MIDDLE WATERWAY SHORE RESTORATION PROJECT MONITORING AND ADAPTIVE MANAGEMENT PLAN DATA REPORT

POST-CONSTRUCTION (YEAR 0-1)

Prepared for

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INTRODUCTION

PROJECT DESCRIPTION

Under the St. Paul Waterway Natural Resource Damage (NRD) settlement agreement, Simpson Tacoma Kraft Company (Simpson) and Champion International Corporation (Champion) funded the completion of an additional restoration project to provide habitat value in Commencement Bay. The Middle Waterway Shore Restoration Project is located on property owned by Simpson along the southeastern shore of the Middle Waterway in Commencement Bay. The project is in close proximity, and functionally related to, the intertidal habitat constructed in 1988 as part of the St. Paul Waterway Area Remedial Action and Habitat Restoration Project by Simpson and Champion at the north end of the Tacoma Kraft mill, as well as other intertidal and subtidal areas near the Puyallup River delta (Parametrix 1993) (Figure 1).

The Middle Waterway Shore Restoration Project (the project) was developed in cooperation with Champion and the Natural Resource Trustees for Commencement Bay (the Trustees), and other cooperating agencies. The Trustees include the National Oceanographic and Atmospheric Administration (NOAA), the U.S. Fish & Wildlife Service (USFWS), the Washington Department of Ecology (Ecology), the Muckleshoot Indian Tribe, and the Puyallup Tribe of Indians. Cooperating agencies include the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (the Corps), the Washington Department of Natural Resources (DNR), and the Washington Department of Fish and Wildlife (WDFW). Together, these organizations and agencies comprise the Restoration Project Planning Group.

The project has twin goals of long-term environmental restoration and study value. Its main objective is to provide valuable estuarine habitat, in perpetuity, that is adjacent to one of the largest remaining areas of original Commencement Bay intertidal mud flat (nearly 20 acres) and functionally related to the intertidal habitat constructed at the north shore of the Tacoma Kraft Mill in 1988, the Puyallup delta, and other nearby intertidal and shallow subtidal habitats. Other environmental restoration objectives of the project include the following:

- Convert approximately 1.5 acres of upland from existing industrial use to estuarine intertidal wetland;
- Increase the length of natural shoreline edge along the +9 to +13 foot contour from 840 to 960 feet;
- Establish approximately 1.2 acres of habitat at known high and low salt marsh elevations;
- Provide a riparian buffer and transition zone from tide flat to upland to screen, protect, and support the integrity of the remaining original Middle Waterway mud flat and the diverse species that use this biologically productive area of the estuary; and

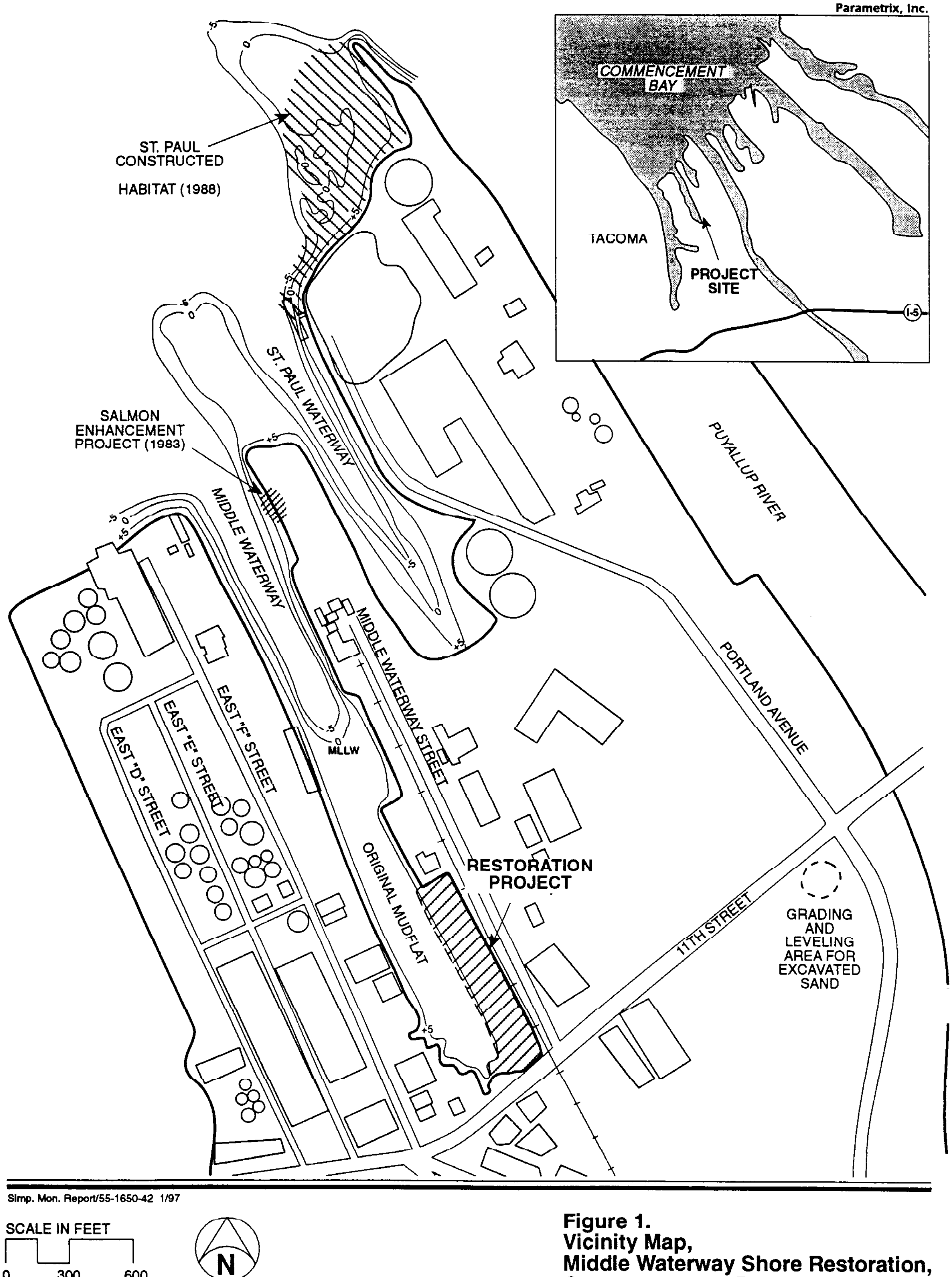

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**Figure 1.
Vicinity Map,
Middle Waterway Shore Restoration,
Commencement Bay**

- Restore a minimum of 0.23 acres of estuarine intertidal mud/sand habitat as mitigation for placing fill on a like acreage of intertidal mud/sand habitat at similar elevations.

