefore approximately 8 centimeters per year at this location. However, sedimentation rates at the mouths of and between the other waterways (except the Puyallup River) are generally lower; Riley et al. (1982) report a natural sedimentation rate of approximately 0.7 cm/year in the area off the mouths of and between Hylebos and Blair Waterways. Therefore, it is suspected that natural sedimentation accounts for only a small portion of the net sediment accumulation between Blair and Sitcum Waterways. Considerable dredging and development activity occurred in the vicinity of the Blair Waterway between 1923 and 1974, including several extensive episodes during which the waterway was deepened and widened. It is expected that the accumulation of sediments between Blair and Sitcum Waterways is more likely a result of the dredging and land development activities during that period than of natural sedimentation.

The vicinity of the mouth of the Puyallup River has experienced the accumulation of as much as 50 to 60 feet of sediment since the rechannelization of the river into its present configuration in the early 1900s. As discussed in the next section, the principal source of these sediments is the Puyallup River, which carries a significant sediment load from its drainage basin. The Puyallup River delta is continually advancing. The general direction of advancement is seaward; however, some lateral transport of sediments is evident from a comparison of historic nautical charts. Sedimentation rates in the lateral direction, though, are considerably less than in the major direction of the delta advancement. As significant as the Puyallup River is as a sediment source, the overall low sedimentation rates in the bay and near the waterways indicate that river sediment which is not deposited at the river mouth is apparently eventually transported out of the bay over a relatively long period of time.

At present, sedimentation rates are very low in all waterways except the Blair Waterway and Puyallup River. Navigation is reported to be very difficult within the lower reaches of the river due to heavy shoaling. However, the lower portion of the river appears to be in relative equilibrium with respect to river sediment load and sediment accumulation. Scouring and sediment deposition undoubtedly occur during periods of flooding and normal to low flows, respectively. Sediment which is scoured from the river bed during high flows is either redeposited in the delta at the river mouth or transported out of the area.

A comparison of historic nautical charts with recent soundings and authorized dredge depths indicates that the apparent sedimentation rate in Blair Waterway is relatively high. Sedimentation rates on the order of 0.3 to 0.6 meter per year are indicated by available recent data (Carpenter et al. 1978). While Wapato Creek discharges to the head of Blair Waterway, this system is unlikely to carry sediment in quantities large enough to account for the significant existing sedimentation. Two more likely causes of sedimentation rates would be: (1) redistribution of sediments within the waterway from underwater sloughing of waterway side slopes and possibly vessel activity and (2) sediment input from undeveloped and lightly developed land adjacent to the waterway through runoff and erosion. As upland development continues to occur, sedimentation rates within Blair Waterway will probably decrease accordingly.

The very low sedimentation rates within the other waterways generally can be attributed to: (1) extensive bulkheading along the waterways, (2) the development and stabilization of land adjacent to the waterways, and (3) the general urbanization of the drainage basins of natural inflows such as Hylebos and Wapato Creeks. Although dredging was required to maintain navigable depths in most waterways in the past, dredging frequency has decreased during recent years for these reasons (see Section 1.5.2 of the Land and Water Use Technical Report).

4.0 GROWTH TRENDS OF THE PUYALLUP RIVER DELTA

Growth of the Puyallup River delta has occurred rapidly since the river was channelized to its present configuration in the early 1900s. Prior to channelization and diking,* the river was somewhat wider, and the sediment load was deposited over a relatively broad area. Floods and high flows caused deposition of sediment over an even larger area. Since the river was channeled, sediment has accumulated in a concentrated area at the river mouth.

Nautical charts and U.S.G.S. topographic maps indicate that the leading edge of the Puyallup River delta has advanced approximately 1,200 feet seaward since 1923, including an advancement of approximately 900 feet between 1946 and 1979. This advancement of the leading edge of the delta has occurred virtually without impedence because dredging in the river and delta area was terminated before 1910 (see Section 1.5.2 of the Land and Water Use Technical Report). As discussed above, the Puyallup River, in addition to advancing seaward, is also spreading laterally from the mouth of the waterway. Although the lateral growth of the delta is significantly less than the seaward advancement, sediments have accumulated in thicknesses of 20 feet and more between the St. Paul Waterway and the Puyallup River.

A natural depositional environment exists at the mouth of the waterway at the interface of fresh river water and saline water from Commencement Bay. The deposition occurs quite rapidly and the leading edge of the delta probably slumps intermittently as the result of over-steepening. This slumping, together with the typical deposition of sediment, is responsible for the growth of the delta. Assuming that the sediment load within the Puyallup River does not significantly increase, the advancement of the edge of the Puyallup River delta will probably

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*Diking of the river was undertaken under the Puyallup River Flood Control Project, which was authorized by the Flood Control Act of June 22, 1936. The project was completed in 1950 by the Seattle District Corps of Engineers. Channel improvements were authorized in 1936 for the 2-mile portion of the river between the 11th Street Bridge and the Tacoma city limits, in order to give flood protection to the industrial section of Tacoma through the channelization of the river, and the construction of levees and revetments (U.S. Army Corps of Engineers 1980).

sediment load within the Puyallup River does not significantly increase, the advancement of the edge of the Puyallup River delta will probably slowly decrease in the future. Nautical charts indicate that the bottom of the bay in front of the delta's leading edge drops off rapidly in the seaward direction from the present delta front. Also, the leading edge of the delta will also be more susceptible to erosion from bay currents as the delta advances seaward.

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TECHNICAL REPORT

NOISE

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1.0 INTRODUCTION

This report characterizes the existing sound environment in the study area. Sound level contours and other data available from the City of Tacoma Planning Department, as well as noise data from other sources, were reviewed and compared to federal and state noise guidelines and regulations to assess the existing sound environment in the study area. As specified under Section 3.10.2 of the U.S. Army Corps of Engineers' Statement of Work for the Commencement Bay Studies (COBS), this report presents: (1) noise nomenclature, (2) a summary of current (July 1980) noise standards and guidelines, and (3) a discussion of principal noise sources within the Commencement Bay study area and their effects on study area sound characteristics.

2.0 NOISE NOMENCLATURE

The range of sound pressures that can be heard by humans is very large. This range varies from two ten-thousand-millionths (2×10^{-10}) of an atmosphere for sounds barely audible to humans to two thousandths (2×10^{-3}) of an atmosphere for sounds which are so loud as to be painful. The decibel unit is used to present sound levels over this wide physical range. Essentially, the decibel unit compresses this range to a workable range using logarithms. The unit is defined as:

$$\text{Sound pressure level (dB)} = 20 \log_{10}\left(\frac{P}{P_o}\right)$$

where P_o is the reference sound pressure required for a minimum sensation of hearing.

Zero decibels is assigned to this minimum level and 140 decibels to sound which is painful. Thus, a range of more than 1 million is expressed on a scale of zero to 140.

The human ear does not perceive sounds at low frequencies in the same manner as those at higher frequencies. Sounds of equal intensity at low frequency do not seem as loud as those at higher frequencies. The A-weighted network is provided in sound analysis systems to simulate the response of the human ear. A-weighted sound levels are expressed in units of dBA. These levels in dB are used by the engineer to evaluate hearing damage risk (OSHA) or community annoyance impact and are also used in federal, state, and local noise guidelines and ordinances. The term "sound level" as used in this report is understood to represent the A-weighted sound level and are expressed in terms of day-night levels unless otherwise noted.

Sound is not constant in time. Statistical analysis is used to describe the temporal distribution of sound and to compute single number descriptors for the time-varying sound. Statistical sound levels used in this report include:

L_{eq} - Equivalent Sound Level that provides an equal amount of acoustical energy as the time-varying sound.

L_d - Day Sound Level, L_{eq}, for the daytime period (0700-2200) only.

L_n - Night Sound Level, L_{eq}, for the nighttime period (0700-2200) only.

L_{dn} - Day-Night Sound Level, defined as:

$$L_{dn} = 10 \log_{10} ([15 \times 10^{L_d/10} + 9 \times 10^{(L_n+10)/10}]/24)$$

Note: A 10 dB correction factor is added to the nighttime equivalent sound level when computing L_{dn}.

3.0 NOISE STANDARDS AND GUIDELINES

3.1 FEDERAL STANDARDS

The federal Environmental Protection Agency (EPA) has established guidelines for limits of L_{dn} requisite for the protection of public health and welfare.* According to EPA guidelines, outdoor ambient sound levels, L_{dn}, below 55 dB will not degrade public health and welfare. EPA guidelines are presented in Table 1.

TABLE 1

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY[a]

Effect	Level[b,c]	Area
Hearing Loss	$L_{eq(24)} \leq 70$ dB	All areas
Outdoor activity	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities such as schools, etc.

(a) Data from: U.S. Environmental Protection Agency, Office of Noise Abatement and Control (1974).
(b) L_{eq} represents the sound energy averaged over a 24-hour period.
(c) L_{dn} represents the L_{eq} with a 10-dB nighttime weighting.

*Information on levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, U.S. EPA, 550/9-74-004, March 1974.

3.2 WASHINGTON STATE STANDARDS

3.2.1 GENERAL

Present noise regulations for the State of Washington are contained in the Washington Administrative Code (WAC) Chapters 173-60, 173-62, and 173-70.

3.2.2 WAC 173-60: MAXIMUM ENVIRONMENTAL NOISE LEVELS

Washington Administrative Code Chapter 173-60 (1976) specifies maximum permissible environmental noise levels for designated land uses. The environmental designation for noise abatement (EDNA) is based on typical land uses, taking into consideration the present, future, and historical usage, as well as the usage of adjacent or other lands in the vicinity.

Class "A" EDNA includes lands where human beings reside and sleep; i.e., single and multiple family dwellings, recreational camps, parks, resorts, hospitals, health, and correctional facilities, etc. Class "A" category uses in the study area include scattered residential uses along Marine View Drive, in the southeast portion of the port industrial area, and also Ruston Way/Schuster Parkway. It should be noted that activities in the study area can impose noise impacts on major residential areas located just outside the study area boundary on both the north and south shore of Commencement Bay.

Class "B" EDNA lands generally involve uses requiring protection from noise interference with speech. Restaurants, motels, hotels, retail and commercial establishments, theaters, stadiums, fairgrounds, amusement parks, churches, schools, and offices are examples of typical Class "B" EDNA lands. Class "B" category uses in the study area include: (1) scattered commercial uses along Marine View Drive and Ruston Way (including Old Tacoma); (2) marinas located along the north shore, within Hylebos Waterway, within City Waterway, and near ASARCO on the south shore (the Tacoma Yacht Club); and (3) the ferry landing facilities for the Vashon Island ferry route.

Class "C" EDNA includes lands involving economic activities of such a nature that higher noise levels than experienced in other areas is normally to be anticipated. Persons working within these areas are generally covered by noise control regulations of the Department of Labor, Occupational Safety and Health Administration (OSHA). Typical Class "C" EDNA properties include industrial, storage, warehouse, and distribution facilities as well as agricultural and silvicultural property used for the production of crops, wood products, or livestock. Class "C" category uses in the study are include: (1) light industrial and log storage operations along the Hylebos Waterway; (2) extensive terminal shipping and nonterminal shipping facilities within the port industrial segment; (3) scattered industrial use along the Puyallup Waterway; (4) warehouse, sand and gravel processing plant, shipbuilding, petroleum storage and paper, metal, and lumber processing operations along the City Waterway; and (5) scattered industries along Ruston Way including the ASARCO copper smelting and the Continental Grain Company facilities.

Washington State limitations are presented in Table 2.

TABLE 2

WASHINGTON STATE MAXIMUM PERMISSIBLE NOISE LEVELS[(a)]

EDNA OF	EDNA of Receiving Property (dBA)		
Noise Source	Class A	Class B	Class C
Class A (residential)	55	57	60
Class B (commercial)	57	60	65
Class C (industrial)	60	65	70

(a) Data from: Washington Administrative Code, Chapter 173-60-040.

Adjustments to these limitations include:

(1) Between the hours of 10 p.m. and 7 a.m. (nighttime hours), the noise limitations presented in Table 2 shall be reduced by 10 dBA for receiving property within Class A EDNA.

(2) At any hour of the day or night, the applicable noise limitations in Table 2 and (1) above may be exceeded for any receiving property by no more than:

(a) 5 dBA for a total of 15 minutes in any 1-hour period, or

(b) 10 dBA for a total of 5 minutes in any 1-hour period, or

(c) 15 dBA for a total of 1.5 minutes in any 1-hour period.

3.2.3 WAC 173-62: MOTOR VEHICLE NOISE PERFORMANCE STANDARDS

Washington Administrative Code Chapter 173-62 (1975, rev. June 4, 1980) regulates the maximum permissible sound levels attributable to motor vehicle operations. Table 3 presents noise performance standards for existing motor vehicle operations at measured distances of 15.2 meters from the center of the lane of travel within specified speed limits. Table 4 presents the standards limiting sound levels for existing motor vehicle operations at distances of 0.5 meter from the exhaust outlet of the motor vehicle. Table 5 presents maximum permissible sound levels for new motor vehicles sold in Washington State under SAE test procedures adopted by the State Commission on Equipment.

TABLE 3

IN-USE MOTOR VEHICLE NOISE PERFORMANCE STANDARDS
MEASURED AT 50 FEET (15.2 METERS)[(a)]

		Maximum Sound Level, dBA		
		Speed Zones		
Vehicle Category (type)	Effective Date	45 mph (72 kph) or Less	Over 45 mph (72 kph)	Stationary Test
Motorcycles	July 1, 1980	78	82	N/A
Automobiles, light trucks and all other motor vehicles 10,000 pounds (4,536 kg) GVWR[(b)] or less	July 1, 1980	72 35 mph (56 kph) or less	78 Over 35 mph (56 kph)	N/A
All motor vehicles over 10,000 pounds (4,536 kg) GVWR[(b)]	June 1, 1977	86	90	86

(a) Data from: Washington Administrative Code, Chapter 173-62 (1980).
(b) GVWR = Gross Vehicle Weight Rating. The value specified by the manufacturer as the loaded weight of a single vehicle.

TABLE 4

IN-USE MOTOR VEHICLE EXHAUST SYSTEM NOISE PERFORMANCE STANDARDS MEASURED AT 20 INCHES (0.5 METER)[a]

Vehicle Category (type)	Model Year	Maximum Sound Level, dBA
Motorcycles	Before 1986	99
	After 1986	(reserved)
Automobiles, light trucks and all other motor vehicles 10,000 pounds (4,536 kg) GVWR[b] or less	Before 1986	95
	After 1986	(reserved)

(a) Data from: Washington Administrative Code, Chapter 173-62 (1980).
(b) GVWR = Gross Vehicle Weight Rating; see Footnote (b), Table 1.

TABLE 5

MAXIMUM SOUND LEVELS FOR NEW MOTOR VEHICLES MEASURED AT 50 FEET (15.2 METERS)[a]

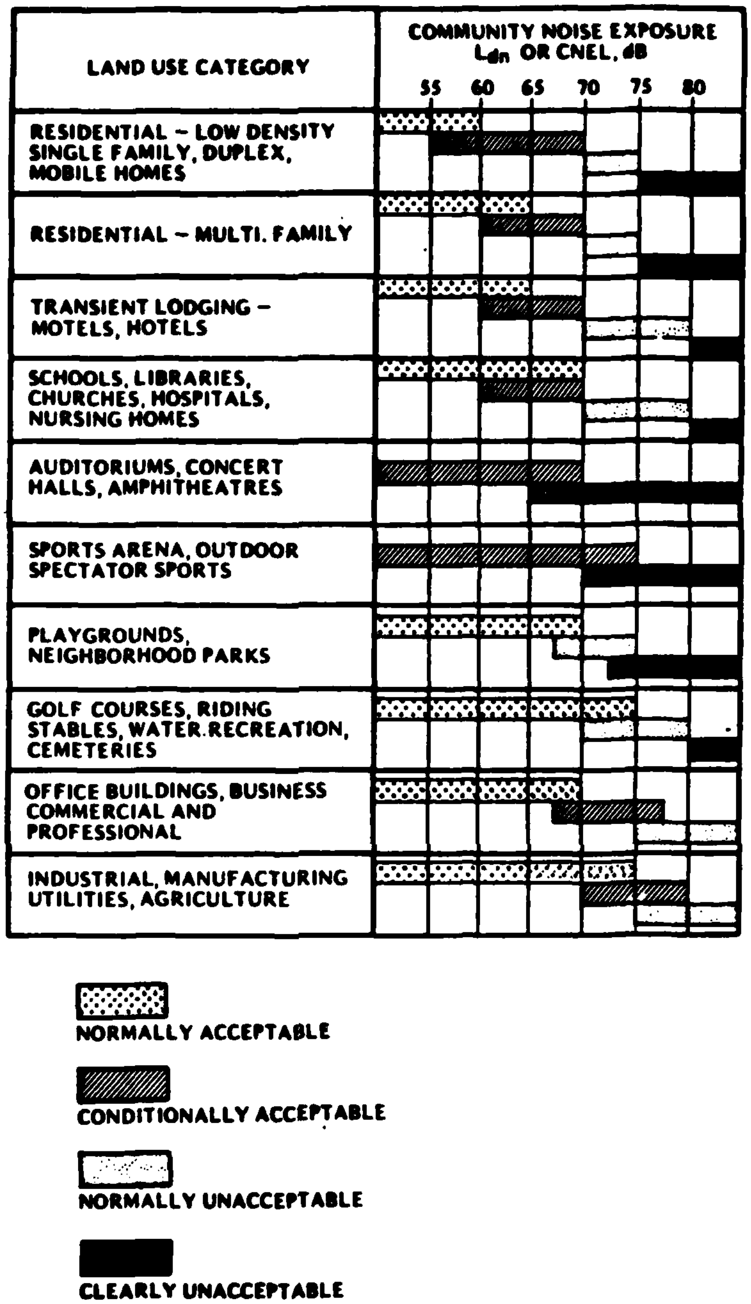
Vehicle Category (type)	Date of Manufacture	Maximum Sound Level, dBA
Any motor vehicle over 10,000 pounds (4,536 kg) GVWR[b] excluding buses	Before January 1, 1978	86
	After January 1, 1978	83
	After January 1, 1982	80
All buses over 10,000 pounds (4,536 kg) GVWR[b]	After January 1, 1980	85
	After January 1, 1983	83
	After January 1, 1986	80
Motorcycles	After January 1, 1976	83
	After January 1, 1986	80
Automobiles, light trucks and all other motor vehicles 10,000 pounds (4,536 kg) GVWR[b] or less	After January 1, 1976	80

(a) Data from: Washington Administrative Code, Chapter 173-62 (1980).
(b) GVWR = Gross Vehicle Weight Rating; see Footnote (b), Table 1.

It should be noted that the existing Washington State motor vehicle noise standards contained in WAC 173-62 impose restrictions on noise generated by specific categories of vehicles, as measured from a specified distance. The standards fall short of regulating the cumulative noise effects of multiple vehicles, each of which may be in compliance with noise performance standards. However, studies by the State of California Office of Noise Control (1976) have yielded criteria of noise acceptability for given land use categories. Figure 1 depicts these criteria graphically; supporting text for Figure 1 describes associated conditions and considerations associated with the criteria. These criteria provide a means for assessing the effects (in terms of relative acceptability) of cumulative noise levels on noise-sensitive uses.

3.2.4 WAC 173-70: WATERCRAFT NOISE PERFORMANCE STANDARDS

Water noise is also governed by regulations contained in the Washington Administrative Code, Chapter 173-70. "Watercraft," as defined in the regulations, means "any contrivance, excluding aircraft, used or capable of being used as a means of transportation or recreation on water." Specifically, watercraft *noise performance* standards limit (1) noise imposed by watercraft on shorelines and other receiving properties (see Table 6); (2) noise emanating from watercraft measured at a distance of not less than 50 feet (15.2 meters) from the closest point of the watercraft's hull (see Table 7), and (3) noise as measured at a distance of 0.5 meter from a watercraft's outlet (see Table 8). Commercial, non-recreational watercraft, and dredging and auxiliary equipment are exempted from watercraft noise regulations.



Source:
State of California, Office of Noise Control, 1976. "Guidelines for the Preparation and Content of Noise Elements of the General Plan", as reproduced in Dames & Moore (1978).

FIGURE 1

LAND USE COMPATABILITY FOR COMMUNITY NOISE ENVIRONMENTS

FIGURE 1 Cont.: LAND USE COMPATABILITY FOR COMMUNITY NOISE ENVIRONMENTS.

INTERPRETATION

NORMALLY ACCEPTABLE: Specified land use is satisfactory, based upon the the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.

CONDITIONALLY ACCEPTABLE: New construction or development should generally be avoided except as possible infill of already developed area. In such cases, new construction or development should be undertaken only after a detailed analysis of the noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply system or air conditioning will normally suffice.

NORMALLY UNACCEPTABLE: New construction or development should generally be discouraged. Conventional construction will generally be inadequate, and special noise insulation features must be included. If new constuction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

CLEARLY UNACCEPTABLE: New construction or development should generally not be undertaken.

CONSIDERATION IN DETERMINATION OF NOISE-COMPATIBLE LAND USE

A. NOISE SOURCE CHARACTERISTICS

The land use-noise compatibility recommendations should be viewed in relation to the specific source of the noise. For example, aircraft and railroad noise is normally made up of higher single noise events than auto traffic but occurs less frequently. Therefore, different sources yielding the same composite noise exposure do not necessarily create the same noise environment.

B. SUITABLE INTERIOR ENVIRONMENTS

One objective of locating residential units relative to a known noise source is to maintain a suitable interior day-night sound environment at no greater than 45 dB. This requirement, coupled with the measured or calculated noise reduction performance of the type of structure under consideration, should govern the minimum acceptable distance to a noise source.

C. ACCEPTABLE OUTDOOR ENVIRONMENTS

Another consideration, which in some communities is an overriding factor, is the desire for an acceptable outdoor sound environment. When this is the case, more restrictive standards for land use compatibility, typically below the maximum considered "normally acceptable" for that land use category, may be appropriate.

TABLE 6

WASHINGTON STATE NOISE STANDARDS FOR WATERCRAFT
(FROM SHORELINE OR RECEIVING PROPERTY)[a]

Time	Maximum Sound Level, dBA
Day or night in any receiving property	74
Sunset to sunrise for Class A EDNA	64

(a) Data from: Washington Adminstrative Code, Chapter 173-70.

TABLE 7

WASHINGTON STATE NOISE STANDARDS FOR WATERCRAFT
(MEASURED AT 50 FEET [15.2 METERS] FROM WATERCRAFT'S HULL)[a]

Date of Manufacture	Maximum Sound Level, dBA
Before January 1, 1980	84
After January 1, 1980	82
After January 1, 1984	80

(a) Data from: Washington Administrative Code, Chapter 173-70.

TABLE 8

WASHINGTON STATE NOISE STANDARDS FOR WATERCRAFT
(MEASURED AT 0.5 METER FROM EXHAUST OUTLET)[a]

Date of Manufacture	Maximum Sound Level, dBA[b]
Before January 1, 1980	98
After January 1, 1980	96
After January 1, 1984	94

(a) Data from: Washington Administrative Code, Chapter 173-70.

(b) Does not apply to exhaust systems which utilize the introduction of water to the exhaust gas flow, or systems that exhaust the gas directly into water.

4.0 STUDY AREA NOISE SOURCES

4.1 GENERAL

Sound level contours in a report prepared for the City of Tacoma Planning Department (Dames & Moore 1978) provided the basis for the description of the sound environment presented below. Supplemental sound level data were obtained from additional reports and limited field observations. The sound level contour maps prepared for the City of Tacoma are not included in this report due to: (1) the physical size of the maps (approximate 5 feet by 5 feet) and (2) the inability to reduce the maps to report size without loss of contour line resolution. However, these maps are available for review at the City of Tacoma Planning Department offices.

Available data indicate that automobile and truck traffic along major roadways generally constitutes the primary source of noise throughout the study area. In the port industrial area and along Ruston Way near the ASARCO smelter, railroad noise and other noises associated with industrial activity become significant elements of ambient noise levels. The primary sources of noise within each major subarea of the greater study area are identified below.

4.2 NORTH SHORE

Sound level contours (Dames & Moore 1978) indicate that the major source of noise along the bluffs from Browns Point to the intersection of Marine View Drive and East 11th Street is from motor vehicles traveling along Marine View Drive. Intermittent background industrial noise adds to ambient sound levels. Calculations indicate day-night (L_{dn}) sound levels of approximately 70 dB within 100 feet of the roadway. Sound levels decrease rapidly to approximately 60 dB at 400 feet from the roadway. L_{dn} sound levels along East 11th Street south of Marine View Drive are slightly higher (approximately 1 dB). Noise measurements taken by URS (1978) show L_{dn} sound levels of 59-63 dB due to traffic noise along Marine View Drive near north Hylebos Waterway.

Data gathered by both Dames & Moore and URS in 1978 confirm noise data collected in northeast Tacoma by the city during 1977 and presented in the Final Environmental Impact Statement for the Northeast Tacoma Plan (City of Tacoma 1979). Field measurements of noise levels indicated that the most significant noise sources in northeast Tacoma, part of which is located within the Commencement Bay study area, were "cars and trucks, followed by industrial operations." At the Cliff House Restaurant, located just inside the study area, noise was dominated by vehicular traffic along Marine View Drive. High L_{10} sound levels at this location ranged from 64 (a.m.) to 67 (p.m.) dBA. The only other noise monitoring locations near the study area are: (1) the Top Eight Apartments on Browns Point Boulevard and Murray Road, and (2) the intersection of 40th Street N.E. and Browns Point Boulevard. Noise at both locations was dominated by automobile and industrial background noise originating from the port industrial area below. High L_{10} sound levels ranged from 54 (p.m.) to 63 (a.m.) dBA at the Top Eight Apartments, and from 56 (p.m.) to 66 (a.m.) dBA at 40th Street N.E. and Browns Point Boulevard (City of Tacoma 1979).

Since the highest noise levels in this portion of the study area are attributable to vehicular traffic and while noise levels imposed by the cumulative effect of multiple vehicles are not restricted by state regulations (see discussion above), an assessment of noise effects on sensitive receptors in the area may be made by applying the State of California criteria for noise acceptability (see Figure 1). Residential uses constitute the noise receptors in the north shore area that are most sensitive to noise originating from sources in the study area. Within the boundaries of the study area such uses are generally limited to a few residences along the shore to the south of Marine View Drive. Just outside the study area, at the top of the surrounding bluffs, residential uses comprise the major land use. In any case, L_{dn} sound levels likely exceed the State of California criteria of acceptability only at those few residences along Marine View Drive. These uses are, for the most part, less than 100 feet from the roadway; therefore, L_{dn} sound levels relative to these uses likely are in the "normally unacceptable" or "clearly unacceptable" range. It should be noted that these levels are likely attenuated by natural noise barriers (such as topography and foliage) and the irregularity of traffic along Marine View Drive.

4.3 PORT INDUSTRIAL AREA

The sound environment in the port industrial area of Tacoma between Hylebos and City Waterways is generally dominated by noise generated by the considerable industrial activity in the area. The major arterials accessing industrial uses constitute the single most significant noise source in the area. Such arterials include East 11th Street, Port of Tacoma Road, Portland Avenue, and Lincoln Avenue. Noise calculations based on traffic along these arterials generally indicate L_{dn} values of 70 to 80 dB at a distance of 100 feet from the center of each of the first three arterials and L_{dn} values of 60 to 70 for Lincoln Avenue.

Measurements taken by URS (1978) between Western Farmers Association and the Tacoma City Light power plant on the south shore of the Hylebos Waterway indicate a L_{dn} sound level of 61 dB. Industrial noise sources, rather than traffic noise, contribute most significantly to sound levels at this location.

Railroad and dredging operations also contribute to noise levels in the port area, although such noise is intermittent in nature. Wheel flange squeals from moving rail cars constitute one of the most significant single sources of noise. Wheel flange squeal measurements conducted at Pier 86 in Seattle indicate peak levels of about 77 dB (Port of Tacoma 1974). Measurements of noise associated with periodic dredging and deepening of waterways activities in the port area indicate noise levels of 68 to 72 dB (U.S. Army Corps of Engineers 1977). Other noise sources in the area include grain elevator operations, marine vessels, shipbuilding activities, petroleum storage, paper and lumber processing, terminal docking, and unloading.

Generally, sensitive receptors are limited within the port industrial area. A few scattered residential uses are located along arterials serving the area, but these uses are relatively distant from industrial noise sources and are affected to a greater degree by traffic noise.

4.4 SOUTH SHORE

The south shore of Commencement Bay, extending from downtown Tacoma to Point Defiance Park, is characterized by industrial activities that include ASARCO's Tacoma smelter and the Burlington Northern Railroad, which runs along most of the shoreline. Automobile and truck traffic along Schuster Parkway and Ruston Way is the main source of noise along with intermittent railroad noises. However, switchgear operations, the operation of the steady-state cooling tower (68 dB at nearby industrial locations), and the venting of storage tanks at the ASARCO smelter also contribute to the local sound environment, as do numerous aircraft flyovers. These noise sources are generally in compliance with state regulations limiting noise imposed on nearby sensitive noise receptors.

Sensitive receptors along the south shore of the study area are limited to a relatively few residential uses in the Old Tacoma area and scattered residential uses to the west along Ruston Way. Like the north shore, residential uses dominate inland from the bluff line paralleling the south shore. Existing data indicate that noise levels in residential areas along the south shore, like other locations in the study area, are dominated by traffic noise from nearby arterials, specifically Schuster Parkway and Ruston Way (Dames & Moore 1978). Traffic noise contours along Schuster Parkway and Ruston Way indicate that L_{dn} sound levels in Old Tacoma and other residential areas are generally in the "conditionally acceptable" category when the State of California criteria are applied. Traffic-generated and railroad noise decreases sharply with distance inland due to the attenuating properties of the terrain. As a result, major arterials and associated activities do not impose severe noise impacts on local sensitive receptors.

5.0 REFERENCES

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TECHNICAL REPORT

CLIMATE AND AIR QUALITY

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1.0 INTRODUCTION

This report summarizes climatological and air quality conditions within the Commencement Bay study area. Data presented herein are responsive to Section 3.10.1 of the U.S. Army Corps of Engineers' Statement of Work for the Commencement Bay Studies (COBS). These data were compiled from a variety of sources including, but not limited to, the Puget Sound Air Pollution Control Agency (PSAPCA); Washington State Department of Ecology (DOE); Washington State Office of Air Programs; U.S. Department of Health, Education, and Welfare; and the Pacific Northwest River Basins Commission.

This report first describes regional and local climatic conditions. Temperature, humidity, precipitation, wind, and storm data compiled over prolonged periods are summarized to determine prevailing conditions.

Second, air quality conditions are summarized and analyzed. Ambient levels of particulates, sulfur oxides, carbon monoxide, photochemical oxidants, ozone, hydrocarbons, nitrogen oxides, lead, and arsenic are examined and compared to existing local, state, and national standards. A summary of excursions of these standards is presented for each monitored pollutant. Data examined consist of the latest years' records which have been processed and analyzed, and which are available as of July 1, 1980.

Third, this report identifies major point sources within the study area and quantifies associated emissions. A brief description of the causes of acid rain and local contribution of the constituents of acid rain is also presented.

2.0 CLIMATOLOGY

2.1 REGIONAL CLIMATOLOGY

In general, the climate and weather of the Puget Sound region is influenced by three geographical features: the Pacific Ocean, the Olympic Mountains, and the Cascade Mountains.

The overall marine influence of the Pacific Ocean results in a much milder climate than that found inland at similar latitudes (Phillips 1972). The gross features of this marine type of climate, which is dominated by the cool, moist prevailing westerlies, include a small annual range in temperature, a distinct cold season precipitation maximum with low daily intensity, and a relatively dry summer with temperatures rarely exceeding 90°F.

The Olympic Mountains to the west provide an effective barrier to the influx of Pacific migrant storm systems. For example, the Seattle-Tacoma lowland area averages less than 40 inches of precipitation annually while Aberdeen, on the coast, averages more than 80 inches.

The passage of winter storm systems moving in from the Pacific Ocean and the local topography greatly influence the winter winds. Occasionally, an overflow of cold, dry air from the interior may cause strong, cold winds. During the summer months, the winds are relatively light as the summer wind patterns are strongly influenced by the location of the predominating Pacific anticyclone. As this Pacific high shunts weather systems further to the north, Pacific storms reaching the area are infrequent and usually weak.

The topographical barrier of the Cascade Mountains also influences the region's climatology by blocking colder continental air from the interior. Occasionally, however, continental air does "spill over" and results in colder weather in the winter and hotter weather in the summer.

Local climatological conditions in the Commencement Bay area can be described by summarized long-term climatological data for three locations: Tacoma City Hall (Tacoma), Seattle-Tacoma International Airport (Sea-Tac), and Vashon Island (Vashon). Of these locations, Tacoma City Hall is physically closest to the study.

2.2 LOCAL METEOROLOGY

2.2.1 TEMPERATURE AND HUMIDITY

Table 1 presents the annual temperature distributions for the three weather stations near Commencement Bay. Despite variations in settings (urban, suburban, and rural), temperature patterns are similar for all three stations. Average winter temperatures range from low to mid-30s (°F) at night to the low to upper 40s (°F) in the daytime. Temperatures below 0°F have occurred in many places in the region but are rare. Summertime temperatures normally have a minimum in the low to mid-50s (°F) and a maximum in the mid-70s (°F). Temperatures may occasionally exceed 90°F in the summer, but rarely exceed 100°F.

Tacoma has never experienced temperatures as low as 0°F. Temperatures can be expected to fall to or below 32°F about 32 times a year; while temperatures above 90°F occur an average of less than 1 time per year (U.S. Weather Bureau 1968). The temperature extremes for each location are presented in Table 2.

Table 3 presents the relative humidity for Tacoma and Sea-Tac. Winter humidity varies little throughout the day while summer humidity is significantly reduced during the afternoon hours. The most humid time of day is 4 a.m., the least humid, 4 p.m. for both stations. The 4 a.m. relative humidity is highest in the summer and fall at Sea-Tac and highest in the fall and winter at Tacoma.

TABLE 1

MONTHLY AND ANNUAL MEAN TEMPERATURES (°F)

	Tacoma[a,b]			Seattle-Tacoma Airport[c,d]			Vashon[b,e]		
Month	High	Low	Mean	High	Low	Mean	High	Low	Mean
January	44.9	34.8	39.9	43.5	33.5	38.5	43.5	33.3	38.4
February	48.4	36.7	42.6	48.5	36.3	42.4	47.6	35.0	41.3
March	52.3	38.6	45.5	51.0	36.9	44.0	52.5	36.6	44.6
April	59.0	42.5	50.8	56.6	40.2	48.4	59.5	40.3	49.9
May	65.0	47.3	56.2	64.3	45.8	55.1	65.5	44.2	54.9
June	68.9	51.6	60.3	69.3	50.8	60.1	70.5	48.3	59.4
July	74.1	54.7	64.4	75.1	53.9	64.5	75.2	50.7	63.0
August	73.4	54.8	64.1	74.0	54.0	64.0	74.1	51.7	62.9
September	68.1	51.5	59.8	68.6	50.6	59.6	68.4	49.3	58.9
October	59.9	46.1	53.0	59.1	44.7	51.9	59.3	44.7	52.0
November	51.1	39.8	45.5	50.2	38.9	44.6	50.7	39.6	45.2
December	47.4	37.6	42.5	45.4	35.8	40.6	46.0	36.5	41.3
Annual	59.4	44.7	52.1	58.8	43.5	51.2	59.4	42.5	51.0

(a) Data period: 1931 - 1960.
(b) Data from: Phillips (1968).
(c) Data period: 1945 - 1978.
(d) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(e) Data period: 1931 - 1954.

TABLE 2

TEMPERATURE EXTREMES (°F)

Month	Tacoma[a,b] High	Tacoma[a,b] Low	Seattle-Tacoma Airport[c,d] High	Seattle-Tacoma Airport[c,d] Low	Vashon[b,e] High	Vashon[b,e] Low
January	67	9	61	0	66	5
February	73	9	70	1	68	9
March	77	18	72	11	78	21
April	86	24	85	29	85	25
May	91	30	93	28	90	29
June	98	37	96	38	95	32
July	98	42	97	43	96	38
August	95	44	99	44	95	40
September	90	35	93	35	93	32
October	82	29	81	28	83	21
November	70	8	74	6	78	15
December	65	7	61	6	68	7
Annual	98	7	99	0	96	5
Year	1925	1924	1960	1950	1942	1922

(a) Data period: 1896 - 1965.
(b) Data from: Pacific Northwest River Basins Commission, Meteorologic Committee (1969a).
(c) Data period: 1945 - 1978.
(d) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(e) Data period: 1888 - 1954.

TABLE 3

RELATIVE HUMIDITY
(in percent)

Month	Tacoma[a,b] 4 a.m.	Tacoma 10 a.m.	Tacoma 4 p.m.	Seattle-Tacoma Airport[c,d] 4 a.m.	Seattle-Tacoma Airport 10 a.m.	Seattle-Tacoma Airport 4 p.m.	Seattle-Tacoma Airport 10 p.m.
January	92	82	81	80	79	74	78
February	90	79	75	80	76	66	75
March	89	73	68	82	74	63	75
April	89	65	60	83	71	58	74
May	88	62	56	82	68	54	71
June	87	62	54	81	66	53	69
July	87	61	50	82	65	49	67
August	88	66	53	84	70	53	72
September	89	69	60	86	74	59	76
October	92	78	72	86	79	68	81
November	92	82	82	83	80	74	80
December	92	83	83	81	80	77	80
Annual Average	89	72	67	83	74	62	75

(a) Data from: Pacific Northwest River Basins Commission, Meteorologic Committee (1968b).
(b) Data period: 1923-1952.
(c) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(d) Data period: 1960 - 1978.

2.2.2 PRECIPITATION

The monthly and annual average precipitation for Tacoma, Sea-Tac, and Vashon is given in Table 4. All three stations exhibit the rain shadow effect of the Olympic Mountains. A little more than 75 percent of the annual rainfall occurs in the six months from October through March; December is the wettest month at all three locations. Summer precipitation is minimal with only about 4 to 5 percent of the annual precipitation occurring during the months of July and August. The monthly and annual extremes of precipitation are presented in Table 5.

The maximum one-day rainfalls for the three locations are given in Table 6. Tacoma has had almost 4 inches and Vashon over 4 inches of rain in one day; the greatest one-day total for Sea-Tac is 3.41 inches.

The monthly and seasonal snowfall totals at the three weather stations are shown in Table 7. Tacoma, the station most representative of the study area, receives less than 10 inches of snowfall annually. Almost half of that total is likely to occur in the month of January. Snowfall through the area is quite variable and, in most cases, melts before any appreciable depth accumulates (Phillips, undated).

2.2.3 WIND

At Tacoma, the prevailing wind for the eight months comprising the storm season (October through May) is southwest, while during the summer months (June through September) the prevailing wind is from the north (U.S. Weather Bureau 1960). Strong winds can occur any time of the year and are generally associated with the south or southwest direction. The fastest 1-minute wind speed, during the period 1903-1951, was 61 miles per hour (mph) and was from the south (U.S. Weather Bureau 1960). The highest monthly average wind speed (8.8 mph) occurs in March and the lowest (6.8 mph) occurs in September (U.S. Weather Bureau 1960).

TABLE 4

MONTHLY AND ANNUAL AVERAGE PRECIPITATION
(inches)

Month	Tacoma[a,b]	Seattle-Tacoma Airport[c,d]	Vashon[b,e]
January	5.34	5.98	6.74
February	4.18	4.39	5.58
March	3.83	3.82	4.56
April	2.37	2.47	2.75
May	1.60	1.64	1.94
June	1.47	1.46	1.69
July	0.74	0.78	0.82
August	0.83	1.24	0.95
September	1.78	2.14	2.21
October	3.81	3.73	4.52
November	4.97	5.74	6.61
December	6.14	6.12	8.16
Annual	37.06	39.51	46.53

(a) Data period: 1931 - 1960.
(b) Data from: Pacific Northwest River Basins Commission, Meteorologic Committee (1969b).
(c) Data period: 1945 - 1978.
(d) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(e) Data period: 1931 - 1954.

TABLE 5

MONTHLY AND ANNUAL PRECIPITATION EXTREMES
(inches)

Month	Tacoma[a,b]		Seattle-Tacoma Airport[c,d]		Vashon[b,e]	
	Greatest	Least	Greatest	Least	Greatest	Least
January	9.57	0.66	12.92	0.86	17.01	1.19
February	7.33	1.52	9.11	1.58	10.48	2.31
March	7.12	1.77	8.40	0.57	7.24	2.25
April	5.27	0.24	4.19	0.33	6.87	0.82
May	4.39	0.16	4.76	0.35	5.12	0.18
June	5.60	0.08	3.90	0.13	5.20	0.15
July	3.00	0.00	2.10	T[f]	2.50	0.00
August	2.26	0.02	4.59	0.01	2.64	0.17
September	3.96	0.16	5.95	T	5.19	0.29
October	8.80	0.51	8.95	0.72	10.30	0.85
November	9.78	0.78	9.69	0.74	13.40	1.21
December	18.87	1.97	9.50	1.37	23.44	2.05
Annual	52.47	16.96	55.14	23.78	64.72	25.84

(a) Data period: 1931 - 1960.
(b) Data from: Phillips (1968).
(c) Data period: 1945 - 1978.
(d) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(e) Data period: 1931 - 1954.
(f) T = Trace

TABLE 6

MAXIMUM PRECIPITATION FOR ONE DAY
(inches)

Month	Tacoma[a,b] Amount	Tacoma[a,b] Year	Seattle-Tacoma Airport[c,d] Amount	Seattle-Tacoma Airport[c,d] Year	Vashon[a,e] Amount	Vashon[a,e] Year
January	3.38	1919	2.41	1967	3.24	1935
February	2.91	1932	3.41	1951	3.90	1951
March	2.63	1908	2.86	1972	2.40	1948
April	2.20	1899	1.85	1965	2.55	1899
May	1.71	1905	1.83	1969	1.40	1895
June	1.97	1936	1.75	1968	1.20	1931
July	1.55	1916	0.84	1974	1.09	1902
August	1.95	1936	1.75	1968	1.06	1936
September	2.13	1945	2.23	1978	1.65	1931
October	2.40	1934	2.27	1947	2.19	1927
November	3.79	1904	3.41	1959	4.29	1906
December	3.67	1921	2.53	1959	3.22	1937
Annual	3.79	1904	3.41	1959	4.29	1906

(a) Data from: Pacific Northwest River Basins Commission, Meteorologic Committee (1969b).
(b) Data period: 1881 - 1965.
(c) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(d) Data period: 1945 - 1978.
(e) Data period: 1895 - 1954.

TABLE 7

MONTHLY AND SEASONAL SNOWFALL
(inches)

Month	Tacoma[a,b,c]			Seattle-Tacoma Airport[c,d,e]			Vashon[a,c,f]		
	Mean	Median	Greatest	Mean	Median	Greatest	Mean	Median	Greatest
July	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0
September	0	0	0	T[g]	0	T	0	0	0
October	0	0	0	0.1	0	2.0	0	0	0
November	0.9	0	18.7	1.2	T	13.7	0.4	0	7.5
December	0.8	T	10.0	3.1	0.6	22.1	0.7	T	7.7
January	4.7	1.3	33.3	6.6	2.5	57.2	4.6	2.7	19.5
February	1.8	0.3	10.8	1.6	T	13.1	1.2	T	20.0
March	0.9	T	12.7	1.6	T	18.2	0.8	T	11.3
April	0.1	0	5.0	0.1	T	2.3	0	0	0
May	0	0	0	T	0	T	0	0	0
June	0	0	0	0	0	0	0	0	0
Season	9.2	--[h]	44.0	14.8	--	67.5	7.7	--	24.7

(a) Data from: Pacific Northwest River Basins Commission, Meteorologic Committee (1969b).
(b) Data period: 24 years in the period 1931 - 1965.
(c) Least monthly is 0, least seasonal is trace.
(d) Data from: U.S. Environmental Data and Information Service, National Climatic Center (1979).
(e) Data period: 1945 - 1978.
(f) Data period: 1931 - 1954.
(g) T = Trace
(h) -- = no value given in data source

Winds at Sea-Tac, based on a 15-year period, show a strong predominance for directions with a southerly component. During 11 months, the prevailing wind is from either the south, south-southwest, or southwest direction with south-southwest being the most common (U.S. Environmental Data and Information Service, National Climatic Center 1979). Only in September, when the prevailing wind is from the north, is this pattern interrupted. The highest monthly mean wind speeds are characteristic of the winter months (10.1 mph in January and March). The lowest mean wind speed (8.0 mph) occurs in August (U.S. Environmental Data and Information Service, National Climatic Center 1979). The strongest winds are generally from the southwest (although occasionally from the south) and usually occur when the more intense Pacific storms move inland. Extreme winds in excess of 55 mph occur on the average of once in 2 years, 80 mph once in 50 years, and 90 mph once in 100 years (Phillips 1968). The fastest 1-minute wind speed, for the data period 1944-1962, is 56 mph and is associated with the south-southwest direction (PNRBC 1968a). The peak wind gust ws 67 mph from the southwest (PNRBC 1968a).