Restoration at the project site enhances and supports the continued existence of the remnant tide flats at the head of the Middle Waterway. The Natural Resource Trustees for Commencement Bay, together with Simpson and Champion, identified no other location that would meet the project environmental restoration objective as well or provide the additional benefit of protecting those tide flats.

A detailed description of the project and its objectives may be found in *Project Analysis: Middle Waterway Shore Restoration Project* (Parametrix 1993) and *Project Supplemental Information Summary: Middle Waterway Shore Restoration Project* (Parametrix 1994a).

PROJECT MONITORING

The Middle Waterway Shore Restoration Project consists of an approximately 3.3-acre nearshore site in Commencement Bay that is being restored to functional estuarine habitat. In early 1995, approximately 1.5 acres of industrial fill was converted into estuarine wetland, and the adjacent lower intertidal area was regraded into a more structurally diverse intertidal area. The site presently comprises a low-elevation mud flat, low salt marsh, high salt marsh, and upland riparian buffer. In mid-1995, the riparian buffer was planted with upland vegetation and a small area of low salt marsh was planted with "sods"[1] of saltgrass (*Distichlis spicata*). On May 22, 1996, additional areas were planted with a variety of high and low salt marsh vegetation. Post-construction site monitoring began in April 1996.

Several descriptive and experimental studies were proposed as elements of the monitoring plan, to collect data that would help determine the success and health of the restoration site over time and assist in future restoration projects in Commencement Bay. The restoration project site monitoring program includes the following descriptive studies:

- Document the general development of estuarine habitat on the project site [through aerial photographs (through Year 5) and photogrammetric elevation mapping (when necessary)];
- Document the general development of new intertidal and salt marsh substrates [through grain size analyses (through Year 5)];
- Document trends in sediment chemistry, including potential transportation of contaminants from adjacent mud flats [through sediment chemistry analyses (Years 0, 1, 3, and 5)];

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1 Sods refer to clumps of vegetation with the root mass surrounded by attached soil.

- Document trends in benthic infauna that correspond to changes in sediment grain size and chemistry [through biological analyses (Years 1-5; trend analysis in Year 5)];

- Evaluate predictions about elevations and salt marsh establishment, using vegetation established on-site [through vegetation analyses (Years 0, 1, 2, and 3) and periodic measurement of elevations (when necessary)]; and

- Document the general use of intertidal, salt marsh, and riparian habitats by wildlife [through general qualitative observations (periodically, through volunteer effort)].

A schedule of annual monitoring activities is provided in Table 1. As originally envisioned in the *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan* (Parametrix 1994b), site construction and vegetation planting were to have been completed in early 1995, followed immediately by Year 0 monitoring for physical and soil characteristics. Vegetation and sediment chemistry monitoring was to begin the second year after construction. Because nearly a year elapsed between the 1995 site construction and the final vegetation planting in 1996, the first year of post-construction monitoring combined some Year 0 and Year 1 activities. Therefore, this report is referred to as Year 0-1.

Table 1. Middle Waterway Shore Restoration post-construction monitoring schedule.

Activity	Frequency	Task Conducted in 1996
Physical Surveys		
Transects	annually (year 0, 1 and 2)	
Topographic Mapping	year 0 (only if necessary thereafter)	X
Sediment Surveys		
Grain Size	annually (year 0, 1, 2, 3, 4, 5)	X
Biological	annually (year 5)	
Chemical	annually (year 1, 3, and 5)	X
Vegetation Surveys		
Transplant/Colonization	semi-annually (year 1), annually (year 2 and 3)	X
Plant Protection	semi-annually (year 1); as needed thereafter	X
Soil Chemistry	annually (year 0, 1 and 3)	X
Wildlife Surveys	periodically per volunteer effort	X
Aerial Photo	annually (year 0, 1, 2, 3, 4, 5)	X

year 0 = year of construction

The monitoring program included the collection of vegetation data that could be used to support the following experimental studies:

- Evaluation of the effectiveness of hand-planting to establish intertidal high and low salt marsh vegetation;
- Evaluation of the effectiveness of natural vegetation to establish intertidal emergent low and high salt marsh vegetation;
- Evaluation of the natural revegetation of estuarine intertidal emergent vegetation on pumped Puyallup River sands; and
- Evaluation of the natural revegetation of estuarine intertidal emergent vegetation on pumped Puyallup River sands top-dressed with salvaged mud flat soils.

These evaluations will be conducted by the Trustees, based on data provided in the annual data reports.

This data report contains the sampling methods, data, analytical results, and other related information collected during the first year of post-construction monitoring. In keeping with the project understanding between Simpson, Champion, and the Trustees, no data interpretation was provided, other than discussions of how sampling methods may have affected or influenced the data. Copies of laboratory analytical results and field survey data can be found in the Data Appendix.

Three general survey elements comprised the initial year of monitoring:

- physical surveys of site elevations and locations of permanent reference points;
- sediment surveys of sediment physical characteristics (i.e., grain size) and chemistry; and
- vegetation surveys of species and substrates present in planted and unplanted areas, and interstitial water sampling for plant nutrients.

Incidental wildlife observations were also provided.