2.2.4 THUNDERSTORMS, HAIL, ICE STORMS, TORNADOES

An average of seven thunderstorms occur per year at Sea-Tac, with about one per month in the spring and summer months (U.S. Environmental Data and Information Service, National Climatic Center 1979). The occurrence of hailstorms is rare in the Puget Sound region. Hailstorms occur primarily in the winter and early spring. Hail of sufficient size or intensity to cause crop or property damage has rarely been reported (Phillips 1968). Freezing rain or drizzle is recorded at Sea-Tac during an average of about two hourly observations per month in January with less in February, November, and December. Twenty-three tornadoes occurred on 17 different days within the State of Washington during the period 1956-1975 (7,305 days), for an average of 0.17 tornado per 10,000 square miles per year. There were 6 tornado-related deaths during this period (Ruffner and Bair 1977).

3.0 AIR QUALITY

3.1 GENERAL

A summary of ambient air quality measurements consisting of monitoring data taken over the last 3 years (1977-1979) is presented in this section. These data have been obtained from air quality monitoring stations operated by Puget Sound Air Pollution Control Agency (PSAPCA); Washington State Department of Ecology (DOE); and ASARCO (through PSAPCA). National, state, and local ambient air quality standards are also discussed in this section.

3.2 AIR QUALITY STANDARDS

The national, Washington State, and PSAPCA ambient air quality standards for the criteria pollutants are given in Table 8. All of the standards limit the number of times a pollutant concentration may exceed the applicable standard over a given time period without being termed a "violation." Concentrations in excess of the respective standards, but in insufficient quantity over the given time period, are not considered as violations; these events are termed "excursions".

The location of nine monitoring stations from which data used in this analysis were taken are depicted in Figure 1 and are described below in Table 9. Three of these stations (1, 2a and 2b, and 3) are located within the study area, while six stations (4, 5, 6, 7, 8, and 9) are located within 2,000 feet of the study area's boundary. These latter stations were included because of the effect any new projects within the study area may have on air quality just outside the boundary area. Table 9 shows the type of sampling performed at each of these stations as well as the station operator. Based on information gathered from these and other monitoring stations, portions of the study area have been designated as nonattainment for certain pollutants. Figure 2 depicts that portion of the study area that is nonattainment for total suspended particulates (TSP). Table 10 describes the portions of the study area that are nonattainment for total suspended particulates, carbon monoxide, and

TABLE 8

AMBIENT AIR QUALITY STANDARDS

	National		Washington	
	Primary	Secondary	State	PSAPCA
Suspended Particulates ($\mu g/m^3$)				
Annual geometric mean[a]	75	60	60	60
24-hour average[b]	260	150	150	150
Lead ($\mu g/m^3$)				
Calendar quarter average[a]	1.5	1.5	NS	NS
Sulfur Dioxide (ppm)				
Annual average[a]	0.03	NS	0.02	0.02
30-day average[a]	NS[b]	NS	NS	0.04
24-hour average[c]	0.14	NS	0.10	NS
24-hour average[a]	NS	NS	NS	0.10
3-hour average[c]	NS	0.50	NS	NS
1-hour average[a]	NS	NS	0.40	0.40
1-hour average[d]	NS	NS	0.25	0.25
5-minute average[e]	NS	NS	NS	1.00
Carbon monoxide (ppm)				
8-hour average[c]	9	9	9	9
1-hour average[c]	35	35	35	35
Photochemical Oxidants (ppm)				
1-hour average[c]	0.12	0.12	0.12[f]	0.12
Nitrogen Oxide (ppm)				
Annual average[a]	0.05	0.05	0.05	0.05
Hydrocarbons (ppm)				
3-hour average[c,g]	0.24	0.24	0.24[h]	0.24

Data from: PSAPCA (1978; 1979).
$\mu g/m^3$ = micrograms per cubic meter
ppm = parts per million
(a) Never to be exceeded.
(b) NS = no corresponding standard for this averaging period.
(c) Not to be exceeded more than once per year.
(d) Not to be exceeded more than twice in 7 days.
(e) Not to be exceeded more than once in 8 hours.
(f) Applies only 10 a.m. to 4 p.m. PST from April 1 through October 31.
(g) Applies only from 6 a.m. to 9 a.m. daily.
(h) Applies only from April 1 through October 31.

TABLE 9

ATMOSPHERIC MONITORING NETWORK WITHIN COMMENCEMENT BAY AREA SINCE 1977[a]

Station Number	Monitoring Station Location[b]	Operator	Type of Monitoring: TSP	SO_2	CO	Pb
1	2340 Taylor Way	PSAPCA	X			
2a	Fire Station #12, 2136 E. 11th St. (1978-present)	PSAPCA	X			X
2b	Mann-Russell Electronics 1401 Thorne Rd. (1977)	PSAPCA	X			
3	Treatment Plant 1241 Cleveland Way	PSAPCA	X			
4	Plaza Parking Garage (Estab. 7/1/79) 1137 Commerce St.	DOE			X	
5	Meeker Jr. High School	ASARCO/ PSAPCA[c]	X	X		X
6	Fife Sr. High School 5616 20th E.	PSAPCA	X			
7	Hess Building 901 Tacoma Ave. S.	PSAPCA	X			
8	Ruston N. 46th and Orchard	ASARCO[d]		X		X
9	Armory Building (10/1/77-7/31/79) 715 S. 11th	DOE			X	

(a) Data from PSAPCA.
(b) See Figure 1 for location.
(c) Monitoring of TSP conducted in 1978 and 1977, SO_2 conducted in 1977 by PSAPCA.
(d) Monitoring of lead began in July 1979.

TABLE 10

NONATTAINMENT AREAS WITHIN CENTRAL PUGET SOUND REGION FOR SPECIFIC NATIONAL AMBIENT AIR QUALITY STANDARDS(a,b)

Pollutant	Primary Standard Exceeded	Secondary Standard Exceeded
TOTAL SUSPENDED PARTICULATE (TSP)		
Tacoma - That area including the port industrial area, east end of the CBD, and the north end of South Tacoma Way Corridor.	X	
Seattle - That area including the north portion of the Duwamish Industrial area, and extending to the southern boundary of the CBD.	X	
Seattle - South Park, an area of the Duwamish Valley extending approximately 2-1/2 miles further south than the above area.		X
Renton		X
Kent		X
CARBON MONOXIDE (CO)		
Greater Seattle-Tacoma Area-- Boundaries to be determined.	X	
OXIDANT (O_x)		
Greater Seattle-Tacoma Area-- In general, from Puget Sound at the west to North Bend at the east, from Puyallup at the south to Edmonds at the north.	X	

(a) Data from: Federal Register, March 3, 1978.
(b) Areas exceeding the primary standard also exceed the secondary standard.

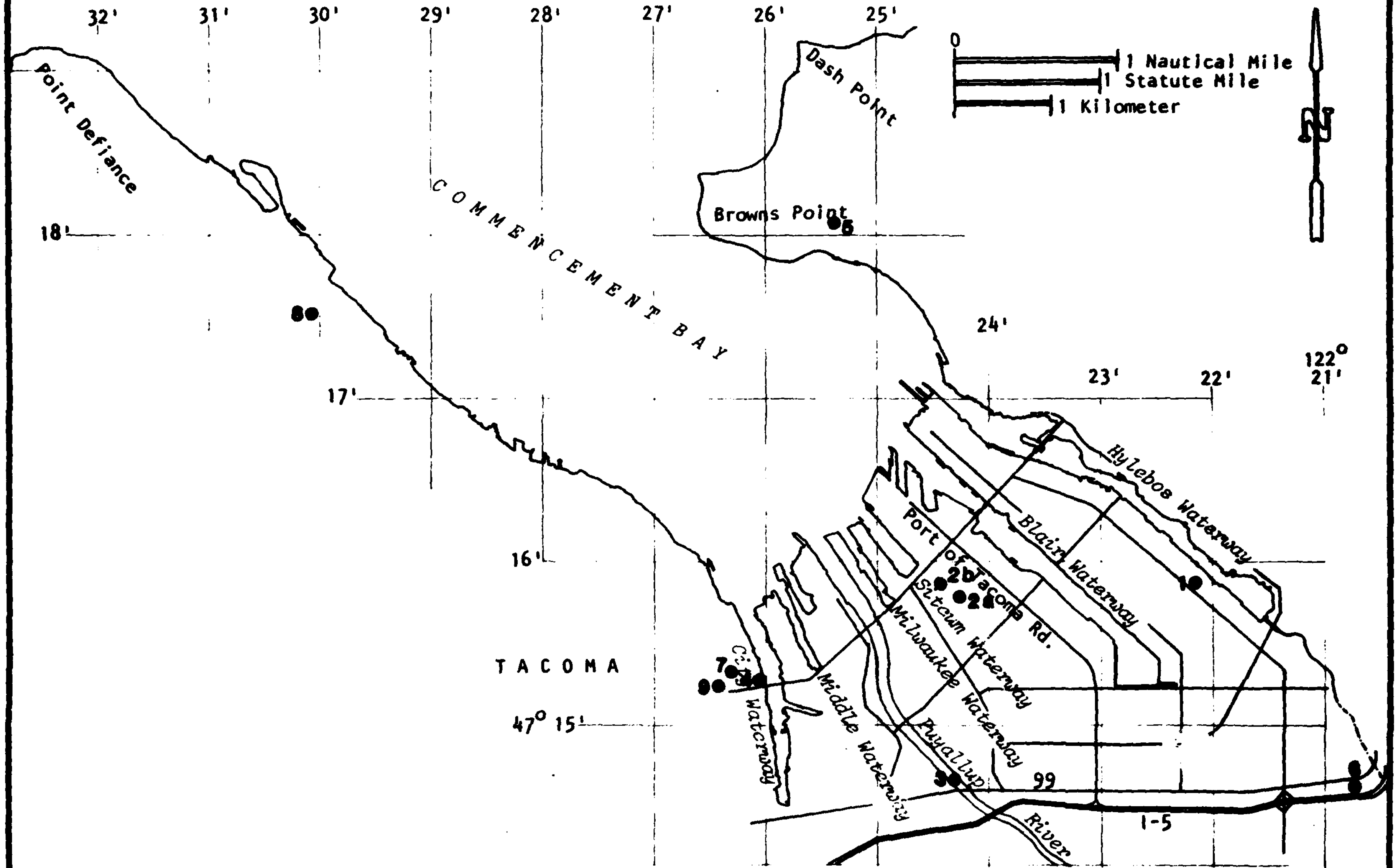

FIGURE 1
AIR QUALITY MONITORING STATIONS

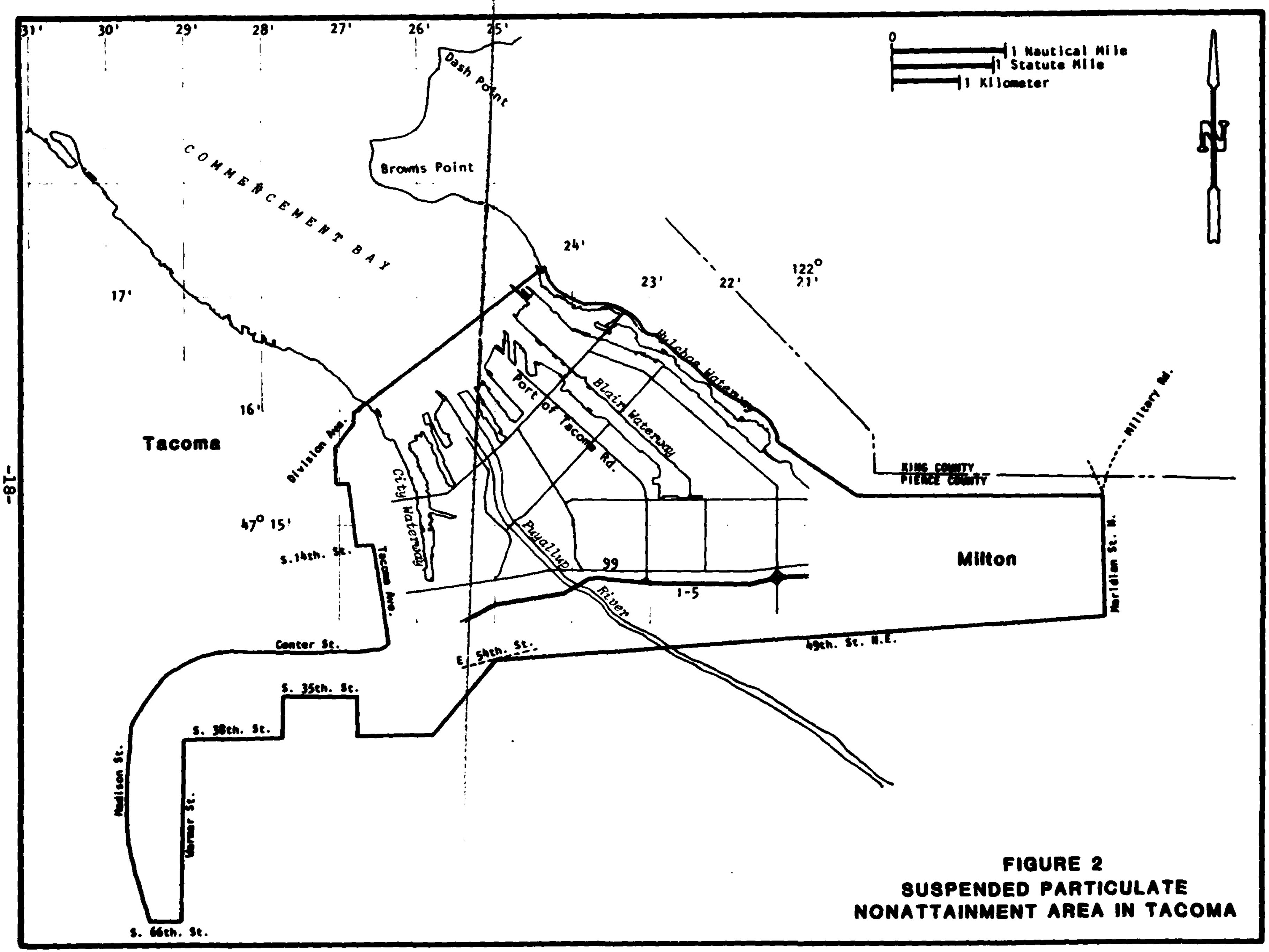

FIGURE 2
SUSPENDED PARTICULATE NONATTAINMENT AREA IN TACOMA

photochemical oxidants. Recent revision in the National Ambient Air Quality Standards (NAAQS) for photochemical oxidants (0.08 ppm to 0.12 ppm) may change the boundaries for the oxidant attainment area. EPA had formerly designated a parabolic area extending about 3-1/2 miles south-southwest from the ASARCO smelter as a sulfur dioxide (SO_2) nonattainment area. The designation for this area has since been changed to "unclassified;" that is, an SO_2 nonattainment area no longer exists locally.

3.3 PARTICULATES

As indicated in Table 9, most of the monitoring done in the Commencement Bay area is for particulates. High volume samplers, operated on an intermittent schedule, are used by PSAPCA to measure suspended particulate levels. Air is drawn through a fabric filter at a known flow rate for 24 hours. Particulate concentrations are determined by weighing the amount of particulate matter on the filter after the 24-hour exposure. The number of observations at each station will vary according to the sampling schedule. Infrequent instrument problems also reduce the number of valid samples.

Within the past 3 years (1977, 1978, and 1979), all three monitoring stations located in the study area have exceeded the PSAPCA, DOE, and NAAQS TSP primary and secondary annual standards. Table 11 presents the number of excursions of the 24-hour TSP standard established by PSAPCA and DOE for each monitoring station where TSP was monitored. For TSP, one excursion is allowed each year before a violation is recorded. Many violations of the state and PSAPCA TSP standards occur within the study area each year. Table 12 presents the number of excursions of the 24-hour TSP NAAQS for each of the monitoring locations listed in Table 11. A definite increasing trend in the number of violations occurring in the Port of Tacoma area, specifically at the fire station (Monitoring Station 2a), can be seen.

Ambient levels of TSP are best seen from the annual TSP concentration levels observed in the Port of Tacoma area. Areas outside the port area but within the study area are presumed to have low TSP concentrations,

TABLE 11

EXCURSIONS OF THE STATE OF WASHINGTON AND PSAPCA STANDARDS FOR THE 24-HOUR AVERAGE OF TSP[(a)]

Monitoring Station/ Location		Number of Excursions Each Year							
		1980[(b)]	No. of Observ.	1979	No. of Observ.	1978	No. of Observ.	1977	No. of Observ.
WITHIN THE STUDY AREA BOUNDARIES									
1	2340 Taylor Way	N/A[(c)]	N/A	9	61	5	60	9	61
2a 2b	Fire Station #12/ Mann-Russell Electronics[(d)]	10	32	42	130	28	118	11	62
3	Treatment Plant	N/A	N/A	9	61	5	60	6	63
NEAR STUDY AREA									
5	Meeker Jr. High School	N/A	N/A	N/A	N/A	0	23	0	61
6	Fife Sr. High School	N/A	N/A	0	56	0	60	0	59
7	Hess Building	1	14	1	60	0	60	0	60

(a) Information from PSAPCA.
(b) First quarter only.
(c) N/A - not available.
(d) Located at 1401 Thorne Road (Mann-Russell Electronics), 1977 only.

TABLE 12

EXCURSIONS OF THE NAAQS FOR THE 24-HOUR AVERAGE OF TSP[a]

Monitoring Station/ Location	Number of Excursions Each Year							
	1980[b]	No. of Observ.	1979	No. of Observ.	1978	No. of Observ.	1977	No. of Observ.
WITHIN THE STUDY AREA BOUNDARIES								
1 2340 Taylor Way	N/A[c]	N/A	1	61	1	60	1	61
2a Fire Station #12/ 2b Mann-Russell Electronics[d]	1	32	5	130	2	118	0	62
3 Treatment Plant	N/A	N/A	0	61	0	60	0	63
NEAR STUDY AREA								
5 Meeker Jr. High School	N/A	N/A	N/A	N/A	0	23	0	61
6 Fife Sr. High School	N/A	N/A	0	56	0	60	0	59
7 Hess Building	0	14	0	60	0	60	0	60

(a) Information from PSAPCA.
(b) First quarter only.
(c) N/A - Not available.
(d) Located at 1401 Thorne Road (Mann-Russell Electronics), 1977 only.

with the possible exception of the Tacoma smelter site. Higher TSP values throughout the area are associated with emissions of fugitive dust particulates from various sources. The highest annual geometric mean was 112 $\mu g/m^3$ in 1977 at the treatment plant monitor (Monitoring Station 3). This portion of the study area exceeds both the NAAQS primary and secondary standards of 75 $\mu g/m^3$ and 60 $\mu g/m^3$, respectively. However, the 1979 values of 112, 88, and 84 $\mu g/m^3$ at the three stations show a steady increase in the annual geometric mean for TSP.

3.4 SULFUR DIOXIDE (SO_2)

This section deals with measured SO_2 concentrations as recorded by the monitoring stations near the study area. Table 13 shows the number of violations of the federal, state, and local ambient air quality standards that have occurred near the Commencement Bay area over a 3-year period. Neither the 24-hour nor the 3-hour NAAQS values of 365 ppm and 1,300 ppm, respectively, have been violated. However, frequent violations of the slightly more stringent PSAPCA and Washington State short-term standards have occurred. Even though the monitoring stations listed in Table 13 are located outside of the Commencement Bay study area (see Figure 1), their proximity and the fact that nearly all of the SO_2 sources in the area lie within the study area indicate that violations of the PSAPCA and State of Washington standards are likely to occur within the study area.

Long-term standards, such as the PSAPCA 30-day standard and the NAAQS, have not been violated at any of these monitoring stations for at least the last 3 years.

3.5 CARBON MONOXIDE (CO)

Table 14 presents the number of days in violation of the NAAQS for CO that occurred at 2 monitoring stations in and near the study area for the past 3 years. The Plaza Parking Garage in the Tacoma Central Business District (CBD) experienced violations of the 8-hour carbon monoxide standard in 1980. Currently the Tacoma CBD is designated as a

TABLE 13

VIOLATIONS OF THE NATIONAL, STATE OF WASHINGTON[a], AND PSAPCA SHORT-TERM AMBIENT AIR QUALITY STANDARDS FOR SO_2[b] NEAR COMMENCEMENT BAY

Year	Location	Number of Violations for: PSAPCA 5-min. 1.0 ppm	PSAPCA 1-hr 0.40 ppm	PSAPCA 1-hr 0.25 ppm	NAAQS 3-hr 0.50 ppm	PSAPCA 24-hr 0.10 ppm	NAAQS 24-hr 0.14 ppm
1977	Meeker Jr. High School[c] (Monitoring Station 5)	0	2	1	0	0	0
	Meeker Jr. High School[d] (Monitoring Station 5)	0	1	1	0	1	0
1978	Meeker Jr. High School	3	4	4	0	0	0
	Ruston[d]	4	0	0	0	0	0
1979	Meeker Jr. High School	0	1	0	0	0	0
	Ruston[d]	3	3	2	0	0	0

(a) Washington State and PSAPCA standards are identical.
(b) Data from ASARCO obtained through PSAPCA.
(c) PSAPCA monitoring system.
(d) ASARCO monitoring system.

TABLE 14

NUMBER OF DAYS IN VIOLATION OF THE NAAQS FOR CARBON MONOXIDE[a]

Year	Location	8-hour[b] Average	1-hour Average
1977			
NEAR STUDY AREA			
	Armory Building (Monitoring Station 9) (10/1/77-7/31/79)	1	0
1978			
NEAR STUDY AREA			
	Armory Building (10/1/77-7/31/79)	1	0
1979			
WITHIN STUDY AREA			
	Plaza Parking Garage (7/1/79-present)	11	1
NEAR STUDY AREA			
	Armory Building (10/1/77-7/31/79)	0	0
1980[c]			
WITHIN STUDY AREA			
	Plaza Parking Garage (7/1/79-present)	8	0

(a) Washington State air monitoring data, 1977, 1978, 1979, first quarter 1980.
(b) Number of violations per day.
(c) Data from: Townes (1981).

portion of the Greater Seattle-Tacoma nonattainment area for carbon monoxide. The extent of this nonattainment area is now being re-evaluated (Schmidt 1981). Future designations of CO nonattainment areas may be amended to include only the local areas around ambient air quality monitors where the CO standards are being exceeded (Schmidt 1981). The Tacoma CBD nonattainment area in this case will not reach Commencement Bay (Schmidt 1981).

3.6 PHOTOCHEMICAL OXIDANTS, OZONE, HYDROCARBONS, AND NITROGEN OXIDES

The oxidant found in the largest amounts is ozone, a reactive form of oxygen. Most oxidants are not directly emitted into the atmosphere but instead result from a series of complex photochemical reactions between nitrogen oxides and reactive hydrocarbons in the presence of sunlight. These photochemical reactions occur over several hours, generally producing maximum ozone levels downwind of the major sources of the oxidant precursors. While monitoring data in the Tacoma area indicate that the oxidant standard is being met, the photochemical process may cause the oxidant standard to be exceeded downwind of the study area. Recent revision of the photochemical oxidant standard to 0.12 ppm may bring areas which exceeded the previous 1-hour ozone standard of 0.08 ppm into compliance of the new standard. Even under the new standard, violations would still have occurred at both Sumner Junior High School and Graham Fire Station #21 (located several miles to the south-southeast) in 1977, 1978, and 1979.

Currently, the State of Washington is considered an attainment area for nitrogen dioxide.

Ambient measurements of hydrocarbons (HC), another of the ozone precursors, have not been undertaken in the study area, due to the difficulty of such measurements. The hydrocarbon standard pertains to a 3-hour period between 6 a.m. and 9 a.m. daily and was intended to assess the impact of automobile-related HC emissions. Several point sources of HC exist in the Commencement Bay area. These sources emit approximately 2,700 tons of HC per year (see Table 16 below). Without monitoring the study area, it is difficult assess ambient HC levels. For a comparison, the heavily industrialized Duwamish area of Seattle exceeded the 3-hour HC standard in 150 days in 1976. The maximum value recorded was 1.61 ppm, well above the standard of 0.24 ppm.

3.7 LEAD

Based on studies of lead health effects, the U.S. EPA established an ambient air quality standard for lead of 1.5 $\mu g/m^3$ per calendar quarter in October 1978. Ambient lead has been monitored at Fire Station #12 in Tacoma (Monitoring Station 2a in Figure 1) since the beginning of 1978 by analyzing the chemical content of a high volume filter. All four quarters in 1978 showed values below the standard (1.21, 1.23, 1.09, and 1.04 $\mu g/m^3$). Similar values were obtained in 1979 for this location. Monthly values of lead concentrations have been measured at both Meeker Junior High School and Ruston (Monitoring Stations 5 and 9, respectively). The highest monthly average since 1977 at Meeker was 0.807 $\mu g/m^3$ and 0.935 $\mu g/m^3$ at Ruston since monitoring began in 1979. These values are below the quarterly standard of 1.5 $\mu g/m^3$; therefore, the study area is in attainment for lead.

3.8 ARSENIC

Although no standard currently exists for arsenic concentrations, high arsenic concentrations may have the potential for causing adverse health effects (U.S. Department of Health, Education, and Welfare 1969). Arsenic concentrations are being measured near the ASARCO Tacoma smelter (see Figure 3). A summary of 24-hour concentrations since 1977 is presented in Table 15.

Over the last 3 years, the year with the greatest number of days in the 2 to 4 $\mu g/m^3$ range is 1979. The year with the greatest number of days above 4 $\mu g/m^3$ is 1978. The highest 24-hour average since 1977 (51.82 $\mu g/m^3$) also occurred in 1978 at the Parking Lot station. In 1979, the Stack station in 1979 was the only station where arsenic levels above 10 $\mu g/m^3$ were measured; this occurred on six occasions, with the highest level that year being 14.40 $\mu g/m^3$.

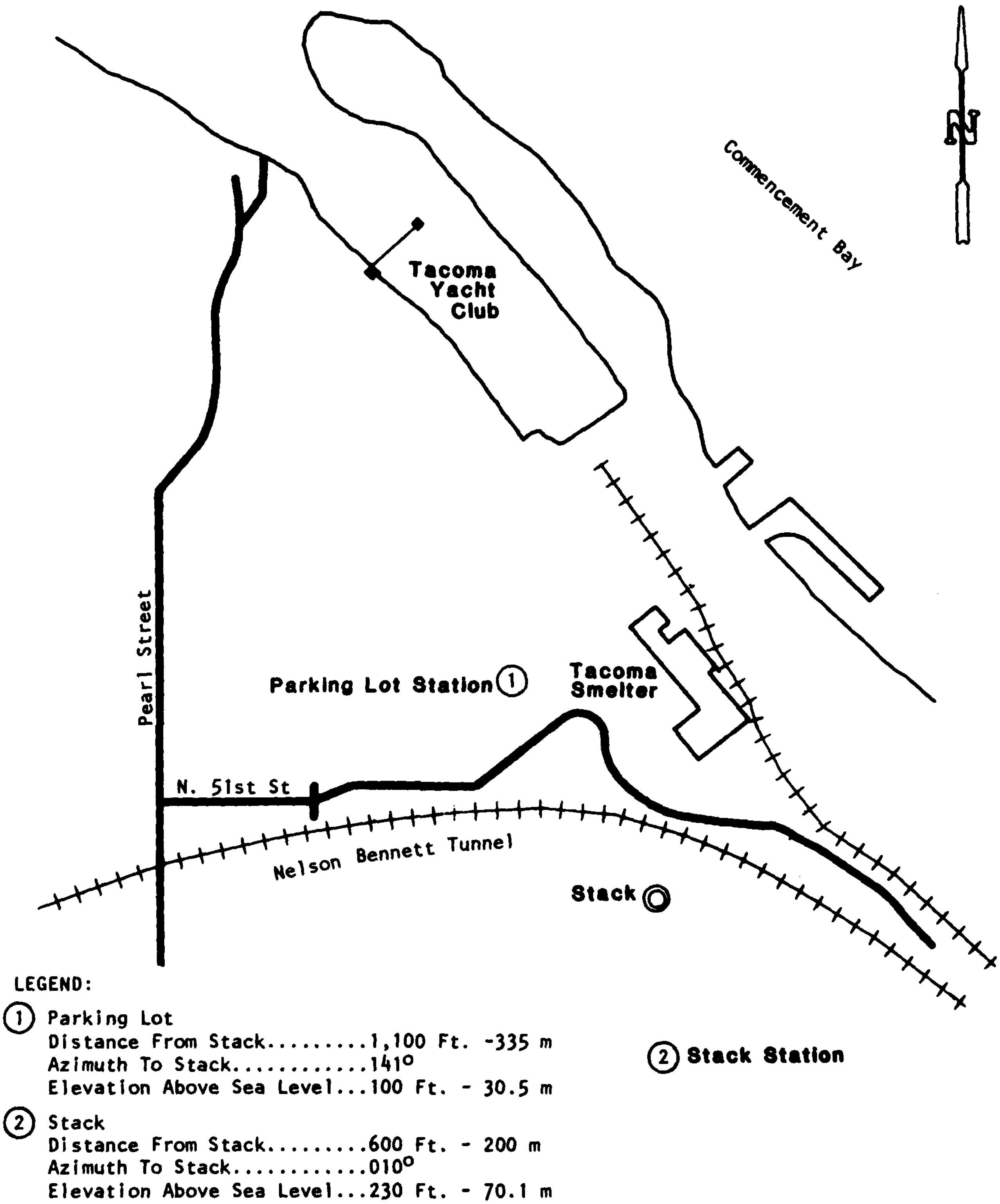

FIGURE 3

AMBIENT ARSENIC SAMPLING LOCATIONS

TABLE 15

DISTRIBUTION OF 24-HOUR AVERAGE ARSENIC CONCENTRATIONS[a]

Station	Total Number of Samples	Concentrations ($\mu g/m^3$) 2 to 4	4 to 7	7 to 10	greater than 10	Maximum
Stack						
1977	333	22	11	0	0	6.56
1978	359	28	20	1	1	10.01
1979	338	43	13	3	6	14.40
1977-79	1,030	93	44	4	7	14.40
Parking Lot						
1977	330	15	2	1	0	7.96
1978	357	22	8	3	2	51.82
1979	342	52	8	4	0	7.70
1977-79	1,029	89	18	8	2	51.82

(a) Data obtained through PSAPCA.

According to two studies done in the area, McClannan (1974) and Roberts (1977), the ASARCO Tacoma smelter is the dominant source of measured ambient arsenic in the surrounding area.

4.0 MAJOR POINT SOURCES

The locations of major point sources of emissions within the study area are depicted in Figure 4. The identity of each source and emissions of pollutants in tons per year (TPY) is presented in Table 16, which is keyed numerically to Figure 4. The sources have been designated by PSAPCA as "major" if they emit in excess of 10 TPY of any pollutant. The indicated locations of sources in Figure 4 and Table 16 represent a general location of the entire plant or facility. Exact locations and amounts of emission at each point are contained in the PSAPCA emission inventory files.

Figure 4 shows that almost all of the major point sources within the study area are located in the port industrial area, with the exception of ASARCO and Continental Grain Company. The Port of Tacoma location (Number 16) is represented by a series of piers and is not linked to any exact location or point source. Overall, the combined emissions from all of the major facilities located within the study area, as depicted in Figure 4 and Table 16, account for more than 99 percent of all point source emissions within the study area.

The major source of particulate matter in the study area is the St. Regis Kraft Mill; emissions from this facility represent a little less than one-third of all the particulate matter emitted from point sources in the study area. The St. Regis Kraft Mill also represents nearly half of the oxides of nitrogen released from stationary sources within the study area.

The ASARCO copper smelter is the largest single source of sulfur dioxide in the study area; SO_2 emissions from ASARCO represent more than 95 percent of all the SO_2 emitted in the study area.

The U.S. Oil Refining Company produces more than one-third of the study area's hydrocarbon and volatile organic compound emissions within the study area while the Kaiser Aluminum and Chemical Corporation facility produces well over half of the carbon monoxide emissions in the area.

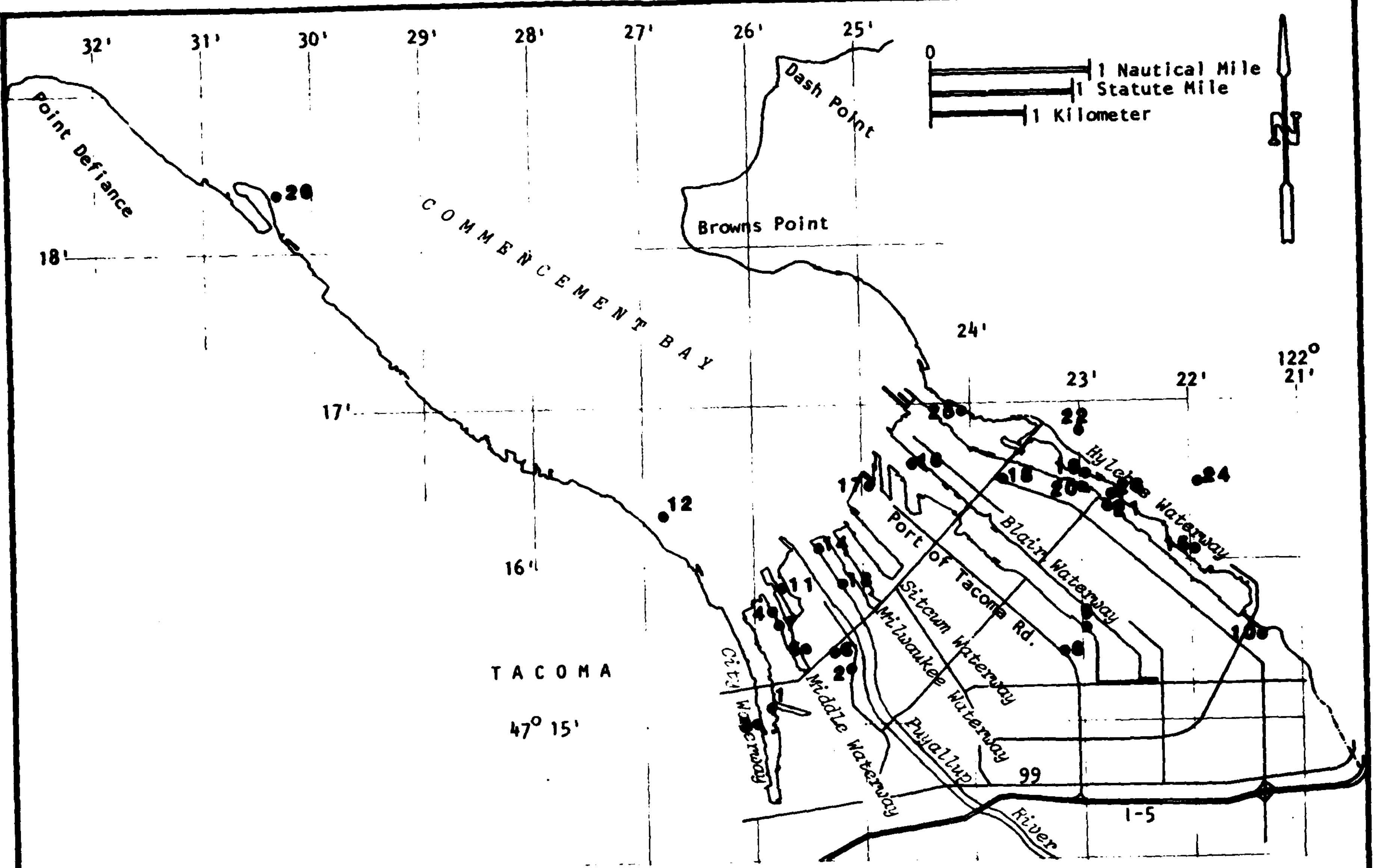

FIGURE 4
LOCATIONS OF
MAJOR STUDY AREA POINT SOURCES

TABLE 16

EMISSIONS FROM MAJOR POINT SOURCES WITHIN THE IMMEDIATE COMMENCEMENT BAY AREA[a]

No.	Source	Location	Pollutants (tons per year)[b]					
			PM	SO_x	NO_x	HC	VOC	CO
1.	North Pacific Plywood Inc.	1549 Dock St.	141	--[c]	61	12	12	12
2.	Hygrade Food Products Corp.	1623 E. J St.	7	--	80	1	1	8
3.	Burlington Northern Railroad, Tacoma switchyard	1713 Pacific St.	9	19	126	32	33	44
4.	Union Oil Co. of CA, Storage Tanks	516 E. D St.	--	--	--	32	32	--
5.	Coastcraft	1002 E. F St.	18	--	18	4	4	4
6.	St. Regis Paper Co. Lumber Mill	1213 St. Paul Ave.	168	--	207	41	41	41
7.	Shell Oil Co. Storage Tanks	702 E. D St.	--	--	--	640	640	--
8.	U.S. Oil & Refining Co.	3001 Marshall Ave.	29	378	183	977	977	17
9.	Lianga Pacific Inc.	2120 Port of Tacoma Rd.	13	--	--	--	--	--
10.	Kaiser Aluminum & Chemical Corp.	3400 Taylor Way	300	1,115	51	20	20	6,617
11.	Puget Sound Plywood Inc.	230 E. F St.	108	--	410	82	82	82
12.	Continental Grain Co.	11 Schuster Pky.	29	--	--	--	--	--
13.	Lyle Wood Products Inc.	951 Portland Ave.	48	--	8	2	2	2
14.	St. Regis Paper Co., Kraft Mill	801 Portland Ave.	1,163	1,461	1,846	280	280	1,475

(a) Extracted from PSAPCA files, current inventories as of June 21, 1980.

(b) PM = Particulate Matter; SO_x = Sulfur Oxides; NO_x = Nitrogen oxides; HC = Hydrocarbons; VOC = Total Volatile Organic Compounds; CO = Carbon Monoxide.

(c) -- = no emissions of specified pollutant

TABLE 16

No.	Source	Location	Pollutants (tons per year)[b] PM	SO_x	NO_x	HC	VOC	CO
15.	Pennwalt Corp.	2901 Taylor Ave.	5	21	75	2	2	8
16.	Port of Tacoma	802 Port of Tacoma Rd.	257	--	--	--	--	--
17.	United Grain Corp.	559 Port of Tacoma Rd.	24	--	--	--	--	--
18.	Domtar Industries Inc.	1220 Alexander Ave.	404	19	44	1	1	4
19.	Buffelen Woodworking Co.	1901 Taylor Way	65	--	127	53	53	26
20.	Lindal Cedar Homes #2	2000 Taylor Way	24	--	16	3	3	3
21.	Reichold Chemicals Inc.	2340 Taylor Way	--	--	14	--	--	178
22.	Sound Refining Co.	2628 Marine View Dr.	2	--	38	489	478	4
23.	U.S. Gypsum Co.	2301 Taylor Way	189	55	--	50	50	2,070
24.	Woodworth & Co. Inc. #3	1900 Highline Rd.	34	--	--	--	--	--
25.	Hooker Chemicals & Plastic Corp.	605 Alexander Ave.	15	122	120	4	3	76
26.	ASARCO, Inc.	N. 51st and Baltimore	528	80,541	372	8	5	36
	TOTALS		3,580	83,731	3,796	2,733	2,719	10,717

Motor vehicles also contribute significantly to air pollution levels in Commencement Bay. Typical significant emissions from motor vehicle traffic are carbon monoxide, hydrocarbons, oxides of nitrogen, and lead. Vehicle traffic also contributes to the levels of particulate matter through resuspension of road dust.

5.0 ACID RAIN

5.1 INTRODUCTION

The occurrence of acid rain in the COBS study area must be examined below in the context of the Puget Sound region due to the nature of the sources and transport of acid rain. It should be noted that even regional studies of the occurrence of acid rain are relatively limited. However, while comprehensive data necessary to determine trends of pH values in rain within the Puget Sound region are not available, studies conducted have indicated that acid rain does occur in the region, particularly in the eastern portions. Several acid rain studies have indicated continuously acidic rainfall or the occurrence of high-acidity rain (pH less than 4) in western Washington (PSAPCA 1981a). A summary of studies conducted on precipitation pH in western Washington is presented in Table 17. A more complete description of these studies and their findings is found in the draft and final environmental impact statements for ASARCO's variance from selected PSAPCA regulations (PSAPCA 1981a and b). The description of sources of acid rain below is also summarized from these two documents.

5.2 SOURCES OF ACID RAIN

Most studies conducted to date identify sulfuric and nitric acid as the primary constituent of acid rain. Sulfuric and nitric acid in acid rain results from the combination of sulfur and nitrogen oxides, respectively, with moisture in the atmosphere. It should be noted, however, that while sulfuric and nitric acid comprise the principal contributors to acid rain, any substance that combines with water to form acid can contribute to acid rain. For example, hydrochloric acid and other substances can be shown to be significant contributors to acid rain in certain geographic areas (U.S. EPA, Offices of Air and Waste Management and Air Quality Planning and Standards 1974).

According to PSAPCA (1981a), certain natural sources contribute substances that can be precursors to acid rain. These sources include volcanoes (SO_2 and H_2S), swamps (H_2S), sea sprays (various salts), and thunderstorms (NO_x).

TABLE 17

SUMMARY OF STUDIES OF PRECIPITATION pH IN WESTERN WASHINGTON

Reference	Location of Monitoring Sites	Dates	Results	Comments
Lodge et al. 1968; Lazrus 1980	Neah Bay, Olympic Peninsula	1960s	Overall average pH was 5.60	Part of early national monitoring program of U.S. Public Health Service and then National Center for Atmospheric Research. Data showed slight seasonal trends.
Powers 1980	Oregon Coast	1979	Weekly pH measurement showed range of 5.2 to 5.8.	Monitoring program of U.S. EPA, Environmental Research Laboratory, Corvallis, Oregon.
Harrison et al. 1977	University of Washington, Seattle	Early 1970s	Individual rain events measured. Overall mean pH value was 4.5. Extreme values were 3.2 to 6.6.	Only about 10 percent of storms had precipitation pH greater than 5.6. Sequential 5-minute collection intervals within single storms show variation of up to 2 pH units (i.e., 100 fold) during a 15-minute period.
Harrison 1980	University of Washington, Seattle	1979-1980	Extended data base of Harrison et al. 1977. Average pH still 4.5 within error of ±0.2 pH units.	Initial rainfall noted as particularly acidic.
Feeley and Larsen 1980	University of Washington, Seattle	July 1976 to June 1979	Collection period was 1 month. Monthly average pH ranged from 4.0 to 4.5; mean monthly pH was 4.25.	Monitoring program of U.S. Department of Energy, Environmental Measurements Laboratory. A second monitoring site in the northwest (Beaverton, Oregon) showed monthly average pH between 4.7 and 7.6; mean monthly pH was 5.57.
Dethier 1979	Copper Lake Basin, Williamson Creek, Cascade Mountains	1974 1975	Mean precipitation pH was 4.85, never exceeding 5.15.	Site is about 50 miles northeast of smelter.
Duncan 1980	Stampede Pass	May to November 1978	Collection period was 2 [illegible]. Over 12 measurement periods, mean pH was 4.66.	Site is about 50 miles east of smelter. Over the data period, precipitation was continuously acidic. Principal acidic component appeared to be sulfate.
Cole and Johnson 1977	Cedar River watershed	1970s (5-year period)	Continuous monitoring showed pH frequently below 4.0; lowest value on March 4, 1973 was below 3.0.	Sites are located about 30 to 40 miles ENE of smelter. Measured pH of less than 3.0 apparently the lowest recorded value in western Washington (prior to the eruption of Mount St. Helens).
Tiedemann et al. 1980	Lake Wenatchee District, Wenatchee National Forest	August 24, 1975 to June 1, 1976	47 individual storm events monitored. Overall mean pH was 5.1	Considerable variability noted among storms. Only known study of precipitation pH east of Cascade crest.
Dana et al. 1972, 1973, 1976; Hales 1980	Centralia coal-fired powerplant	1970s	Precipitation collection sites up to 12 miles from power plant stack. Markedly lower pH in rainfall through plume with values at and slightly below 4.0 observed.	Almost all precipitation acidity found due to SO_x rather than NO_x emissions. Part of precipitation scavenging studies by Battelle Pacific Northwest Laboratories.
Larson et al. 1975; Harrison et al. 1977	42 monitoring locations downwind of Tacoma smelter	November 1973	5-hour collection period. Observed pH values were 3.7 to 5.2. Isopleths developed for pH, sulfate, and arsenic concentrations.	Single storm event monitored concurrently at multiple locations.
Larson 1980	12 monitoring locations downwind of Tacoma smelter	Summer 1974	Minimal rainfall. Correlations of precipitation chemistry measurements.	Tacoma smelter on strike during this study. Limited results.
Knudson et al. 1977; Harrison 1980	22 monitoring locations downwind of Tacoma smelter	April 1975	24-hour collection period. Observed pH values were 3.95 to 4.75. Factor analyses showed three major influences on precipitation chemistry.	Single storm event monitored concurrently at multiple locations.