METHODS AND RESULTS

PHYSICAL MONITORING

Physical monitoring is intended to record the post-construction elevations at the restoration site and document elevation changes over time. The reconstructed elevations ranged between 9 ft mean lower low water (MLLW) and 14 ft MLLW. The monitoring plan specified that several reference locations be permanently established and their locations recorded. Physical monitoring reference locations included:

- two permanent benchmarks on-site,
- five permanent transects for elevation monitoring, and
- three photo reference points.

Two permanent benchmarks, one on each end of the site, were established by the National Ocean Service in 1995. Each benchmark consists of a 12-in-square concrete base with a 3-in-diameter domed brass cap. The benchmark locations were surveyed using Project horizontal datum (NAD 1927) and City of Tacoma MLLW elevation datum. Post-construction measurement and mapping of constructed elevations were completed by Parametrix surveyors in July 1995. Elevation contours for the entire site were mapped; this information was used for the figures in this report. Post-construction contours and elevations closely resembled pre-construction design contours and elevations.

Four permanent transects (A, B, C, and D) were established in June 1996 for subsequent annual elevation monitoring. A fifth transect (E) was inadvertently omitted, but could be established whenever subsequent elevation monitoring might be necessary. The transects' endpoints were marked with concrete reinforcing bar (rebar) stakes labeled T-A (extending to stake T-AA), T-B (to stake T-BB), T-C (to stake T-CC), and T-D (to stake T-DD). The endpoint locations were established at relatively high elevations on opposite sides of the waterway to protect the stakes from drifting logs. No transect elevation profiles were surveyed in 1996.

State plane coordinates for all survey locations are listed in Table 2. Three photo reference points were established in September, but not surveyed. Survey coordinates can be obtained for these points during the following year of monitoring. Approximate locations of all physical monitoring reference locations are depicted in Figure 2.

An aerial photo was taken of the Middle Waterway on July 31, 1996, during a low tide of -2.2 ft MLLW. Photographic conditions were good, so the aerial photo provided clear images of the re-constructed shore, intertidal zone, newly planted vegetation, transplant enclosures, bare substrate, logs, and the benchmark monuments in the project area. Photogrammetric pre-marks will be placed at the benchmarks for elevation monitoring (if needed) in Year 2.

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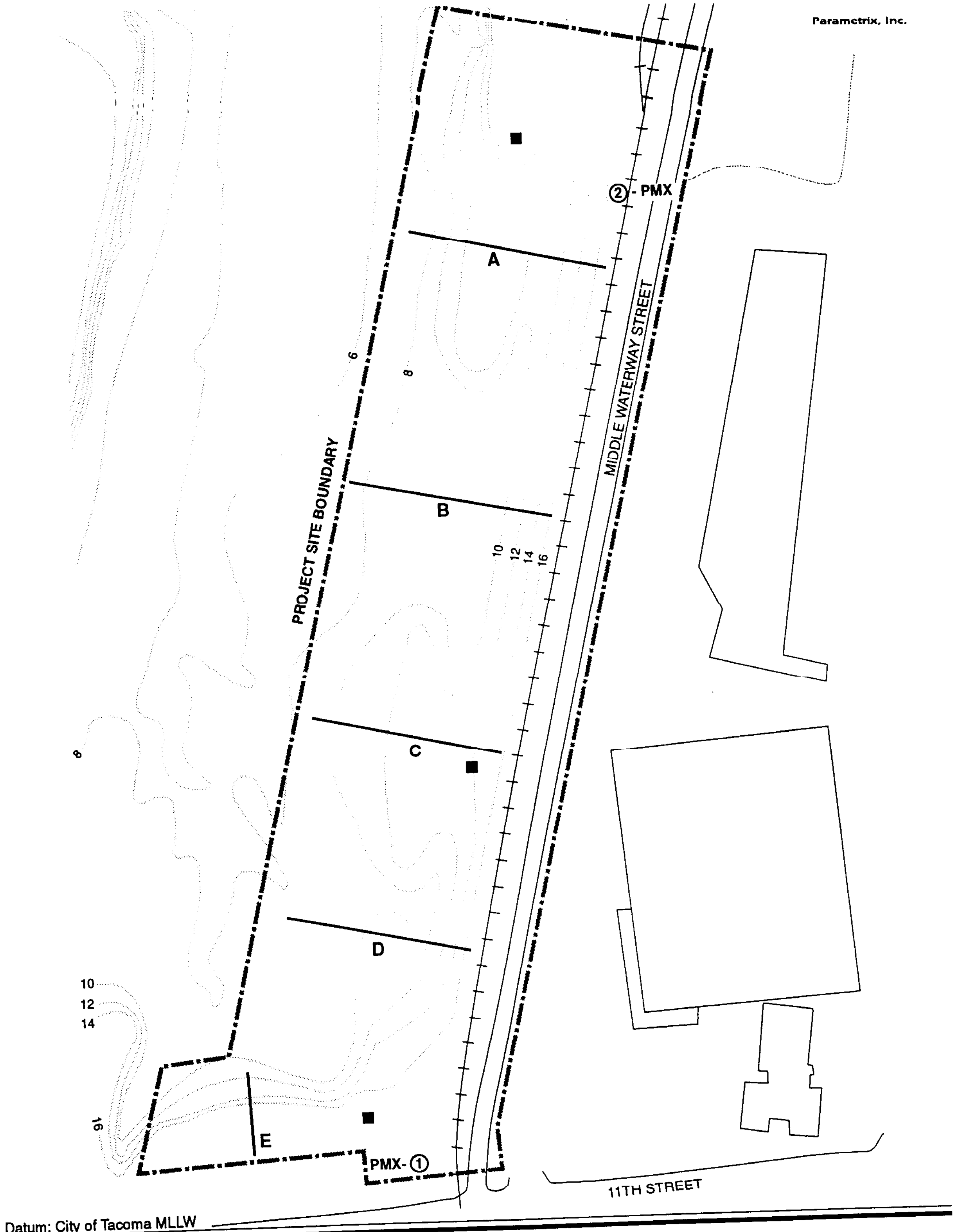

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SCALE IN FEET

0 50 100

PMX- ① Bench Mark Locations

■ Photopoint Locations

—— Survey Transects

Figure 2.
Physical Monitoring Reference Locations

Table 2. State plane coordinates and elevations (ft MLLW) for 1996 Middle Waterway Shore Restoration stations.

Station	North	East	Elevation[a]	Descriptor
GS-1	707091.2	1521953.9	14.9	Sediment-Grain Size #1
GS-2	707125.5	1521909.3	11.6	Sediment-Grain Size #2
GS-3	707179.8	1521892.2	9.7	Sediment-Grain Size #3
GS-4	707175.1	1521851.4	9.8	Sediment-Grain Size #4
GS-5	707240.7	1521810.2	11.1	Sediment-Grain Size #5
GS-6	707279.4	1521838.6	12.4	Sediment-Grain Size #6
GS-7	707330.2	1521851.0	14.2	Sediment-Grain Size #7
GS-8	707345.9	1521806.6	12.3	Sediment-Grain Size #8
GS-9	707302.7	1521765.0	11.2	Sediment-Grain Size #9
GS-10	707418.1	1521742.1	11.1	Sediment-Grain Size #10
GS-11	707490.8	1521745.3	10.1	Sediment-Grain Size #11
GS-12	707561.1	1521676.1	9.8	Sediment-Grain Size #12
GS-13	707668.2	1521655.3	12.2	Sediment-Grain Size #13
GS-14	707767.9	1521642.7	10.3	Sediment-Grain Size #14
GS-15	707792.5	1521600.4	12.8	Sediment-Grain Size #15
HC-2	707120.0	1521797.0	7.1	Sediment-Chemistry
C	707198.8	1521891.3	10.0	Sediment-Chemistry
A	707432.5	1521715.0	8.6	Sediment-Chemistry
F	707315.0	1521733.0	10.1	Sediment-Chemistry
MW-1(a)	707652.0	1521609.0	9.4	Sediment-Chemistry
T-A	707790.0	1521689.0	18.9	Survey Elevation Endpoint
T-AA	707621.0	1521280.2	11.5	Survey Elevation Endpoint
T-B	707566.0	1521780.0	18.9	Survey Elevation Endpoint
T-BB	707397.0	1521371.5	9.7	Survey Elevation Endpoint
T-C	707353.5	1521867.4	19.4	Survey Elevation Endpoint
T-CC	707181.9	1521452.4	12.2	Survey Elevation Endpoint
T-D	707180.0	1521939.0	19.0	Survey Elevation Endpoint
T-DD	707020.9	1521554.1	11.5	Survey Elevation Endpoint
PMX-1	707007.57	1522034.22	15.90	Benchmark (project datum)
PMX-2	707868.65	1521666.84	16.65	Benchmark (project datum)

a = City of Tacoma datum

SEDIMENT MONITORING

Sediment Physical Characteristics

Surface sediments on the restored habitat were monitored to assess initial physical characteristics (i.e., grain size) following site construction. Sampling methods and analyses adhered to the methods specified in the monitoring plan.

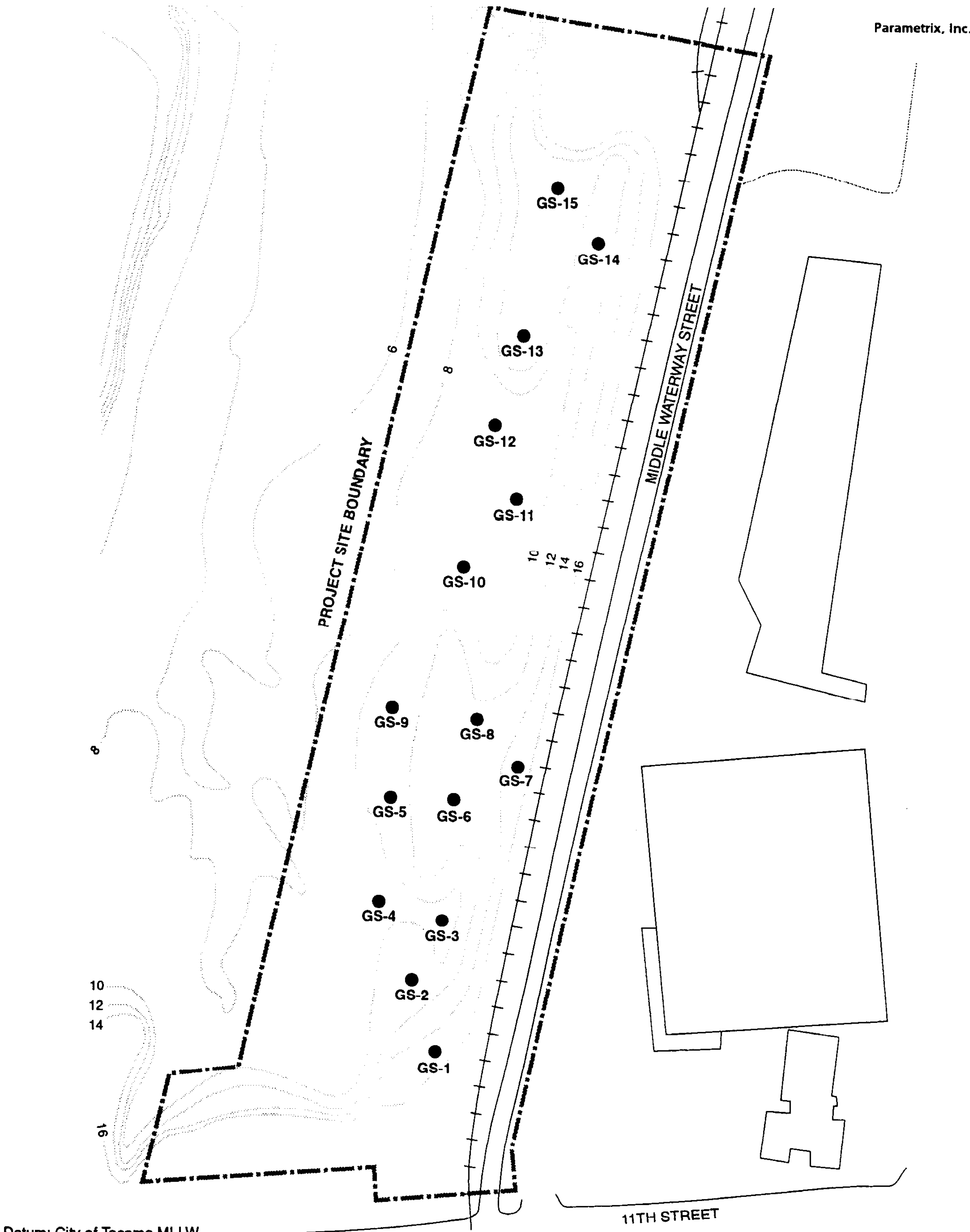
Grain size samples were collected on April 26, 1996 at fifteen stations (Figure 3). Station coordinates are provided in Table 2. A duplicate sample was collected at station GS-7. Station locations were based on approximate locations indicated in the monitoring plan.