Dominant man-made sources of SO_2 are power plants that burn fossil fuels and smelters (such as the ASARCO Tacoma smelter) that process sulfur-containing ores. Man-made sources of NO_x include power plants, automobile emissions (often included in a so-called "urban plume"), and other industrial combustion processes. The relative importance of man-made sources compared to natural sources in contributing to acid rain is cited by several authors (Likens et al. 1979; Glass et al. 1979). Volcanic eruptions can produce large quantities of SO_2; the current activity of Mount St. Helens produces as much as 3,000 tons of SO_2 per day (Dethier 1980). Such eruptions, however, are infrequent, and the average annual contribution of volcanic emissions is estimated to be only a small fraction of man-made sources (Likens et al. 1979).

While all of these sources can be expected to contribute to acid rain in the region, certain sources can be identified as producing the most significant amounts of SO_2 and NO_x, and as such, potentially contribute to measured precipitation pH at any given location and time. Since the prevailing winds in the area are normally south to southwest, the precipitation pH in the Seattle-Tacoma area would be primarily affected by SO_x and NO_x sources in five counties: King, Kitsap, Lewis, Pierce, and Thurston.

Data on countywide emissions are available from PSAPCA and the Washington Emissions Data System maintained by the Office of Air Programs, Washington (State) Department of Ecology. Table 18 presents estimates for emissions of SO_x and NO_x from point and area sources in each of these five counties for the year 1977. Local sources account for less than 15 percent of the total estimated SO_x emissions; on the other hand, local sources for NO_x (primarily transportation sources) constitute over 56 percent of the total (PSAPCA 1981a).

In PSAPCA (1981a), the principal sources for SO_x and NO_x emissions were identified using rank-order listings of point sources for 1978 from the Washington Emissions Data System (Nelson 1980), combined with PSAPCA data on Tacoma smelter emissions. Two point sources account for most of

TABLE 18

SOURCES OF SO_x AND NO_x IN FIVE-COUNTY AREA[a]

County	SO_x (tons/year) Point Sources	Area Sources[b]	NO_x (tons/year) Point Sources	Area Sources[b]
King	5,556	16,285	5,917	47,167
Kitsap	1,532	874	317	4,791
Lewis	59,615	518	48,957	3,096
Pierce[c]	77,097	6,692	5,474	19,315
Thurston	0	526	6	4,125
Totals	143,800	24,895	60,671	78,494
All Sources	168,695		139,165	

Data from: PSAPCA Countywide Emissions Inventory October 18, 1980 (King, Kitsap, and Pierce Counties0; Nelson 1980 (Lewis and Thurston Counties), data from Washington Emissions Data System, as presented in PSAPCA (1981a).

(a) Data are annual totals for 1977.

(b) Includes transportation.

(c) Includes Tacoma smelter; 1977 was a relatively low SO_2 emissions year for the smelter.

the total SO_x emissions within the five-county area: the Tacoma smelter (located in the COBS study area) and the Centralia coal-fired power plant, owned by Pacific Power and Light. Tacoma smelter emissions of 86,710 tons in 1978 contributed almost 56 percent of all point source emissions, while the Centralia power plant contributed 59,870 tons, or about 38 percent. No other source contributed more than 1,728 tons (1.1 percent) of SO_x in 1978. The predominant point source for NO_x was the Centralia power plant, whose estimated 40,000 tons of NO_x emissions were 80 percent of the total for all point sources. No other source contributed more than 1,539 tons of NO_x in 1978; the Tacoma smelter contributed only 43 tons, or less than 0.1 percent of the point source NO_x total. As shown in Table 18, however, point sources are not as important as area sources for NO_x emissions in the region.

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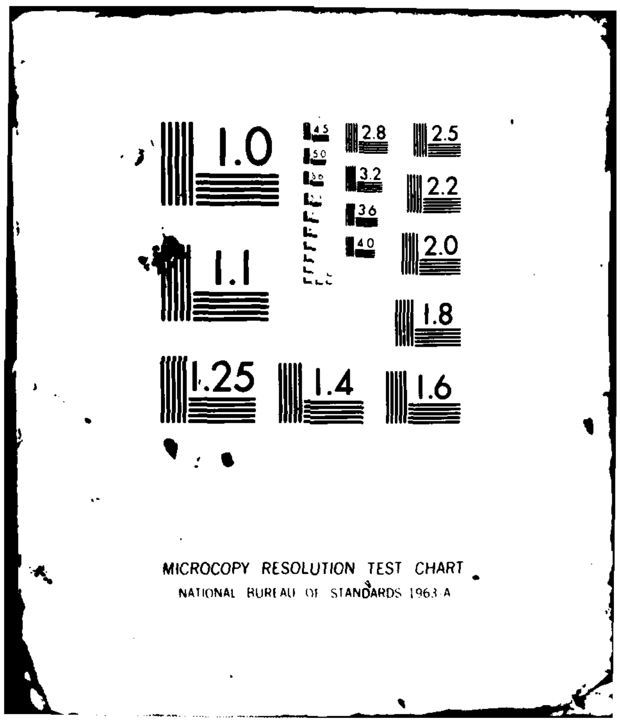
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MICROCOPY RESOLUTION TEST CHART
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Between a source of emissions and an eventual receptor, several processes can take place: transport of the emissions by winds; diffusion due to mixing actions within the atmosphere; transformation, both physical and chemical, of emission constituents; and eventual deposition through precipitation rainout or washout or dry deposition (particulate fallout and absorption). The occurrence of acid rain in both Europe and the northeastern U.S. has been attributed to long-range transport of man-made emissions (PSAPCA 1981a). While many transformations can take place, one of the most critical is apparently the conversion of SO_2 to sulfates, which then form sulfuric acid.

Within the Puget Sound region, long-range transport of SO_2 and other emissions may be somewhat limited due to the meteorological consequences of the Cascade Mountains (Harrison 1980). As air masses move upward over the mountains, they are cooled and produce markedly increased rainfall. This increase in precipitation may provide an effective rainout mechanism removing much, if not all, of the acidity (Likens et al. 1979). North and south winds that transport emissions along the Puget Sound lowlands, rather than toward the mountains, would be least affected by such mountain-induced rainout of acidity.

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TECHNICAL REPORT

AESTHETICS

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Ruth L. Van Dyke, Dames & Moore

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1.0 INTRODUCTION

The purpose of the Aesthetics Technical Report, as specified in Section 3.10.5 of the U.S. Army Corps of Engineers' Statement of Work for the Commencement Bay Studies (COBS), is to characterize view quality in the Commencement Bay study area in terms of existing viewsheds and components of urban design. The overview presented below examines the dominant visual elements in the foreground, middleground, and background of the surface area visible from given locations within the study area. Viewsheds, or the surface area visible from a given location, are assessed in terms of salient characteristics from which visual change due to future development can be predicted. This section does not attempt to assess the visual quality of the study area in terms of relative attractiveness or as being either "visually pleasing" or "not visually pleasing," since the quality of a view is subject to viewer interpretation. However, areas sensitive to visual change are identified.

2.0 STUDY AREA VIEWSHEDS

2.1 GENERAL

Commencement Bay, a horseshoe-shaped deep water bay trending northwest to southeast, dominates the viewshed of the study area. Bluffs bound the north and south shores of the bay. The landward end of the bay is occupied by the port industrial area (an extensive low-lying industrial flat created by historic dredging and filling) and the City of Tacoma. To the northeast, the bay opens into south Puget Sound. Typical urban, industrial, and undeveloped land areas are visible simultaneously within the study area. Viewsheds across Commencement Bay are dependent on two factors: (1) the distance from the viewing location to the opposing shoreline and (2) the proximity and elevation of the viewing location to the near shoreline. While panoramic views predominate in the study region, a view from near the Continental Grain Company terminal, for example, would include both a distant view (Browns Point) and a close-up view (the industrial area) (see Figure 1). For the purposes of this study, viewsheds will be analyzed according to the distance across Commencement Bay from a viewing location; that is, only a portion of a panoramic view from a location will be analyzed at one time.

2.2 CROSS-BAY VIEWSHEDS (GREATER THAN 2 MILES)

When the distance across Commencement Bay is beyond 2 miles (see Figure 1), the dark narrow shape of the bluffs of the north or the south shore (depending on the observer's position) dominates the background of the viewshed. Contrasting lighter colors representing individual or massed structures are discernible. However, at this distance only large structures, such as the ASARCO stack and the Continental Grain Company terminal (viewed from the north shore), are specifically identifiable.

Along the north shore of Commencement Bay, the bluffs reach an elevation of approximately 400 feet, peaking at over 500 feet (Indian Hill). Viewed from the south shore, these bluffs appear approximately level, only the right (west) side of the viewshed, Browns Point, appears

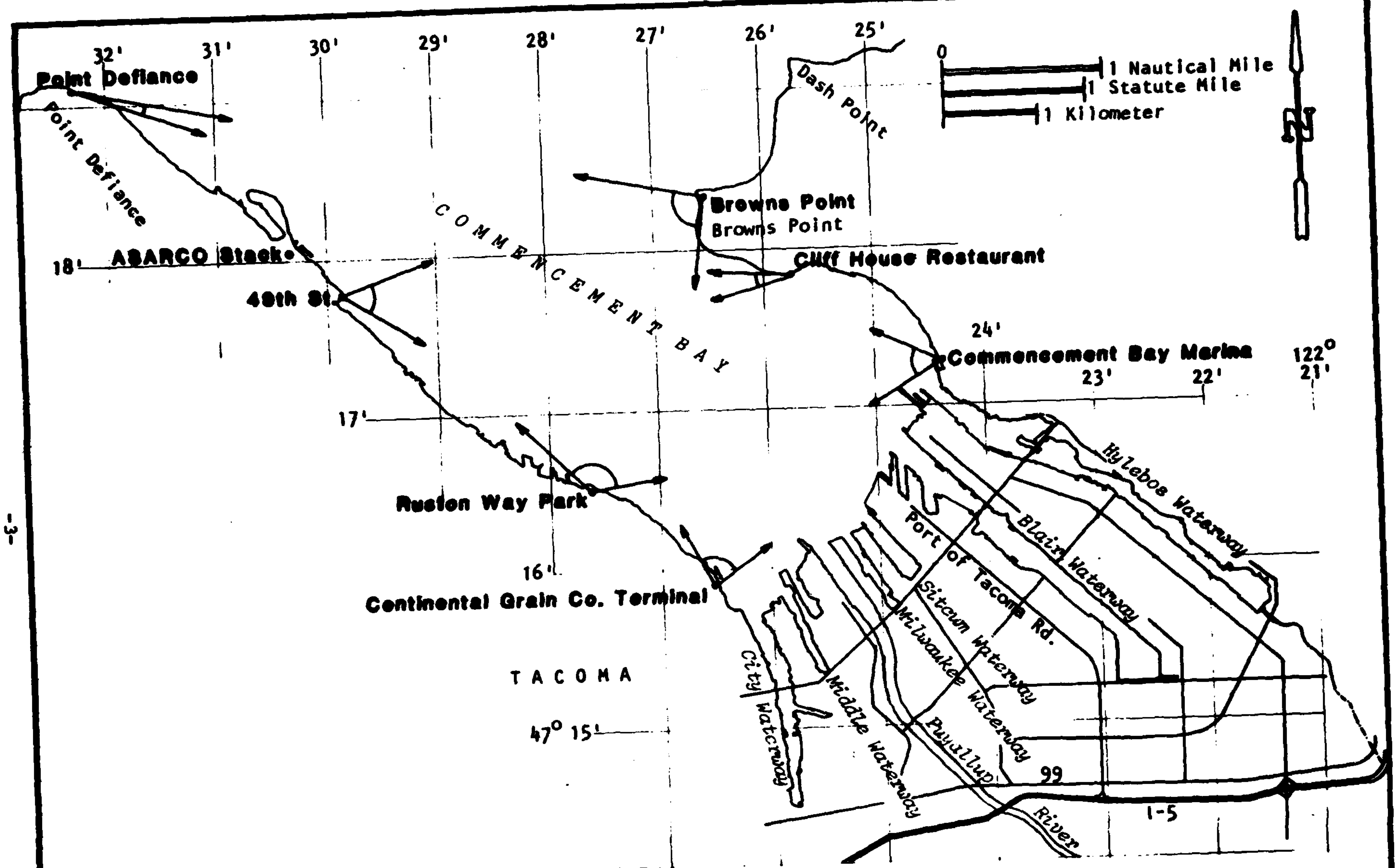

FIGURE 1

REPRESENTATIVE VIEWSHEDS BACKGROUND DISTANCE GREATER THAN 2 MILES

appreciably lower. The uninterrupted shoreline and bluffs create a strong horizontal line. The south shore of Commencement Bay has similar horizontal features when viewed from the north shore.

The industrial area shoreline, viewed across the bay at distances in excess of 2 miles, is nearly indistinguishable from the surface of Commencement Bay. The horizontal line of the surrounding hills is repeated. However, the hemispherical shapes of the Port of Tacoma, the rectangular solid of the United Grain Company elevator, and the main structures at the St. Regis Paper Company are readily identifiable because of their size, shape, and whitish color. Some buildings in the Tacoma Central Business District (CBD) are also visible. The rectangular vertical shapes are on a scale comparable to the adjacent hillside, although contrasting in color.

Depending on meteorological conditions, Mount Rainier is often visible beyond the industrial area. Rising above a visually horizontal background, its size, conical shape, and white color make it a readily identifiable natural feature.

The flat expanse of Commencement Bay occupies the entire middleground of views from the shoreline. Large ships may be visible, but on a small scale. The color of the sky is reflected in the water of the bay; together these two features usually compose over 50 percent of the view.

The foreground of these distant views depends on the elevation and proximity of the view location relative to the beach. Shoreline and beaches dominate the foreground at sea-level viewing locations on both sides of the bay along Ruston Way and Marine View Drive. Rubble (concrete riprap) and decaying pilings comprise the major visual components along those segments of th Ruston Way/Schuster Parkway shoreline that have been extensively modified. Sand and gravel beaches and limited mudflats are dominant foreground components along the shorelines from Browns Point to the Hylebos Waterway and the north edge of Point Defiance Park. Driftwood scattered along composite beaches also provide significant foreground elements at certain locations. Any buildings along the shore dominate the entire foreground, either partially or completely obstructing views beyond them. Ships and barges close to shore may be equally prominent.

Elevated viewing locations feature similar views to those at sea level. In many locations, the foreground will be dominated by vegetation or other visual elements which may either partially or completely block the view beyond.

In general, distant views (greater than 2 miles) across Commencement Bay are: (1) wide-angled, (2) horizontally oriented, and (3) dominated by sky and water. Mount Rainier is the only outstanding feature in the far distant background of views oriented to the east. The visual background of long-range cross-bay views is composed of the dark horizontal line of high ground on opposing shores. The middleground is generally dominated by Commencement Bay. Foreground features are noticeable only as they contrast with or obscure the above characteristics.

2.3 CROSS-BAY VIEWSHEDS (LESS THAN 2 MILES)

Viewsheds across Commencement Bay of less than 2 nautical miles (see Figure 2) include natural shoreline and the port industrial area. The unbroken horizontal mass bounded by the top of the bluffs and the shoreline tapers to sea level at each end of the north shore. A rough texture comprised of varying vegetation is visible. Buildings again are noticeable only as a contrast in color; specific shapes are not readily distinguishable. Individual features of the port industrial area are more readily apparent than in distant views. From elevated viewing locations, the waterways are distinguishable. Individual cranes and buildings at the end of the piers are identifiable, although the United Grain Company elevator, the container crane, and St. Regis Paper Company provide the most contrast. The horizontal lines of the area are reinforced by the far distant hills when seen from any elevation. Colors are light and muted; the few orange structures (cranes, etc.) are exceptions. Mount Rainier is as visually prominent as for more distant views.

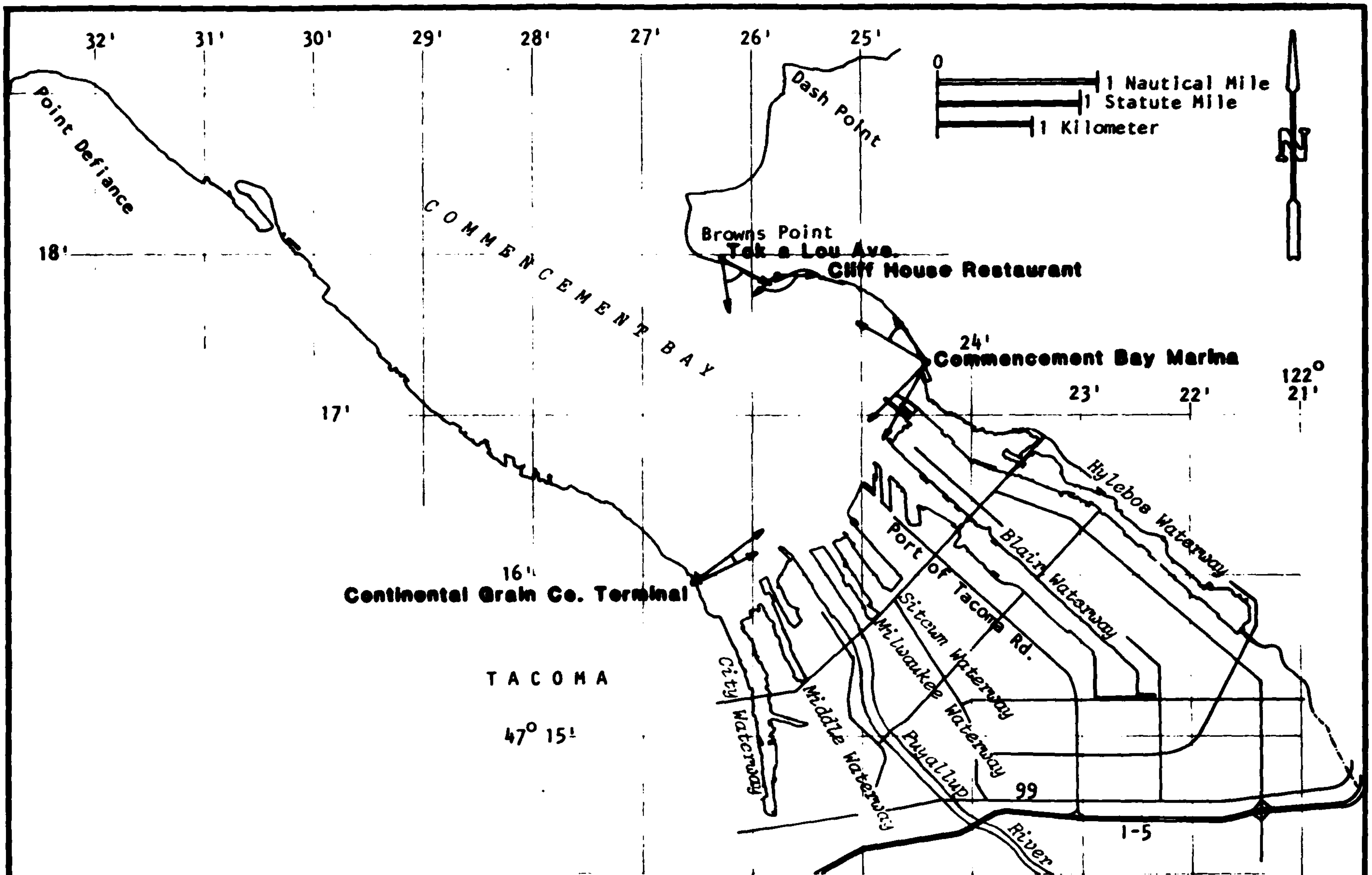

FIGURE 2

REPRESENTATIVE VIEWSHEDS
BACKGROUND DISTANCE
APPROXIMATELY 1 TO 2 MILES

The middleground of most of these less distant viewsheds is again Commencement Bay. Ships, barges, and other vessels are much more visually prominent against the background. Larger ships are clearly three-dimensional. Details of color, texture, and depth can be seen, all of which provide visual contrast to the two-dimensionality of the background and the bay itself. The horizontal line of the ships is reinforced by the background. Where viewing locations are at sea level, the ships obscure part of the background.

At a few viewing locations, the shoreline occupies part of the middleground. Individual buildings are visible as distinct shapes. Distant dock facilities and other over-water structures become visually distinct from the water.

The characteristics of the foreground are identical to those identified for viewsheds of greater distance with one exception. The contrast in size between the foreground and the middle- and backgrounds is not as marked.

The dominant characteristics of viewsheds less than 2 miles across Commencement Bay still include a wide-angled scope and horizontal orientation. However, for the most part, background details are more visually distinct, the sky and bay are less visually dominant. Mount Rainier remains the outstanding natural distant landmark. When present, larger ships in the middleground can dominate the viewshed, depending upon their size and mass. Foreground features are dependent upon the viewing location as to the degree with which they contrast with or obscure the above characteristics.

2.4 PORT INDUSTRIAL AREA VIEWSHEDS

The viewshed of the port industrial area is dependent upon the elevation of the viewing location. Analysis of the aesthetics of this area will be made for two general situations: (1) locations at or near sea level and (2) elevated locations.

When a viewing location is near sea level, the foreground of the viewshed is filled with scenes of typical industrial waterfront activity, including cargo ship, crane, warehouse, and railroad activities. Large-scale structures and equipment dominate the viewshed; vacant land is distributed among developed areas. Landscaping is largely absent throughout the port industrial area. Horizontal lines and solid masses of buildings characterize the area. The narrow height of vertical elements (such as industrial stacks, container cranes, or transmission towers) and the non-rectangular shapes of other structures (such as storage tanks and storage bins) contrast markedly with the surroundings.

Overall, viewsheds of the port industrial area at elevations near sea level are dominated by elements in the foreground. These elements (usually buildings, equipment, or ships) are typically characterized by significant height, solid mass, horizontal lines, and large scale. Mount Rainier and buildings in the Tacoma CBD may be visible at a smaller scale.

When the viewing location is above sea level, such as from buildings and other elevated locations in downtown Tacoma or from Browns Point Boulevard, the viewshed is bounded in the background by bluffs on the north and northeast, the city to the south and southwest, and the distant hills to the southeast. Mount Rainier is visible to the southeast. These background elements appear as described previously for distant viewsheds across Commencement Bay.