Samples were collected by hand, using clean stainless steel spoons, from the upper 2 cm of sediment. In years when biological sampling for benthic infauna is conducted, a sediment core of the upper 5 cm will be collected for grain size characterization of the biologically active zone. This year, only shallow (0-2 cm) surface sediments were examined to see what initial post-construction sedimentation had taken place.

Sediments were placed in clean 200 ml glass jars, labeled, and stored on ice in a cooler. Sediment samples were transported to an analytical laboratory (AmTest, Inc.) the same day for analysis.

Laboratory analysis followed Puget Sound Estuarine Program (PSEP) protocols. Samples were analyzed within the PSEP-specified holding time. A copy of the complete laboratory data package, including quality assurance/quality control (QA/QC) procedures, is in the Data Appendix. As an additional data validation measure, Relative Percent Difference (RPD) was calculated for all particle sizes (i.e., Wentworth scale in phi units) for the sample, the laboratory duplicate, and the laboratory replicate analyses at stations GS-1 and GS-11. All RPD results were within an acceptable range of ± 20%, all differing less than 2% (see Data Appendix). Results of the sediment grain size analysis are summarized in Table 3.

In general, all stations were relatively similar, dominated by sand (coarser than phi mesh size +4). GS-1, GS-7, and GS-14 were greater than 90% sand. These stations were all in the high intertidal. Twelve other stations were greater than 72% sand and one station was 59.2% sand. The siltiest station, GS-12, was in the mud flat area. Stations GS-4, -5, -10, and -11, the next siltiest stations, were also in the mud flat areas and, for the most part, at the lowest elevations on the site. The dominance of coarse sand or fine silt/clay substrates in the grain size data corresponded to site observations and vegetation substrate data.



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SCALE IN FEET
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Figure 3.
Sediment Grain Size Stations

Table 3. Sediment grain size distribution at 1996 Middle Waterway Shore Restoration stations.

																% Sand/	% Silt/	% Total
Upper (mm) Mesh Size	4.75	4.00	2.00	1.00	0.50	0.25	0.125	0.063	0.032	0.016	0.008	0.004	0.002	0.001		Gravel	Clay	Solids
Lower (mm) Mesh Size	4.00	2.00	1.00	0.50	0.25	0.125	0.063	0.032	0.016	0.008	0.004	0.002	0.001	<0.001	<0.001			
Finer than Phi Mesh Size		-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	> +10			
Relative Percent of Sediment Present in Each Mesh Size																		
GS-1	0.1	0.1	2.0	5.8	34.6	41.0	10.1	2.7	1.5	0.4	1.0	0.2	< 0.1	< 0.1	0.5	93.7	6.3	94.9
GS-2	0.5	0.1	0.4	1.3	13.0	40.6	26.4	9.8	5.7	0.4	1.0	0.8	0.1	< 0.1	< 0.1	82.3	17.8	79.8
GS-3	1.0	0.4	1.1	2.8	17.5	41.6	17.0	7.7	6.1	1.5	1.2	1.1	0.1	< 0.1	0.7	81.4	18.4	70.4
GS-4	1.7	0.3	1.0	4.1	19.1	32.3	19.1	10.7	6.7	1.7	1.6	0.9	0.1	< 0.1	0.7	77.6	22.4	70.2
GS-5	0.9	0.4	1.2	3.0	17.9	37.0	17.1	10.3	5.1	3.3	1.5	0.8	0.1	< 0.1	1.4	77.5	22.5	73.8
GS-6	< 0.1	0.3	1.1	3.6	21.8	36.4	18.5	6.9	6.6	0.9	1.2	1.3	0.2	< 0.1	1.3	81.7	18.4	78.5
GS-7	0.1	< 0.1	1.1	5.0	34.5	42.0	10.2	2.6	2.4	0.8	1.1	0.2	< 0.1	< 0.1	< 0.1	92.9	7.1	93.5
GS-8	0.9	< 0.1	1.0	2.7	21.8	35.6	18.3	6.9	5.9	3.1	2.2	1.4	0.2	< 0.1	< 0.1	80.3	19.7	76.7
GS-9	5.7	0.8	4.6	6.1	22.4	33.1	12.0	5.0	5.3	1.9	1.5	1.4	0.2	< 0.1	< 0.1	84.7	15.3	75.6
GS-10	3.2	0.1	1.9	4.4	17.6	30.5	17.4	9.2	9.0	3.2	2.1	1.2	0.2	< 0.1	< 0.1	75.1	24.9	68.8
GS-11	0.8	< 0.1	0.3	2.0	14.8	32.6	21.8	13.6	7.6	3.6	1.6	1.3	0.2	< 0.1	< 0.1	72.3	27.9	78.6
GS-12	< 0.1	< 0.1	0.4	1.0	5.6	18.6	33.6	21.7	10.5	4.9	1.9	1.6	0.2	< 0.1	< 0.1	59.2	40.8	77.0
GS-13	< 0.1	0.2	0.8	2.3	14.8	37.6	24.8	11.6	5.2	1.5	1.1	0.2	< 0.1	< 0.1	< 0.1	80.5	19.6	87.6
GS-14	0.1	0.1	0.4	3.3	34.7	41.0	12.3	2.2	3.9	0.5	1.0	0.5	< 0.1	< 0.1	< 0.1	91.9	8.1	76.4
GS-15	< 0.1	0.2	1.0	2.4	20.3	38.4	21.4	8.9	5.5	0.7	1.1	< 0.1	< 0.1	< 0.1	< 0.1	83.7	16.2	87.3
GS-16 (GS-7 Dup.)	0.2	< 0.1	1.0	5.3	37.4	39.8	10.4	2.0	2.8	0.4	0.6	< 0.1	< 0.1	< 0.1	< 0.1	94.1	5.8	93.5

Sediment Chemical Characteristics

Sediment samples were collected to monitor chemical concentrations in project site sediments. Sediment samples were analyzed for mercury, semi-volatile organics (low- and high-density polynuclear aromatic hydrocarbons), and conventionals (total solids, total volatile solids, acid volatile sulfide, and total organic carbon). Sampling methods and analyses adhered to the methods specified in the monitoring plan.

Samples were collected on June 28, 1996, at five stations (Figure 4). These stations correspond to the benthic infauna stations that will be monitored for biological characteristics beginning in subsequent years. A duplicate sample, labeled F3, was collected at station F and archived. Samples were collected from the upper 2 cm of sediment by hand, using a stainless steel spoon, and placed either directly into a laboratory container (for acid-volatile sulfide (AVS) analysis) or into a stainless steel mixing bowl (for all other analyses). Sediment samples placed in mixing bowls were completely homogenized before their transfer into laboratory containers. All containers were stored on ice in a cooler. Spoons and mixing bowls were decontaminated before sampling and between stations.

Sediment chemistry samples were transported with a chain-of-custody form and delivered to the analytical laboratory (AmTest, Inc.) on the day they were collected. Chemistry samples were analyzed for the compounds listed in Table 4, using analytical methods specified in the monitoring plan. For comparison, sediment chemistry results from pre-construction (1993) monitoring were included. The pre-construction chemistry results were taken from two reports (Parametrix 1994c, d). Pre-construction chemistry data for Station F that was incorrectly entered in Parametrix 1994d has been corrected for Table 4. Following monitoring plan protocols, sediment chemistry results are presented with Washington Sediment Quality Standards (SQS) for comparison. Following Ecology guidelines, all organic compound results with organic carbon content greater than 0.5% were normalized for organic carbon. No project sample data values exceeded SQS.

Quality control and analysis procedures in the laboratory were consistent with the procedures recommended under PSEP guidelines. A Certified Laboratory Practices (CLP) type of data package, modified by PSEP, was received with the analyses.

Validation of laboratory data was conducted according to EPA functional guidelines for evaluating organics and inorganics (U.S. EPA 1988). Checklists were used to document quality control checks and data qualifiers attached to results. Checklists included the following major categories:

- holding times
- GC/MS tuning
- calibration (initial and continuing)
- blanks, surrogate recovery