The broad expanse of the port industrial area occupies the entire middleground. Since much development has occurred along the waterways the lines of the area are predominantly horizontal. The overall area is flat with a strongly uneven texture. The aforementioned vertical elements are less prominent due to a reduced scale. However, when viewed from lower elevations, they are noticeable as silhouettes against the sky. Again, the few nonrectangular shapes contrast with the definite right-angled appearance of most structures.

The foreground of these viewsheds is dependent on the elevation of the viewing location. From downtown buildings, rooftops, treetops, and the City Waterway are visible to some extent. From locations on the northeast side of Commencement Bay, vegetation, roofs, or buildings may be visible. The dominance of these features will depend on the degree to which they obstruct the view beyond them.

The viewsheds of the port industrial area from locations with elevation are generally wide-angled and horizontally oriented. A visually natural background is juxtaposed with an intensive, visually complex middle- and foreground. Color and texture are variable, becoming indistinct with distance.

3.0 AESTHETIC SENSITIVITY

While previous discussion has centered on characteristics of the viewshed from different locations, viewer perception and expectation must also be considered. Certain areas of present or planned development around Commencement Bay are more sensitive to changes in the viewshed due to the number of viewers and/or their expectations. For example, the port industrial area itself is not an aesthetically sensitive location. The area offers no significant natural visual attractions; any visual interest in the area is derived from industrial activity. Expected future development of similar uses will not alter the viewshed and will be consistent with viewer expectation. On the other hand, water-oriented urban development is planned along both sides of City Waterway to the immediate south of the port industrial area as part of the City Waterway Policy Plan currently under development (see the Land/Water Use Technical Report). Policies governing such development are directed in part at improving the visual character of the waterway in order to attract large numbers of viewers. Planned improvements include parks, pedestrian walkways, and marinas (see the Land/Water Use Technical Report). Implementation of these improvements would contribute to making City Waterway a more aesthetically sensitive area. In fact, the proximity of the waterway to the highly intense and human-oriented Tacoma CBD combined with recent development of expanded marina and restaurant uses along the waterway have already increased viewer expectations relative to the waterway.

The two major areas of aesthetic significance along the south shore of Commencement Bay are Point Defiance Park and Ruston Way. Although a visually sensitive area itself, views from Point Defiance Park rarely include the study area. In the Ruston Way Plan, Design and Development Guidelines for Waterfront Revitalization, the City of Tacoma proposes to develop the Ruston Way waterfront to enhance its recréational use. The plan states that: "Panoramic views will be maintained to the extent possible as development occurs. Viewing points will be encouraged wherever possible" (Tacoma Planning Department 1980). This development, like planned development of City Waterway, will require cosmetic improvement of these areas (removal of old piles, concrete riprap, etc.) These improvements will in turn increase viewer expectation and, thus, the aesthetic sensitivity of the study area.

Along the north shore of Commencement Bay, view property along the bluff and Marine View Drive constitute aesthetically sensitive areas. Development along the bluffs is primarily residential, while development along Marine View Drive is presently limited to a few residences, marinas, and yacht clubs. These uses are all, at least in part, viewshed dependent. Existing plans and policies recognize the aesthetic sensitivity of these areas, and call for continued development of relatively low-intensity residential and marine-oriented uses and general protection of existing visual qualities.

The City of Tacoma's Shoreline Amenities Study identifies five sites in the Commencement Bay study area as possessing the best potential for providing shoreline access and scenic viewing (Tacoma Planning Department 1981). The views from five sites, which are depicted in Figure 3 below, closely correspond to the views assessed on pages 2 through 5 of this report.

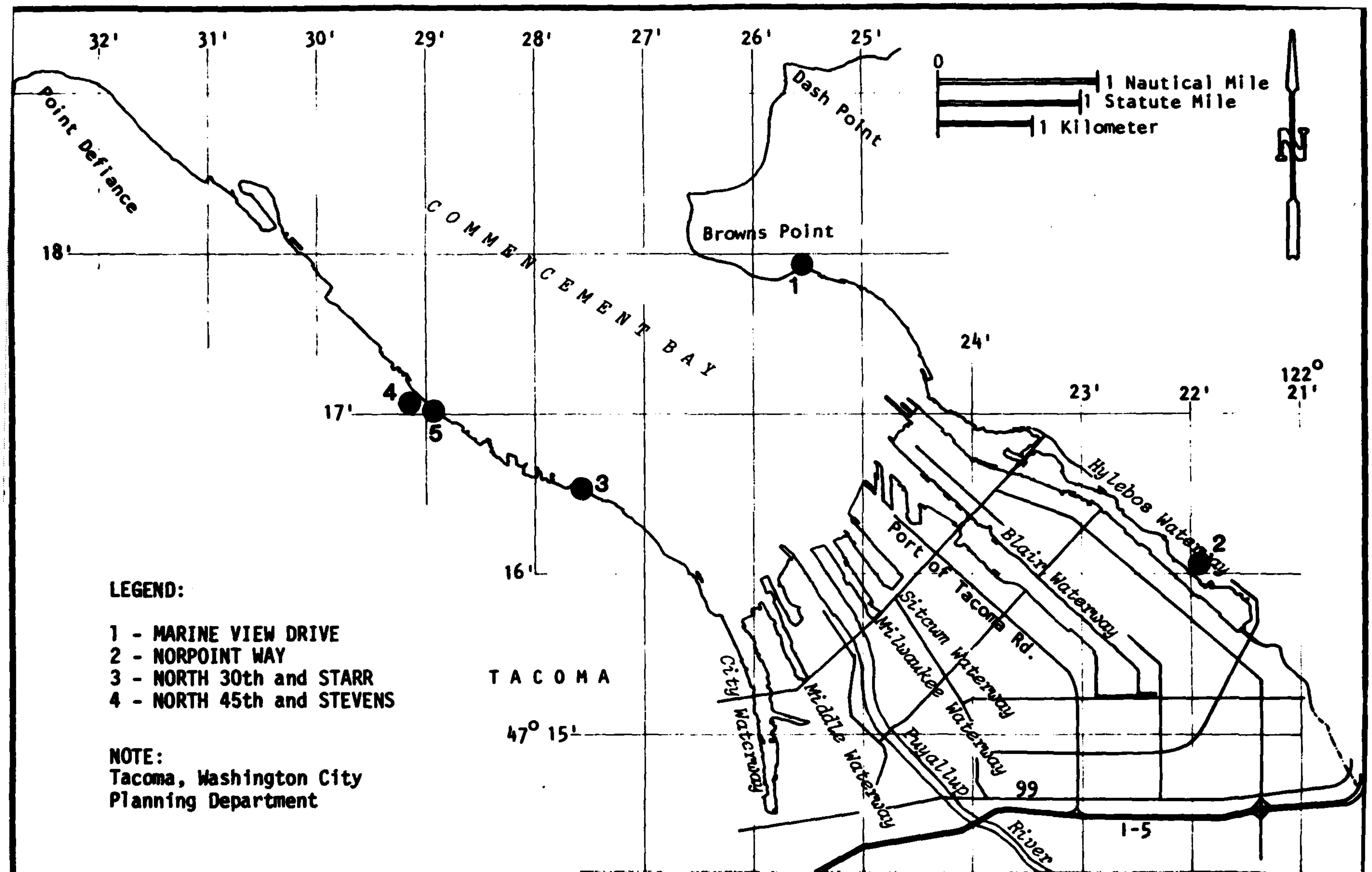

Figure 3

POTENTIAL SITES FOR SHORELINE ACCESS & SCENIC VIEWING AS DESIGNATED IN TACOMA'S SHORELINES AMENITIES STUDY

4.0 REFERENCES

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TECHNICAL REPORT

BIRDS

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1.0 INTRODUCTION

This report characterizes bird use of the Commencement Bay study area as specified by the objectives of the COE Statement of Work. These are:

a. Identify migratory and resident birds within the study area.

b. Characterize the seasonality, distribution, and abundance of migratory and resident bird populations.

c. Determine feeding, nesting, and resting areas.

d. Identify major bird food resources.

2.0 METHODS

The Commencement Bay study area is shown in Figure 1. It includes both aquatic and terrestrial habitats and extends seaward to a line between Browns Point and Point Defiance and landward to U.S. Highway 99.

2.1 GENERAL

Information for the report was gathered from several sources, including federal and state government agencies, university sources, and individuals with knowledge and data on birds in the study area. The available data were supplemented by general bird observations made by field biologists while conducting other technical services in support of the Commencement Bay Studies (COBS).

2.2 DATA SOURCES

The Tahoma Audubon Society, Tacoma, Washington, provided data from midwinter bird counts taken on January 1, 1978, December 31, 1978, and December 30, 1979. Additional sightings during the spring and fall were also included. These counts were made from shore on all the waterways.

The Washington State Department of Game, Nongame section, conducts yearly waterfowl surveys of Puget Sound. Data for the Commencement Bay transect (#113), 1970 through 1980, were obtained from Richard Parker of the department's waterfowl laboratory in Ephrata, Washington. These surveys are primarily concerned with counts of diving ducks; however, other species of waterfowl are also noted.

Tom Deming, biologist for the Puyallup Nation, was interviewed to obtain tribal data and accounts of bird use of the study area. This information generally concerned nesting observations for certain species of waterfowl but also covered feeding and roosting areas.

Data from Tahoma Audubon Society, Washington State Department of Game, and the Puyallup Nation are included in the appendix to this report.

Persons with knowledge of bird use of the study area were interviewed. These people included: Mr. Bob Kavanaugh, Washington State Department of Ecology; Dr. Gordon Alcorn, University of Puget Sound; Dr. Steve Hermann, The Evergreen State College; Ms. Carla Hansmann, Tahoma Audubon Society; and Ms. Carole Sheridan, Tahoma Audubon Society.

A literature review was conducted to determine bird feeding habits and food resources in the study area. The primary source for this information was Salo (1975). Alcorn (1978), Larrison and Sonnenberg (1968), and U.S. Fish and Wildlife Service (USFWS 1979) were also used as references. Identification of preferred food items of a group of birds made it possible to determine feeding areas by correlating the known habitat of the food items with habitat availability in the study area.

Although no primary data were collected for the bird study, field notes of bird species present and concentration areas were taken during the performance of other phases of the Commencement Bay studies. These observations, made during April, June, August, September, November, and December 1980, were meant to supplement the data available from other sources.

3.0 RESULTS

3.1 MIGRATORY AND RESIDENT BIRDS

Table 1 lists the migratory and resident birds identified in the study area. Species present have been divided into 6 categories: shorebirds and waders (21 species), waterfowl and divers (36 species), gulls and terns (11 species), seabirds (9 species), raptors (8 species), and songbirds and others (24 species). All the categories listed contain both migratory and resident species except for the seabirds, which are primarily winter residents in the open bay.

Table 1 is not meant to be a complete checklist of birds found in the Commencement Bay study area. This list was compiled from field observations by several sources taken primarily during the winter months when use by waterfowl and shorebirds is particularly high. Many additional species could be included. For instance, snowy owls were sighted several years ago during a particularly cold winter (Sheridan 1981). Comprehensive lists of birds that may be found in the study area are available in Alcorn (1978), Gabrielson and Jewett (1970), and Larrison and Sonnenberg (1968).

3.2 SEASONALITY, DISTRIBUTION, AND ABUNDANCE

3.2.1 Seasonality

The seasonality of bird species identified in Commencement Bay is indicated in Table 1. Species listed as migrants pass through the study area during fall and spring flights along the Pacific Flyway. Resident birds were subdivided into three categories: resident, winter resident, and summer resident. Those listed as resident could be expected in the study area at all times of the year. Winter and summer residents spend an extended period of time (1 to several months) in the study area during their respective seasons. Several shorebird and numerous waterfowl species were listed as both migrants and winter residents. These birds remain in the study area during mild winters but continue south on their

TABLE 1

SEASONALITY, DISTRIBUTION, AND ABUNDANCE OF BIRD SPECIES IN COMMENCEMENT BAY

Group	Seasonality[a]	Distribution[b] Near-shore	Open Bay	Abundance[b] 1-100	101-200	>200
SHOREBIRDS AND WADERS						
Semipalmated Plover	migrant	X		X		
Killdeer	resident/nesting	X		X		
Surfbird	migrant	X		X		
Ruddy Turnstone	migrant	X		X		
Black Turnstone	migrant	X		X		
Spotted Sandpiper	summer resident/ nesting	X		X		
Least Sandpiper	migrant	X		X		
Western Sandpiper	migrant	X		X		
Whimbrel	migrant	X		X		
Lesser Yellowlegs	migrant	X		X		
Greater Yellowlegs	migrant	X		X		
Dunlin	migrant/ winter resident	X		X	X	
Long-Billed Dowitcher	migrant	X		X		
Sanderling	migrant/ winter resident	X		X		
Wilson's Phalarope	migrant	X		X		
Northern Phalarope	migrant	X		X		
Common Snipe	migrant	X		X		
Great Blue Heron	resident	X		X		
Green Heron	resident	X		X		
Belted Kingfisher	resident/nesting	X		X		
WATERFOWL AND DIVERS						
Mallard	resident/nesting	X	X	X	X	X
Pintail	migrant/ winter resident	X	X	X	X	X
Gadwall	migrant/ winter resident	X		X		
American Wigeon	winter resident	X	X	X		
Green-Winged Teal	migrant/ winter resident	X		X	X	
Blue-Winged Teal	migrant	X		X		
Northern Shoveler	winter resident	X	X	X		
Redhead	migrant	X		X		
Canvasback	migrant/ winter resident	X	X	X		

(a) Data from: Alcorn (1978), Gabrielson and Jewett (1970), Larrison and Sonnenberg (1968), and Salo (1975).

(b) Data from: Salo (1975), Tahoma Audubon Society midwinter bird counts, and Washington State Department of Game winter waterfowl census. Abundance reflects average flock size rather than total numbers of birds sighted and represents winter count data. Xs in more than one column indicate yearly variation.

TABLE 1

Group	Seasonality[a]	Distribution[b] Near-shore	Distribution[b] Open Bay	Abundance[b] 1-100	Abundance[b] 101-200	Abundance[b] >200
WATERFOWL AND DIVERS (continued)						
Ring-Necked Duck	migrant	X	X	X	X	
Greater Scaup	migrant/ winter resident	X	X	X	X	
Lesser Scaup	migrant/ winter resident	X	X	X		
Common Goldeneye	migrant/ winter resident	X	X	X		
Barrow's Goldeneye	resident/nesting	X	X	X		
Bufflehead	migrant/ winter resident	X	X	X		
Oldsquaw	migrant/ winter resident		X	X		
Harlequin	migrant/ winter resident		X	X		
White-Winged Scoter	migrant/ winter resident		X	X		
Surf Scoter	migrant/ winter resident	X	X	X		
Black Scoter	migrant/ winter resident	X	X	X		
Common Merganser	resident	X	X	X		
Red-Breasted Merganser	migrant/ winter resident	X	X	X		
Hooded Merganser	migrant	X	X	X		
Coot	resident	X	X	X		
Canada Goose	resident/nesting	X	X	X		
Black Brant	migrant		X	X		
White-Fronted Goose	migrant		X	X		
Snow Goose	migrant		X	X		
Common Loon	migrant/ winter resident	X	X	X		
Arctic Loon	winter resident	X	X	X		
Red-Throated Loon	winter resident	X	X	X		
Red-Necked Grebe	winter resident	X	X	X		
Horned Grebe	migrant/ winter resident	X	X	X		
Eared Grebe	winter resident	X	X	X		
Western Grebe	resident	X	X			X
Pied-Billed Grebe	winter resident	X		X		
GULLS AND TERNS						
Glaucous-Winged Gull	resident/nesting	X	X	X		X
Thayer's Gull	winter resident		X	X		
Franklin's Gull	migrant	X		X		
Herring Gull	uncommon migrant		X	X		

Group	Seasonality[a]	Distribution[b] Near-shore	Open Bay	Abundance[b,c] 1-100	101-200	>200
GULLS AND TERNS (continued)						
California Gull	winter resident		X	X		
Ring-Billed Gull	winter resident		X	X		
Mew Gull	winter resident		X	X	X	X
Bonaparte's Gull	winter resident	X	X	X		
Common Tern	migrant	X	X	X	X	
Black-Legged Kittiwake	migrant		X	X		
Parasitic Jaeger	migrant		X			
SEABIRDS						
Brandt's Cormorant	winter resident	X		X		
Pelagic Cormorant	winter resident	X	X	X		
Double-Crested Cormorant	winter resident	X		X		
Common Murre	winter resident		X	X		
Pigeon Guillemot	winter resident		X	X		
Cassin's Auklet	winter resident (uncommon)		X	X		
Ancient Murrelet	winter resident (uncommon)		X	X		
Marbled Murrelet	winter resident		X	X		
Rhinoceros Auklet	winter resident		X	X		
RAPTORS						
Bald Eagle	uncommon winter resident	X	X			
Peregrine Falcon	uncommon winter resident	X	X			
Osprey	uncommon summer resident	X	X			
Rough-Legged Hawk	migrant/winter resident	X				
Marsh Hawk	migrant/winter resident	X				
Red-Tailed Hawk	resident/nesting	X				
American Kestrel	resident	X				
Barn Owl	resident/nesting	X				
SONGBIRDS AND OTHERS						
California Quail	resident	X				
Mourning Dove	resident	X				
Common Flicker	resident	X				
Steller's Jay	resident	X				
Common Crow	resident	X				

(c) No abundance data available for raptors, songbirds.

TABLE 1

Group	Seasonality[a]	Distribution[b] Near-shore	Open Bay	Abundance[b,c] 1-100	101-200	>200
SONGBIRDS AND OTHERS (continued)						
Black-Capped Chickadee	resident	X				
Long-Billed Marsh Wren	uncommon visitor	X				
Bewick's Wren	resident	X				
Hermit Thrush	winter resident	X				
Varied Thrush	winter resident	X				
American Robin	resident	X				
Water Pipit	winter resident	X				
Northern Shrike	migrant	X				
Starlings	resident/nesting	X				
Meadowlark	resident	X				
Red-Winged Blackbird	resident	X				
White-Crowned Sparrow	migrant	X				
Song Sparrow	resident	X				
Golden-Crowned Sparrow	migrant/winter resident	X				
Lazuli Bunting	uncommon visitor	X				
Purple Martin	resident/nesting	X				
Band-Tailed Pigeon	resident	X				
Rock Dove	resident/nesting	X				
House Sparrow	resident/nesting	X				

migatory route during severe winters. They use the study area for resting and feeding or overwintering habitat. Resident birds in the study area include several gull species and most of the raptors and songbirds.

3.2.2 Distribution

Distribution was recorded as being either nearshore (consisting of the shoreline of the bay and waterways and upland areas) or open bay. These distributional patterns represent areas where an individual bird species is most likely to be found based on data from Tahoma Audubon Society (1980), Washington State Department of Game (1981), and Salo (1975).

The shorebirds and waders were sighted exclusively in nearshore areas except for periods of flight over the open bay. Areas of shorebird and wader concentration include the mud flats of Hylebos Waterway and the sandflats off the mouth of the Puyallup River. Waterfowl flocks are present in both nearshore and open bay regions, concentrating along the Marine View Drive and Ruston Way shorelines, the banks of the Puyallup River, and the open water off the mouth of the Puyallup River. Gulls and terns move widely throughout the study area, both nearshore and open bay, and concentrations can be seen on intertidal mudflats, log storage areas, and a group of pier pilings located between the mouths of Middle and St. Paul Waterways. Seabirds are primarily found in open bay waters except for cormorants which roost along the Ruston Way shoreline and on pilings elsewhere throughout the bay. Raptors are generally present along the forested sections adjacent to the shoreline of Hylebos Waterway, Point Defiance Park, and the Puyallup River. During fieldwork on other projects, a pair of red-tailed hawks were consistently observed perching on an abandoned stack near the Western Farmers Association property on Hylebos Waterway. Songbirds are distributed throughout the nearshore and upland sections of the study area.

Three raptor species found in the study area merit special attention. The bald eagle (federally classified as threatened in Washington) and the

American and Arctic peregrine falcons (federally classified as endangered over their entire range) (Federal Register, May 20, 1980) are uncommon winter residents. A bald eagle nest site is located in Point Defiance Park (Washington State Department of Ecology 1979) and was one of the few successful nest sites in south Puget Sound during 1980 (Weber 1981). Peregrine falcons have been present the past two winters in the area, using the study area for some of its feeding activities (Hansmann 1981). Both of these raptors occupy large feeding territories and it is doubtful that they use the Commencement Bay study area exclusively over other feeding areas.

3.2.3 Abundance

The abundance of bird species in the study area is indicated in Table 1. Abundance, as expressed in Table 1, relates to average flock size rather than number of sightings. Most shorebirds and waterfowl are present in flocks of less than 100 birds. Exceptions are Dunlin, mallards, pintail, green-winged teal, ring-necked duck, greater scaup, and western grebe. Pintail and western grebes were consistently the most abundant waterfowl. No pintails were noted during field observations; however, large flocks of western grebe were consistently observed within several of the waterways and in the Puyallup River delta.

Glaucous-winged gulls and mew gulls were the most abundant gull species in the study area. During fieldwork in September, large flocks of common terns were sighted on log rafts near the mouth of Sitcum Waterway. All seabirds occurred in flocks of less than 100 birds. No abundance estimates were available for the raptors and songbirds.

The waterways containing the highest number of sightings were Hylebos and Blair (Tahoma Audubon Society 1980). The Puyallup River and Middle Waterway were next in terms of frequency of occurrence, followed by Milwaukee, St. Paul, Sitcum, and City Waterways. The shoreline along Ruston Way and Marine View Drive also contained a high number of sightings.

Year-to-year variation in numbers and species present in the study area, particularly among shorebirds and waterfowl, is to be expected since birds are highly mobile and the Puget Sound region contains numerous bays and inlets. For example, large flocks of the dunlin sandpiper may be present in the study area for a few days and absent the rest of the year. Counts made during peak migratory periods will show large numbers of birds and should not be interpreted as typical for the area throughout the year. Data on abundance of bird species were from counts during winter months, with few observations made during other seasons of the year. Because of this, the abundance estimates in Table 1 are best interpreted as general winter trends with seasonal and year-to-year variation expected.

In order to adequately assess the abundance of birds in the study area a seasonal, quantitative sampling program would be required. Previous counting efforts have concentrated on waterfowl, shorebirds, gulls, and seabirds. Birds associated with terrestrial habitats, such as raptors and songbirds, are represented by observational records only.