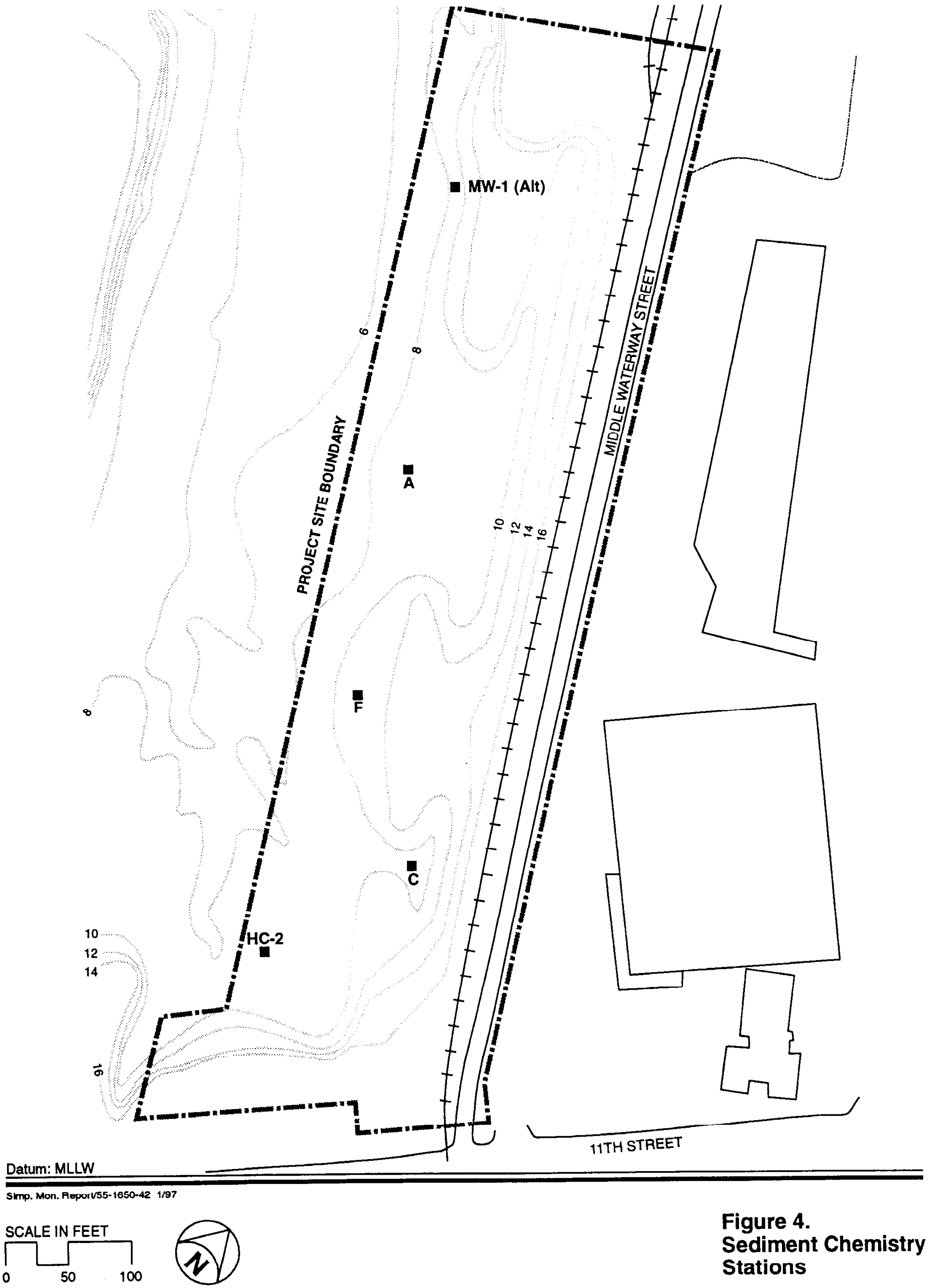

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Figure 4.
Sediment Chemistry Stations

Table 4. Sediment chemistry results (dry weight) for Middle Waterway Shore Restoration Project, 1996.

		Pre-Construction (1993)					Post - Construction (1996)				
Chemical	State SQS*	MW-1(a)**	A***	HC-2**	C***	F**	MW-1 (a)	A	HC-2	C	F
METALS (mg/kg)******											
Mercury	0.41	0.31	0.493	1.18	0.038	0.59	0.198	0.175	0.352	0.031	0.129
ORGANICS (mg/kg OC)											
LPAH											
Acenaphthylene	66	0.6	3.4	2.3	7.5 U	3.0	2.5 U	0.8 U	1.4	4.9 U	0.5 U
Acenaphthene	16	0.5 U	2.6	8.3	7.5 U	2.9	2.5 U	0.8 U	1.3	4.9 U	0.6
Anthracene	220	1.0	5.4	11.4	7.5 U	5.8	2.5 U	1.6	7.8	4.9 U	1.3
Fluorene	23	0.6	4.0	6.1	7.5 U	3.9	2.5 U	0.8	2.4	4.9 U	0.7
Naphthalene	99	1.2	7.7	3.6	7.5 U	10.0	2.5 U	0.8 U	2.4	4.9 U	0.7
Phenanthrene	100	5.3	23.0	97.1 D	7.5 U	20.0	4.5	6.5	17.3	4.9 U	6.7
2-Methylnaphthalene	38	0.5 U	2.8	2.0	8.8 U	3.6	2.5 U	0.8 U	1.2 U	4.9 U	0.5 U
Total LPAH's	370	9.8	48.9	130.8	53.8 U	49.2	19.4	12.1	33.7	34.1	10.9
HPAH											
Benzo(a)anthracene	110	5.3	26.0	43.7 D	7.5 U	20.0	6.5	7.7	17.8	4.9 U	6.9
Benzo(a) pyrene	99	5.3	34.0	43.7 D	17.0	29.0	8.2	8.7	18.2	4.9 U	8.6
Benzo(b)fluoranthene	--	4.4	43.0	29.1 D	23.0	39.0 D	10.6	10.3	15.6	4.9 U	8.3
Benzo(k)fluoranthene	--	8.9	14.0	19.4	7.5 U	11.0	8.6	8.1	15.8	4.9 U	6.9
Total Benzofluoranthenes	209	13.3	57.0	48.5	30.5	50.0	19.2	18.4	31.5	9.7 U	15.3
Benzo(g,h,i)perylene	31	2.8	22.0	9.7	27.0	14.0	6.4	5.5	9.5	4.9 U	5.8
Chrysene	110	8.0	26.0	58.3 D	11.0	23.0	12.7	11.6	25.5	4.9 U	9.4
Dibenzo(a,h)anthracene	12	1.1	4.9	4.6	7.5 U	3.0	2.5 U	0.8 U	1.2 U	4.9 U	0.5 U
Fluoranthene	160	11.6	26.0	77.7 D	13.0	22.0	11.7	14.2	32.7	6.2	10.8
Indeno(1,2,3,-c,d)pyrene	34	3.0	23.0	10.4	21.0	15.0	6.2	5.8	1.2 U	4.9 U	5.8
Pyrene	1,000	7.6	34.0	116.5 D	17.0	48.0 D	10.3	13.5	32.7	7.2	10.0
Total HPAH's	1,347	57.9	252.9	413.1	151.5	224.0	83.6	86.3	170.2	52.3	73.3
CONVENTIONALS											
Total solids (%)	--	66.59	55.7	39.17	82.6	57.4	77.8	59	45.5	76.9	81.5
Total volatile solids (%)	--	--	11.5	--	1.40	13.4	1.9	5.4	12.1	1.3	3.6
Total organic carbon (%)	--	2.25	3.5	4.12	0.24 d	3.3	0.77	3.1	5.5	0.39 d	3.6
Acid volatile sulfides (mg/kg)	--	348	--	2.33 U	--	--	90 b, j	5500 b, j	1300 b, j	780 b, j	100 b, j

Data qualifiers:

-- = No Data
D = Dilution required.
U = Value below stated detection limit.
b = The associated value was detected in the method blank analysis, possible blank contamination.
d = Per Ecology guidelines, samples with <0.5% OC should not be compared to organic carbon-based criteria.
j = The associated value is an estimate.

Notes:

mg/kg OC = mg/kg of Organic Carbon
* = Washington Sediment Quality Standard
** = Data from Parametrix 1994c
*** = Data corrected from Parametrix 1994d
**** = Not normalized for total organic carbon.