3.3 FEEDING, NESTING, AND RESTING AREAS

3.3.1 Feeding

Preferred feeding areas differ among the various types of birds. Major feeding areas in Commencement Bay include the intertidal mudflats in Hylebos Waterway and the Puyallup River delta area, the waterways, nearshore areas of the bay, and the undeveloped terrestrial sites in the study area.

Intertidal mudflat feeding areas are shown in Figure 1. Shorebirds, waterfowl, gulls, and great blue heron were consistently observed at these sites during fieldwork in the study area. The largest concentrations of birds and feeding activities were in the Hylebos Waterway mudflat areas (Tahoma Audubon Society 1980) and the Puyallup River delta area (Deming 1980). Other intertidal areas such as in Middle Waterway and along the shoreline adjacent to Ruston Way and Marine View Drive also support feeding activity.

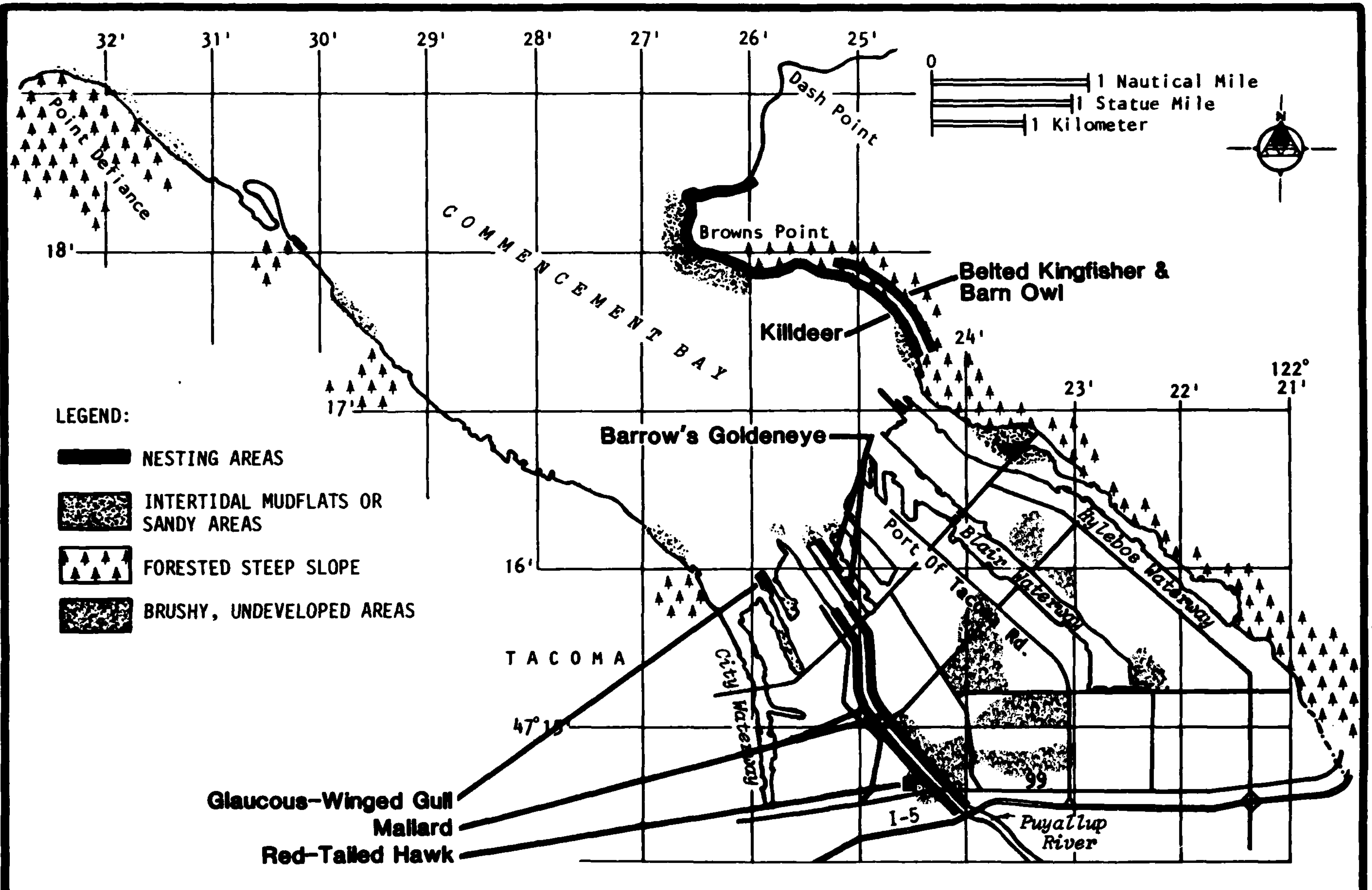

FIGURE 1

NESTING AREAS AND IMPORTANT HABITATS FOR BIRD SPECIES IN COMMENCEMENT BAY

Seabirds and diving ducks feed in the open water areas of the bay and to a lesser extent in the waterways. Waterfowl such as grebes, goldeneye, scoters, and coots were observed to be feeding along the shoreline of the waterways and in open water areas. All these species probably feed in the intertidal mudflat areas when the tide is in and the mudflats are covered by water.

The shoreline of the waterways is used for feeding by both the belted kingfisher and the great blue heron. Kingfishers perch on man-made structures such as bulkheads and wires and dive from these into the water to capture their prey. Great blue heron were frequently observed on floating piers and log booms along the waterways. These structures are apparently used as hunting platforms by the heron although wading or stalking in shallow water is their common hunting mode.

The forested, brushy, and undeveloped terrestrial sites in the study area serve as feeding areas for a large number of birds. Raptors depend on the small mammal populations living in these areas. The many seed- and insect-eating birds present also use these areas for feeding.

Nearshore and intertidal portions of the study area appear to be of prime importance as feeding areas. All mudflat and wetland habitats receive heavy feeding use by a wide variety of bird species. Intertidal areas in Hylebos Waterway and the Puyallup River experience the greatest amount of feeding activity in the study area. Their intensive use by birds reflects the high productivity and abundance of food items available in these habitats.

3.3.2 Nesting

Nesting sites for seven bird species in the study area are shown in Figure 1. Glaucous-winged gulls maintain an active breeding colony atop the boards and bulkheads of an abandoned pier at the water's edge between Middle and St. Paul Waterways. This nesting colony contained approximately 270 birds during the 1978 breeding season (Tahoma Audubon Society 1980).

Three species nest along the shoreline above and below Marine View Drive (Figure 1). Belted kingfishers and barn owls nest in burrows in the bluffs overlooking the bay (Salo 1975, Hansmann 1981). Killdeer build nests along the shoreline in vegetated areas near the water's edge (Salo 1975). Field observations indicate that killdeer also nest in the undeveloped brushy sites in the study area (Figure 1).

Two species of waterfowl, mallard and Barrow's goldeneye, nest and raise young in the study area (Deming 1980). Mallard nest among vegetation along the banks of the Puyallup River from its mouth to the Interstate 5 bridge (Figure 1) and occasionally nest in wetland areas between the Puyallup River and Blair Waterway. Barrow's goldeneye nest among the pilings in Milwaukee Waterway (Figure 1).

A pair of red-tailed hawks maintain an active nest site in a large cottonwood tree on the southwest bank of the Puyallup River between the Tacoma sewage treatment facility and Highway 99 (Tahoma Audubon Society 1981). Recent (May-June 1981) field observations by Tahoma Audubon Society members indicate a pair of young were hatched during the 1981 season.

Numerous other species nest in the study area but actual locations of nest sites are not known. Several pairs of Canada geese nest on the northeast shore of Hylebos Waterway. These birds are most likely wanderers from a local game farm and not a wild population (Kavanaugh 1981). The bald eagle nest in Point Defiance Park is near but not within the study area. A few spotted sandpipers nest in nearshore regions of the study area (Hansmann 1981). Many passerine birds, including swallows, purple martins, sparrows, starlings, and rock doves (domestic pigeons), build nests in man-made structures such as buildings and bridges throughout the study area.

There is undoubtedly more nesting activity going on in the study area than is reported in this study, especially among the passerine birds. Forested and undeveloped portions of the study area represent nesting habitat for a number of passerines. Seasonal field sampling in these areas would be required to indicate the extent of nesting activity.

3.3.3 Resting

Field observations and sighting records indicate that intertidal mudflats, forested areas, log booms, piers, and bulkheads are the major resting areas for bird species in the study area.

Shorebirds, waterfowl, and gulls were often observed resting on the intertidal mudflats. Gulls and terns were consistently sighted perched on log booms, piers, and bulkheads. During field studies in August, September, and November 1980, flocks of greater than 200 common terns were observed perched on the log booms in the bay along Marine View Drive and at the edge of the shore between Sitcum and Blair Waterways. The gull species present use bulkheads and piers throughout the study area as resting sites. Cormorants perch atop the bulkheads located along the Ruston Way shoreline.

3.4 FOOD RESOURCES

Table 2 lists the food resources of the groups of birds present in the study area. Many of the groups depend on intertidal and mudflat invertebrate organisms, others feed primarily on small fish. Gulls, which are opportunistic feeders, have the widest range of food items.

A comparison of food items taken with feeding areas in the bay illustrates the importance of intertidal mudflat areas as a major bird food resource. Five of the eight groups listed feed on organisms found in the mudflats. Shorebirds appear to be entirely dependent on these areas for food. Even species that primarily feed on fish, such as loons, grebes, terns, and seabirds are dependent on the mudflat areas since small fish such as juvenile salmon and herring congregate and feed in these nearshore areas.

Undeveloped terrestrial portions of the study area (Figure 1) provide a major food resource for many other bird species. Included here are the marsh and wetland areas identified by Shapiro and Associates, Inc. (1980). Raptors are dependent on populations of small mammals such

TABLE 2

MAJOR BIRD FOOD SOURCES

Group	Food Source	References
SHOREBIRDS AND WADERS	Beach and intertidal mudflat fauna, including small molluscs, crustaceans, barnacles, worms. Tend to utilize whatever species are available in feeding area. Great blue heron and kingfisher feed on fish and small aquatic organisms.	Bent (1937) Couch (1966) Jewett et al. (1953) Salo (1975) Smith and Mudd (1976)
WATERFOWL AND DIVERS		
Dabbling Ducks	Primarily plant material such as pond weeds, grasses, algae, and sedges. Small crustaceans and molluscs are secondary items.	Kortright (1942) Martin et al. (1951) Salo (1975 Smith and Mudd (1976)
Diving Ducks	Primarily animal material such as small crustaceans, molluscs, insects, and fish. Mergansers feed primarily on fish.	Kortright (1942) Salo (1975)
Loons and Grebes	Primarily fish. Crustaceans and molluscs appear to be secondary sources.	Jewett et al. (1953) Martin et al. (1951) Salo (1975)
GULLS AND TERNS	Gulls are generally omnivorous; feeding on fish, invertebrates, carrion, and beached and floating garbage. Terns feed primarily on small fish.	Jewett et al. (1953) Salo (1975) Smith and Mudd (1976)
SEABIRDS	Seabirds feed primarily on small fish. Some pelagic zooplankters are also consumed.	Jewett et al. (1953) Salo (1975)
RAPTORS	Raptors feed on rodents, birds, fish, and carrion.	Gabrielson and Jewett (1970)
SONGBIRDS AND OTHERS	A diverse group feeding on a variety of food types, including seeds, small fruits, nuts, and insects.	Gabrielson and Jewett (1970) Sonnenberg and Larrison (1968)

as rats, mice, and gophers that live in these areas. Passerine birds that feed on weed seeds and insects also use these areas.

3.5 IMPORTANCE OF THE STUDY AREA TO BIRD SPECIES

The southern Puget Sound region, consisting of King, Pierce, Thurston, Mason, Kitsap, and parts of Jefferson and Clallam Counties, supports approximately 30 percent of the total midwinter waterfowl use of Washington coastal areas (USFWS 1979). Migratory waterfowl use this region for resting, feeding, or overwintering habitat (Manuwal 1977). Waterfowl are not confined to any one area but move among the wetlands and bays in response to changes in season, weather, water conditions, and food availability. Coastal areas are especially important during severe winter cold spells when inland habitat is unavailable to waterfowl due to ice.

Although the Commencement Bay study area is identified as a waterfowl concentration area (Washington State Department of Natural Resources 1974), it is not listed as being of major importance in the south Puget Sound region (USFWS 1979) nor does it contain any critical biological areas (Department of Ecology 1979). The Nisqually Reach, Carr Inlet, and Quartermaster Harbor, all near Commencement Bay, support substantially larger winter waterfowl populations (USFWS 1979). This is probably due to their lesser degree of industrialization compared to Commencement Bay resulting in an abundance of habitat and food availability.

Historically, Commencement Bay has suffered greatly from loss of wetland habitat, both marsh and intertidal, and present-day wetland acreage is only a fraction of what it formerly was (USFWS 1979).* This loss was due to agricultural practices such as diking and filling and development activities leading to the present-day industrial and port facilities. Declines in abundance and use of the study area by nearly all types of birds probably followed wetlands loss. However, the Commencement Bay area still provides habitat and food for a relatively wide variety of bird species.

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*The loss of intertidal and wetland areas is summarized in Section 1.5.3 of the Land and Water Use Technical Report that comprises part of the Commencement Bay Studies.

4.0 NEED FOR ADDITIONAL STUDY

Available bird data summarized for the purposes of this study are adequate to provide a generalization of current bird use of the Commencement Bay study area. However, a systematic bird survey in the study area is required to quantify species using the study area and accurately assess seasonal and site-specific land/water use by species. Such data collected over a period of several years would be required to establish a baseline upon which the impacts of future site-specific development on the bird populations in the study area could be measured and assessed.

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APPENDIX

BIRD DATA OBTAINED FROM VARIOUS SOURCES

29620 10th Pl. So.
Federal Way, Wa.

August 5, 1980

John S. Isakson
DAMES & MOORE
Seattle, WA 98125

Dear Sir:

This is in reply to your June 30th letter to Ms. Nancy Thomas requesting any information available to add to studies being conducted on Tacoma's Commencement Bay by the U.S. Corps of Engineers.

The enclosed 3-page chart defines the diversity of bird species that regularly feed in and around the bay as shown by the yearly census taken in mid-winter, specifically covering the past three years with additional sightings recorded at other seasons.

I trust this information may be useful to you.

Sincerely,

Thais Bock
TAHOMA AUDUBON SOCIETY
Field Trip Chairperson

RJ-69-3

DATE: Jan. 7 1980 OBSERVERS: Fred Martinsen, Jeff Skriletz

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce Co.	113				4		4					
	114				1	1						
	115				2							
	117				5	2	1					
	118						21					
	119			2	2		6					
	120			4	3	5	20		2			3 mallards
	138			5	2	2	5					
	139				4	1	18					
	144			1	17		4					
	145				1		4		17			25 wigeon
	146			7	8		25					1 Bald Eagle - Imm
	147			2	6	3	81					
	148				4		18					2 mallard
	149		22	10	14	6	64					
	150			5	18	1	16					
	151			3	2				3			
	152			3			3					
	153				1		4					
Nisqually	Delta OFF RESERVE											15 Pintail
	Totals		22	42	94	21	294		22			
Expanded	Totals (x10)		220	420	940	210	2940		220			

DATE: 1? JAN 1974 OBSERVERS: R. Beiler – T. Wilson

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
PIERCE	113			3	2				6		15- W. Grebe	
	114										2-W. Grebe	
	115				2							
	117				9							
	118				8		15				50-W. Grebe	
	119						13		2		[illegible] 2-Widgeon	
	120				4						[illegible]	
	138			29		8	13				[illegible] Widgeon	
	139			4	24	8	24					
	144				3	1	21				3-W. Grebe 39-Widgeon	
	145			33	7		18				1-W. Grebe	
	146				2	3	2					
	147				16		[illegible]				[illegible] Widgeon	
	148			6	24	3	32				[illegible] 39-Widgeon	
	149			1	35						500 W. Grebe	
	150						7				[illegible]	1-W. Grebe
	151				1		2				100 [illegible]	W. Grebe - 649
	152				1	1					25- [illegible]	Widgeon - 88
	153				22		1					Mallard - 168
				89	171	18	162		8		310 mallards in Pierce; [illegible] Widgeon	
SUB-TOTAL												
Nisqually Delta				89	171	18	162		8			W. Grebe = 649
Total												Widgeon = 539
												[illegible] = 3
												[illegible] = 10

		Redhead	Canvas back	Scaup	Golden eye	Buffle head	Mallard	Ruddy	Merg	Coots	Geese	Remarks
					3	49	1022	1200	3	986	68	Widgeon - 842
KING	Lake Washington	3	101	56								
					13	1	192	30	1	480	12	Widgeon - 32
	Lake Sammamish	–	6	–								
					16	50	1214	1230	4	1466	80	Western Grebe - 100
TOTAL		3	107	56								[illegible]

-3-3

DATE: 16 JAN 75

OBSERVERS: P. POELKER, R. JOHNSON, R. STARKEY

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
[illegible]RCE	113		8		14				1			2 – WIDGEON, 1 – COOT
	114											1 – MURRE, 3 – HARLEQUIN [?]
	115				4							7 – WESTERN GREBE
	117				9		5		4			23 – WESTERN GREBE, 2 – COOT; 1 – AD. BALD EAGLE
	118				22		48					1 – WESTERN GREBE
	119				12		11					15 – MALLARD, 8 – WESTERN GREBE
	120											10 – MALLARD, 13 – WESTERN GREBE
	138				12	6	205					24 – SCAUP
	139				28		10					6 – WESTERN GREBE, 50 – WIDGEON
	144				12		3					30 – WESTERN GREBE, 12 – WIDGEON
	145				12		4		1			1 – WESTERN GREBE, 60 – WIDGEON
	146			8	13	1	8					6 – WIDGEON
	147				26		31					12 – MALLARD
	148			2	26		71		2			
	149		20	30	1		28					58 – MALLARD, 13 – COOT, 2 – [illegible]
	150				5		17					113 – WESTERN GREBE [?]
	151			4	2		1					14 – WESTERN GREBE, 1 – MURRE
	152			10					1			20 – MALLARD, 120 – WIDGEON
	153			2								4 – WESTERN GREBE
TOTAL			28	56	198	7	452		9			

83-69-3

DATE: 5 Jan 76 OBSERVERS: R. Poelker, R. Starkey

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113										5 - 1 -	Western Grebe Coot
	114											Nothing Observed
	115											Nothing Observed
	117				1	1					67 -	Western Grebe
	118											Nothing Observed
	119				1							
	120					1					70 - 3 -	Western Grebe Widgeon
	138			16	10		120		3			
	139					3	31				52 - 16 -	Mallard Widgeon
	144			10	25		15				52 -	[illegible]
	145			10	3						30 -	W. Grebe
	146			1	1	1	3				1 -	[illegible]
	147			1	2		2					
	148				8		5				6 -	Mallard
	149			15	1	1	10				30 -	Western Grebe
	150			20	3				1			
	151			2	4	1	2					
	152			6								
	153											Nothing Observed
Totals		0	0	76	58	8	178		4		154 -	Western Grebe
											1 -	Coot
Expanded T				760	580	80	1780		40		531 -	Widgeon
											520 -	Mallards
											1 -	[illegible]

J-89-3

DATE: 3 JAN 78 OBSERVERS: R. Poelker R. Starkey

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113	—	—	—	8	—	6	—	—	—	16	Western Grebe
	114	—	—	—	2	—	2	—	—	—	2	Bald Eagle (AD)
	115	—	—	4	1	—	—	—	—	—	4	Western Grebe
	117	—	—	—	8	—	—	—	—	—		6-Mallard, 4 Western Grebe, 1 Coot
	118	—	—	—	15	—	10	—	—	—	20	Western Grebe
	119	—	—	—	10	—	3	—	—	—		50-Mallard, 110 Western Grebe
	120	—	—	30	6	—	50	—	—	—		125-Western Grebe, 20-Widgeon
	138	—	—	—	20	—	350	—	—	—		80-Widgeon
	139	—	—	15	8	20	10	—	—	—		6-Western Grebe
	144	—	—	—	10	—	10	—	—	—		20-Widgeon
	145	—	—	—	10	—	7	—	—	—		25-Mallard, 50-Widgeon, 5-Gadwall
	146	—	—	—	7	10	16	—	—	—		30-Western Grebe, 5-Widgeon
	147	—	—	5	15	— 5	96	—	—	—	10	Widgeon
	148	—	—	4	25	—	48	—	—	—		16-Western Grebe
	149	—	—	22	—	—	32	—	—	—		2-Western Grebe, 25-Widgeon
	150	—	—	50	4	—	—	—	—	—		
	151	—	—	—	4	—	—	—	—	—		130-Western Grebe
	152	—	—	—	1	—	2	—	—	—		2-Widgeon
	157	—	—	—	8	8	—	—	—	—		2-Mallard, 1 Western Grebe, 40-Coots
TOTALS				130	164	35	660				2	Bald Eagles (AD)
											454	Western Grebe
											95	Mallard
											41	Coot
											202	Widgeon
											5	Gadwall

DA ME

COMMENCEMENT BAY AVIAN NOTES

JAN 1981

I. Marine-View Dr. sites CH-1 8

on bluff above spring-summer
- nesting pair of red-tailed hawks

along shoreline
- Mallard ducks-pairs & females with brood
- American Wigeons-small flocks in early spring
- Dunlins-in small flocks during the summer

II. Areas of Outer Hylebos sites HY-0 HY-18

numerous shorebirds during spring & summer
- Dunlins-in small flocks during the summer
- Yellowlegs (lesser)-feeding
- Dowitchers (long-billed)-small flocks
- Sanderlings-only a few noted
- Semipalmated Plover-only a few noted
- Killdeer-nesting within area

water fowl
- Mallard-flocks & nesting with brood rearing
- American Wigeon-flocks
- Redhead-pairs in spring
- Ring-necked / Greater Scaup — small flocks in spring
- Bufflehead / Barrow's Goldeneye — few observed
- Canada Geese-nesting with brood rearing
- Domestic Geese-

- Double crested cormorant-early spring only
- Great Blue Heron-feeding during summer
- American Coot-common
- Common loon-spring through early summer
- Western Grebe-common
- Herring gull-common
- Rock Dove-common
- Belted Kingfisher-common

numerous-Passeriformes

III. Inner Hylebos

several of the species common to outer Hylebos.

IV. Blair Waterway & Sitcum Waterway

very few species
- Rock Dove-few
- Herring Gull
- Mallard-females with broods believed to be from near-by limited fresh water marshes broods observed only at inner Blair near the mouth of Wapato Creek.
- Western Grebe-only a few feeding on juvenile herring and chinook.

V. Mill-Waterway

waterfowl
- Barrow's Goldeneye-nesting within pilings
- Mallard-only a few
- Rock dove- massive nesting under structures
- Herring gulls-nesting in same area
- Western Grebe-large feeding flocks present during June near site ML-4 (sand spit between mouth of Puyallup & Mill. Waterway).

numerous Passeriformes

VI. Sand-spit at mouth of Puyallup River

numerous shore birds feeding
- Western Grede-large flocks
- Double Crested Cormorant-spring only
- Herring gulls-common

VII. Puyallup River from mouth to I-5 bridge

waterfowl
- Mallard-common during summer and fall females with broods nesting along river banks and near-by marsh area
- Redhead-pairs and females with brood through summer and fall
- American Wigeon- small flocks in fall
- Barrow's Goldeneye-during spring near 11th St. bridge
- Red-Breasted Merganser-uncommon
- Hooded Merganser-uncommon
- Rock dove-common
- Herring Gulls-common
- Great Blue Heron-common along river
- Barn owl-common feeding along river at night
- American Coot-common
- Belted Kingfisher-common;nesting in bank along 11th St. bridge.

numerous Passeriformes.

VIII. St. Paul Waterway-only a few notes taken

Great Blue Herons
several shorebirds
- Dunlins
- Plover
- Killdeer

IX. Pilings between St. Paul & Middle

extensive nesting of Herring Gulls

X. Middle Waterway

Great Blue Herons-feeding during summer
Belted Kingfisher-feeding
many of the species observed at outer Hylebos
Waterfowl
- Mallards   Red-Breasted Merganser

XI. City Waterway-to include Wheeler-Osgood

all of the species noted within Outer Hylebos and Middle Waterway.

of special note-

during peak migration of coho; large numbers of Western Grebe were observed feeding estimated numbers of Grebes 500 during this period; a harbor seal and a single pilot whale were also observed to be feeding within the waterway

XII. Ruston Way Shoreline

numerous shorebirds feeding along with several species of waterfowl.

main species feeding on schools of juvenile herring & salmonids

- Western Grebe
- Common Loon
- Double-Crested Cormorant-early spring only

waterfowl-

- Redhead- a few
- Ring-necked Duck
- Greater Scaup numerous
- Black Scoter
- White winged Scoter

numerous Passeriformes

XIII. Freshwater Marsh areas between the Puyallup River and Blair Waterway

waterfowl

- Mallard-common; paired, nesting and rearing young
- Northern Shoveler-paired and nesting only a few noted
- American Green-Winged teal-only a few noted
- American Wigeon-small flocks in fall
- Pintail-large flock for a short time during early spring.
- American Coot-common
- Great Blue Heron-common
- California Quail-small flock near marsh area under Hy 99 bridge
- Marsh Hawk
- Red-tailed Hawk hunting within area
- Rock Dove-common

numerous species of Passeriformes

- Red-winged Blackbird-extremely common
- numerous warbler and sparrow species

Those areas of most importance to avian species also appear to be those inter-tidal and near shore areas utilized to the greatest extent by juvenile salmonids. In several observations, large flocks of Western Grebes and other species were feeding on juvenile fish. Be beach seine and loop seine methods, these prey items were found to be juvenile salmonids and herring.

SUMMARY OF RECENT COMMENCEMENT BAY SIGHTINGS OF BIRDS AS seen FROM SHORE. RECENT SIGHTINGS FROM A BOAT IN THE BAY INDICATE THE NUMBERS AS SHOWN BELOW WOULD BE ALMOST DOUBLED IN MOST INSTANCES.

A = January 1, 1978; B = December 31, 1978; C = December 30, 1979; other dates as noted. EXAMPLE: A-1 means 1 bird at specified location on January 1, 1978; B-5 means 5 birds at specified location on December 31, 1978 etc.

	Marine View Dr. Hylebos Waterway	Blair Waterway	Sitcum Waterway	Milwaukee Waterway	Puyallup Waterway	St. Paul Waterway	(Incomplete) Ruston Way	Middle Waterway	TOTAL
✓ ARCTIC LOON	A-1, B-1,			A-1,			11/17/78-1	A-1,	5
✓ RED-THROATED LOON	C-2	A-1,							3
✓ RED-NECKED GREBE	B-1, C-5,		A-2, B-2,						10
✓ HORNED GREBE	A-5, B-4, C-6	A-4,			B-1,			B-8,	23
✓ EARED GREBE									
✓ WESTERN GREBE	A-498, B-304, C-158,	A-149, C-1477	A-105, B-88, C-221		A-2, C-3, B-252	C-1,		A-1, B-37,	1888
✓ PIED-BILLED GREBE	B-1, C-3,		B-1,						5
✓ DBL.-CREST. CORMORANT	C-5, 3/26/78-3	C-18,			B-2,				28
✓ BRANDT'S CORMORANT	5/24/78-1								1
✓ PELAGIC CORMORANT	A-1, B-1, 4/3/78-1, 3/25/78-1	C-5,	C-1,						10
✓ GREAT BLUE HERON	A-81, B-78, C-60, 3/4/78-20,	A-1, C-1,	C-20,	A-1, C-1,				B-1,	240
✓ CANADA GOOSE	A-6, 3/4/78-1,								7
✓ MALLARD	A-12, B-132, C-25	A-2, C-17,		C-18	A-4, B-2, C-2,			B-4	221
✓ GADWALL	B-4, 3/12/78-5	C-2, 3/25/78-2		C-1,	A-2, B-1,	C-24, 3/?/78-10		A-27, B-17,	98
✓ PINTAIL	A-210, B-249, C-18, 12/20/77-31	C-15,		C-3,					526
✓ GREEN-WINGED TEAL	A-139, B-113, C-105, 3/4/78-150							A-6, B-17,	520
✓ BLUE-WINGED TEAL					C-1,				1
✓ AMERICAN WIGEON	A-74, B-19, C-11,	C-41,				C-10,		B-1,	156
✓ NO. SHOVELER	A-10, B-21, C-13, 3/4/78-10,			A-3,					57
✓ CANVASBACK	A-4, B-4, 3/4/78-1,								9
✓ GREATER SCAUP	A-36, B-18, C-19, 3/4/78-125	A-88, B-2, C-10	A-13, C-110,				11/17/78-10		451
✓ LESSER SCAUP	C-1								1

	Marine View Dr. Hylebos Waterway	Blair Waterway	Sitcum Waterway	Milwaukee Waterway	Puyallup Waterway	St. Paul Waterway	(Sec. incomplete) Ruston Way	Middle Waterway	TOTAL
✓ COMMON GOLDENEYE	A-2, B-5, C-4 2/4/78-4	A-12, C-2			A-2, B-3				38
✓ BARROW'S GOLDENEYE	A-78, B-20, 4/4/78-3, C-2 4/6/77-30	A-39, B-39, C-4	A-2, C-25	A-4, C-3			11/17/75-6	B-9,	276
✓ BUFFLEHEAD	A-1, C-1, 4/4/78-2,	C-1;		A-1,					6
✓ SURF SCOTER	A-10, B-5, C-1	A-2							18
✓ COMMON MERGANSER		C-1	C-5,		A-4, B-2,				12
✓ RED-BR. MERGANSER	A-6, B-11, 4/4/78-1, C-1, 4/4/78-4	A-8, B-5, C-14			A-1, B-2,				55
✓ AMERICAN COOT	A-44, B-70, C-42	A-2, C-2,	A-1, C-5,	C-5,	B-2, C-1,				178
✓ KILLDEER	A-9, B-24, 10/20/77-2,	C-1,			A-4, B-7			A-13, B-20,	82
✓ BLACK TURNSTONE	A-2, B-2,	C-24					11/17/75-8, 1/29/76-15		52
✓ RUDDY TURNSTONE		C-1							1
✓ COMMON SNIPE					C-1,				1
✓ WESTERN SANDPIPER	A-2, 12/26/77-8							A-3,	13
✓ SPOTTED SANDPIPER	B-3, C-2, 4/4/78-1, 11/6/77-1, 9/6/78-2	C-1,							10
✓ LEAST SANDPIPER	B-20,				A-7 4/14/77				30
✓ DUNLIN	A-105, B-2..., 3/10/76-25	A-42, C-15,						A-31, B-20,	521
✓ NORTHERN PHALAROPE					12/16/77=1				1
✓ GLAUCOUS-WINGED GULL	A-24, B-256	A-16, B-210, C-3	C-28,		A-40, B-50, C-35	C-250,		A-3, B-18, 4/4/78-330 (feeding along)	1218
✓ THAYER'S GULL	11/6/77-2,								2
✓ MEW GULL	A-360, B-90, C-22	A-23, B-4,	A-100,	A-170, C-90,	A-300, B-10	B-85,		A-300, B-119,	1551
✓ FRANKLIN'S GULL							1/24/78-3		3
✓ BONAPARTE'S GULL							8/14/78-8		8
✓ BLACK-LEGGED KITTIWAKE							C-1		1
✓ COMMON TERN							9/6/77-10		10

Copy [illegible] does not permit fully legible reproduction

-3-

	Marine View Dr. Hylebos Waterway	Blair Waterway	Sitcum Waterway	Milwaukee Waterway	Puyallup Waterway	St. Paul Waterway	(Incomplete) Ruston Way	Middle Waterway	TOTAL
COMMON MURRE	A-1, C-1								2
PIGEON GUILLEMOT									
ANCIENT MURRELET							C-23		23
MARBLED MURRELET							8/8/77		1
RHINOCEROS AUKLET	A-1, C-6,	A-2, C-8,	C-10,						22
KINGFISHER	A-1, B-2, C-1	A-2	A-1, C-3,	A-1					16

THE FOLLOWING SPECIES HAVE BEEN OBSERVED ON TIDEFLATS [illegible] THE WATERWAYS, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] AS THE CALIFORNIA QUAIL AND [illegible] [illegible] [illegible] [illegible]

ROUGH-LEGGED HAWK	BAND-TAILED PIGEON
MARSH HAWK	HERMIT THRUSH
RED-TAILED HAWK	AMERICAN ROBIN
AMERICAN KESTREL	WATER PIPIT
CALIFORNIA QUAIL	NORTHERN SHRIKE
PARASITIC JAEGER	STARLING
MOURNING DOVE	
BARN OWL	MEADOWLARK
COMMON FLICKER	RED-WINGED BLACKBIRD
STELLER'S JAY	VARIED THRUSH
COMMON CROW	WHITE-CROWNED SPARROW
BLACK-CAPPED CHICKADEE	SONG SPARROW
LONG-BILLED MARSH WREN	ROCK DOVES
BEWICK'S WREN	

Water Bird Species 49
Other Species 26
Total 75

Compiled by: Thais Bock
Tahoma Audubon Society
July 25, 1980

U

Prince		[illegible]	[illegible]	11[illegible]	151	153	155-6	167	129-30	154
	[illegible]									
	[illegible]									
	115									
	117									
	118									
	119									
	120									
	138									
	139									
	144									
	145									
	146									
	147									
	148									
	149									
	150									
	151									
	152									
	153			2	1		1			
King	57			1			14			
	52			1400			5			
	53				7		3			
	54				10		8			
	55					1	70		2	
	56			5	6		43			
	57				6	2	5			
	58			13	3	4	38			
	59			1	4	1	25			
Total				1420.0	360	80	2110		210	

Not Counted

Jan 18

Pierce 1969

	146	147	148-9	151	153	105-6	107	129-30	154
113			16	5		2			
114				5					
115				None					
117						2			
118			2	6	3	58			
119				10	1	3			
120				10	5				
138				17	2	64			
139				2		1			
144				None					
145			2	16	4				
146				4	1	1			
47			6	15		2			
48			5	25	9	10			
49			2	7		60			
50			3	2		3			
51				8					
52				5		14			
53				8	1	4		2	
			360	1450	260	2240		20	

DATE: [illegible] 20 1970 OBSERVERS: Jeffrey PA-11 Cub Counting Conditions excellent

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113			15			7					
	114						17		8			
	115				2		10					
	117			1	9		17					
	118				12		65					[illegible] 15 widgeon
	119				6		10					NE side Fox Island [illegible] widgeon
	120			1	2	1	2					
	138			10	23	5	462					5 mi W. Vaughn [illegible] widgeon
	139			21	3		83					
	144						2					
	145				3		1					
	146				2	2	34		5			
	147			20	28	2	50					[illegible] widgeon
	148			20	25		18					4 mi E. Vaughn [illegible] widgeon
	149		10	28		7	76					
	150				12	10	55					N. End Fox Island 15 widgeon
	151				9		10					Cromwell 15 widgeon
	152				4		3					Gig Harbor - 10 widgeon
	153				3				6			[illegible] S. Olalla 2 mallards
Unexpanded	totals		[illegible]	[illegible]	[illegible]	27	[illegible]		17			
Expanded		[illegible]	[illegible]	[illegible]	1430	[illegible]	[illegible]		[illegible]			

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RJ-69-3

DATE: Jan 4.6 1971 OBSERVERS: Garrison, Jeffrey

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113						5					
	114				7	2						
	115			8	20							2 coot
	117				16	1	3					
	118				None							
	119			3	17	1						3 coot
	120			4	7							52 widgeon
	138				14		167			1		20 widg.
	139			2	7	3	8					6 widg
	144						8					
	145			1	7		3					30 widg.
	146			1	11	3	6					3 coot
	147			5	34	4	39					10 Mall. 195 widg.
	148			13	31	12	10		4			
	149				10	2	1					16 Mall. 93 widg
	150				8	10	21					6 Mall. 8 widg.
	151				34		10					5 coot 16 widgeon
	152				9	2	30					[illegible] widg.
	153				2	2						[illegible]
Unexpanded T.				37	234	42	311		4	1		
Expanded T.				370	2,340	420	3,110		40	10		

RJ-69-3

DATE: [illegible] OBSERVERS: [illegible]

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113				11							
	114				1							
	115				15		1					
	117				1		2					
	118			2	20	3						
	119				3	2						
	120			2	20	10	20					
	138			5	100	25	100					
	139				2	20	5					2 Teal
	144			2	15		2					
	145				20		25					35 Teal 35 Gadwall
	146				16	5	10					
	147				20	15	10					4 Teal
	148				15	20	5					3 Harl [illegible] 2 Widgeon
	149				25		10	5				50 Mallard
	150				10	5	3					2 Mallard
	151				3	2	7					
	152				15							44 Mallard 8 Canada Geese
	153				5	1	3					
												35 Gadwall, 8 Canada Geese
	Total			56	320	108	210	5				96 Mallard, 41 Teal 3 Harlequin 2 Widgeon
Expanded total (x10)				560	3200	1080	2100	50			~~[illegible]~~	
												960 Mallard 410 Teal 30 Harlequin 20 Widgeon,
												350 Gadwall, 80 Canada Geese

RJ-69-3

DATE: Jan 9, 1973 OBSERVERS: Poelker

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113				1		9					See Poelker's
	114								3			field form form
	115						10					for dabblers
	117			1	2		3					
	118			1	4		41					
	119				15							
	120				3		2					
	138			12	26	15	100					
	139			2	6	1	6					
	144				4		12		1			
	145						12					
	146					1	12					
	147			20	14		14					
	148			10	35	6	15					
	149			2	7		6					
	150			3			6					
	151						2					
	152				3		11					
	153				4							
Unexpanded Tot				51	124	23	261		4			
Expanded Tot				510	1,240	230	2,610		40			

[illegible]
Bellingham

DATE: 10 JAN 1974 OBSERVERS: [illegible] BELLER [illegible]

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
PIERCE	113			3	2						15- W. Grebe	
	114								6			
	115				2						2-W Grebe	
	117				9							
	[illegible]2				8		15					
	119						10				[illegible]	
	120				[illegible]				2		[illegible] W Grebe 2-Widgeon	
	132			29		8	[illegible]				2-W Grebe 9-Widgeon	
	139			4	[illegible]	[illegible]	[illegible]				Widgeon	
	144				3		21					
	145			33	[illegible]		18				3-W Grebe 37-Widgeon	
	146				2	3	2				[illegible] Grebe	
	147				[illegible]		[illegible]					
	148			6	[illegible]	3	32				[illegible]	
	149			1	35						[illegible] 30-Widgeon	
	150						[illegible]				500 W. Grebe	
	151						[illegible]				2-Mallards 2 Widgeon [illegible]	[illegible]
	152				1	1					100 [illegible]	W. Grebe - 649
	153				22		1				25- West Grebe	Widgeon = 88
SUB-TOTAL				89	171	18	162		8			Mallard = 168
Nisqually Delta											810 mallards 12 Pintails 473 Widgeon	
Total				89	171	18	162		8			W. Grebe = 649
												Widgeon = 539
		RedHead	CANVAS BACK	SCAUP	GOLDEN EYE	BUFFLE HEAD	MALLARD	RUDDY	MERG	COOTS	GEESE	[illegible]
KING	Lake Washington	3	101	56	3	49	1022	1200	3	986	68	← WIDGEON - 842
	Lake Sammamish	-	6	-	13	1	192	30	1	480	12	← WIDGEON - 32
TOTAL		3	107	56	16	50	1214	1230	4	1466	80	← Western Grebe - 100

PINTAIL - ?

DATE: 16 JAN 75 OBSERVERS: R. POELKER, R. JOHNSON, R. STARKEY

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
RCE	113		8		14						2- 1-	WIDGEON COOT
	114								1		1- 2-	MURRE MALLARD
	115				4						9-	WESTERN GREBE
	117				9		5		4		23- 2-	WESTERN GREBE 1-AD. BALD [illegible] COOT
	118				22		48				1-	WESTERN GREBE
	119				12		11				10- 9-	MALLARD WESTERN GREBE
	120										10- 13-	MALLARD WESTERN GREBE
	138				12	6	205				24-	SCAUP
	139				28		10				6- 50-	WESTERN GREBE WIDGEON
	144				12		3				30- 12-	WESTERN GREBE WIDGEON
	145				12		4		1		1- 60-	WESTERN GREBE WIDGEON
	146			8	13	1	8				6-	WIDGEON
	147				26		31				12-	MALLARD
	148			2	26		91		2			
	149		20	30	1		28				58- 12-	MALLARD 2-GADWALL COOT
	150				5		17				113-	WESTERN GREBE
	151			4	2		1				14- 1-	WESTERN GREBE MURRE
	152			10							80- 130-	MALLARD WIDGEON
	153			2					1		4-	WESTERN GREBE
TOTAL			28	56	198	7	452		9			

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RJ-69-3

Bob To[illegible]

DATE: 5 Jan 76 **OBSERVERS:** R. Poelker, R. Stockey

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113										3 – 1 –	Western Grebe Coot
	114											Nothing Observed
	115											Nothing Observed
	117				1	1					60 –	Western Grebe
	118											Nothing Observed
	119				1							
	120					1					70 – 3 –	Western Grebe Widgeon
	138			16	10		120		3			
	139					3	31				52 – 10 –	Mallard Widgeon
	144			10	25		15				52 –	Widgeon
	145			10	3						20 –	Widgeon
	146			1	1	1	3					
	147			1	2		2				1 –	White fronted goose
	148				8		5					
	149			15	1	1	10				6 –	Mallard
	150			20	3				1		30 –	Western Grebe
	151			2	4	1	2					
	152			6								
	153											Nothing Observed
TOTALS		0	0	76	58	8	178		4		154 –	Western Grebe
											1 –	Coot
Equivalent				760	580	8[illegible]	17[illegible]		40		53 –	Widgeon
											56 –	Mallards
											1 –	White fronted goose

J-69-3

SEND TO Doug Bellingham
Bob Jeffrey

DATE: 3 JAN 79

OBSERVERS: R. Poelker R. Starkey

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce	113	—	—	—	8	—	6	—	—	—	16	Western Grebe
	114	—	—	—	2	—	2	—	—	—	2	Bald Eagles (AD)
	115	—	—	4	1	—	—	—	—	—	4	Western Grebe
	117	—	—	—	8	—	—	—	—	—		6-Mallard, 4 Western Grebe, 1-Coot
	118	—	—	—	15	—	10	—	—	—	20	Western Grebe
	119	—	—	—	10	—	3	—	—	—		50-Mallards, 110 Western Grebe
	120	—	—	30	6	—	50	—	—	—		125-Western Grebe, 20-Widgeon
	138	—	—	—	20	—	350	—	—	—		80-Widgeon
	139	—	—	15	8	20	10	—	—	—		6-Western Grebe
	144	—	—	—	10	—	10	—	—	—		20-Widgeon
	145	—	—	—	10	—	7	—	—	—		25-Mallard, 50-Widgeon, 5-Gadwall
	146	—	—	—	7	10	16	—	—	—		30-Western Grebe, 5-Widgeon
	147	—	—	5	15	~~—~~ 5	96	—	—	—	10	Widgeon
	148	—	—	4	25	—	48	—	—	—		16-Western Grebe
	149	—	—	22	—	—	30	—	—	—		2-Western Grebe, 20-Widgeon
	150	—	—	50	4	—	—	—	—	—		
	151	—	—	—	4	—	—	—	—	—		130-Western Grebe
	152	—	—	—	1	—	2	—	—	—		2-Widgeon
	157	—	—	—	8	~~—~~	—	—	—	—		2-Mallard, 1 Western Grebe, 40-Coots
TOTALS				130	164	35	640				2	Bald Eagles (AD)
											454	Western Grebe
											95	Mallard
											41	Coot
											202	Widgeon
											5	Gadwall

RJ-69-3

DATE: Jan. 2 1980 OBSERVERS: Fred Martinsen, Jeff Skriletz

County	Sample	Redhead	Canvas back	Scaup	Golden eye	Buffle head	Scoter	Ruddy	Merganser	Old Squaw	Other	Remarks
Pierce Co.	113				4		4					
	114				1	1						
	115				2							
	117				5	2	1					
	118						21					
	119			2	2		6					
	120			4	3	5	20		2			
	138			5	2	2	5					3 mallards
	139				4	1	18					
	144			1	17		4					
	145				1		4		17			25 wigeon
	146			7	8		25					
	147			2	6	3	81					1 BALD EAGLE - IMM
	148				4		18					
	149		22	10	14	6	64					2 mallard
	150			5	18	1	16					
	151			3	2				3			
	152			3			3					
	153				1		4					
NISQUALLY	DELTA REACH											150 Pintail
	Totals		22	42	94	21	294		22			
Expanded	Totals (x10)		220	420	940	210	2940		220			

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