- matrix spike and matrix spike duplicate
- internal standards
- TCL compound identification
- compound quantification and reported detection limits
- system performance and overall data assessment
- reference sample
- laboratory duplicate analysis
- furnace AA and ICP controls

(Some categories are applicable only to some analyses.) All summary tables generated from the laboratory data were checked for transcription errors. Copies of raw data, data validation checklists, and a data validation summary memorandum are provided in the Data Appendix. AVS results were qualified as estimates because of a high percent relative standard deviation and AVS detection in the method blank analysis. No other data results were qualified during the data quality review. No results were rejected.

VEGETATION SAMPLING

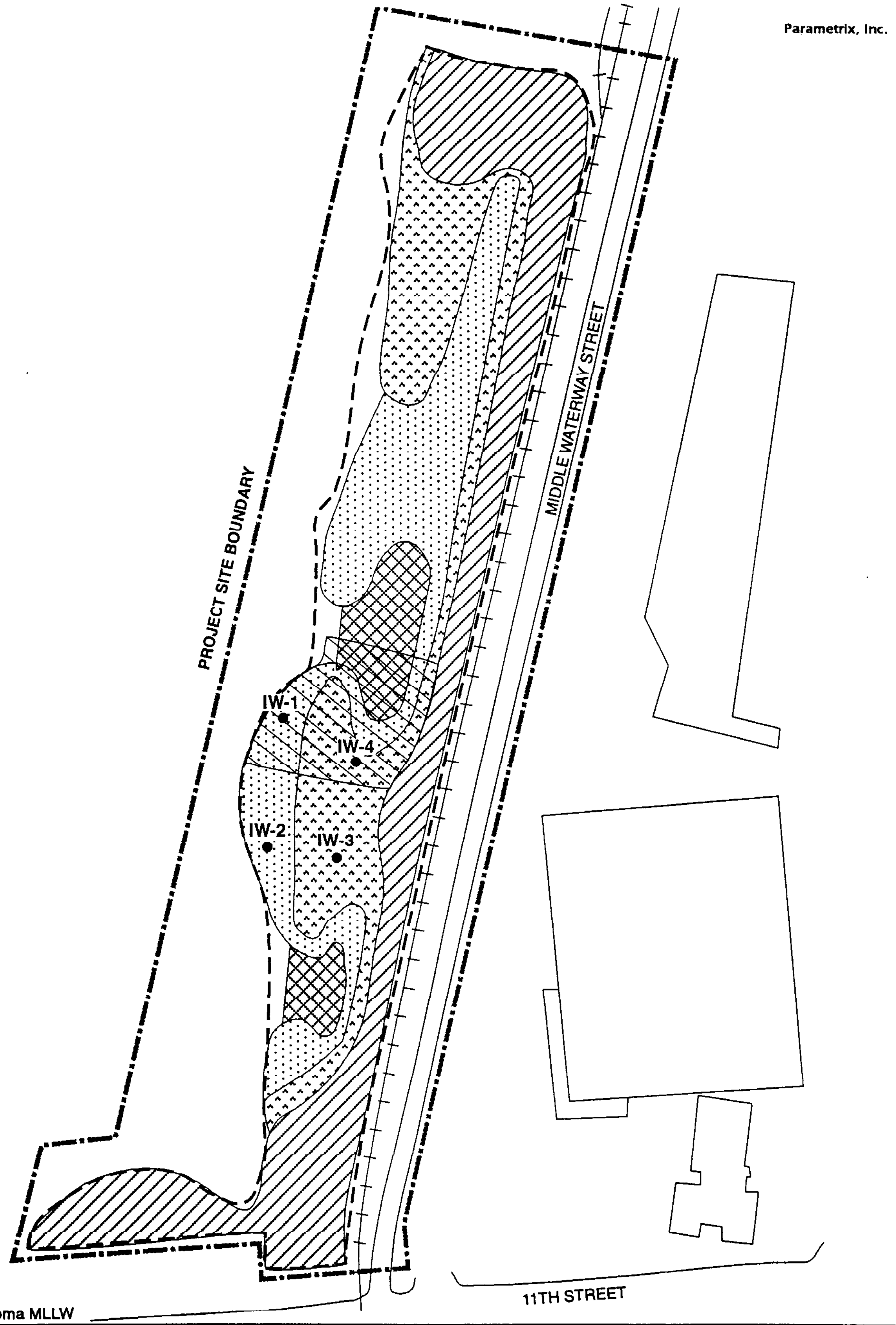
The Middle Waterway Shore Restoration site was planted with high and low salt marsh vegetation on May 22, 1996. Vegetation monitoring was designed to assess the post-construction presence, species composition, and distribution of planted and colonizing vegetation. Both vascular (e.g., salt marsh plants) and non-vascular (e.g., seaweeds) macrophytes were surveyed. Survey methods generally adhered to methods described in the monitoring plan. In several cases, the monitoring plan did not specify how the data were to be collected, but instead discussed sampling goals and objectives for data comparisons. Thus, the vegetation sampling approach was modified or augmented to collect data that would meet the goals and objectives. The methods used to sample vegetation are described below.

Aerial Photo Mapping

An aerial photo of the Middle Waterway, taken July 31, 1996, was used to document the initial post-construction condition of site vegetation. Photographic conditions were good, so the aerial photo provided clear images of the re-constructed shore, various elevations within the intertidal zone, newly planted vegetation, transplant enclosures, bare substrate, logs, and debris within the project area. The aerial photo was used to map the approximate locations of the planting zones (Figure 5) and newly planted vegetation (Figure 6).

Vegetation Sampling

Biologists monitoring site sediment observed new growth on the planted salt marsh vegetation in June and July. In August, the aerial photo was examined for further evidence of planted or volunteer vegetation, including macroalgae (i.e., large seaweeds). Because the planted vegetation had not yet spread and macroalgae had not colonized the lower intertidal areas,



Datum: City of Tacoma MLLW

Simp. Mon. Report/55-1650-42 1/97

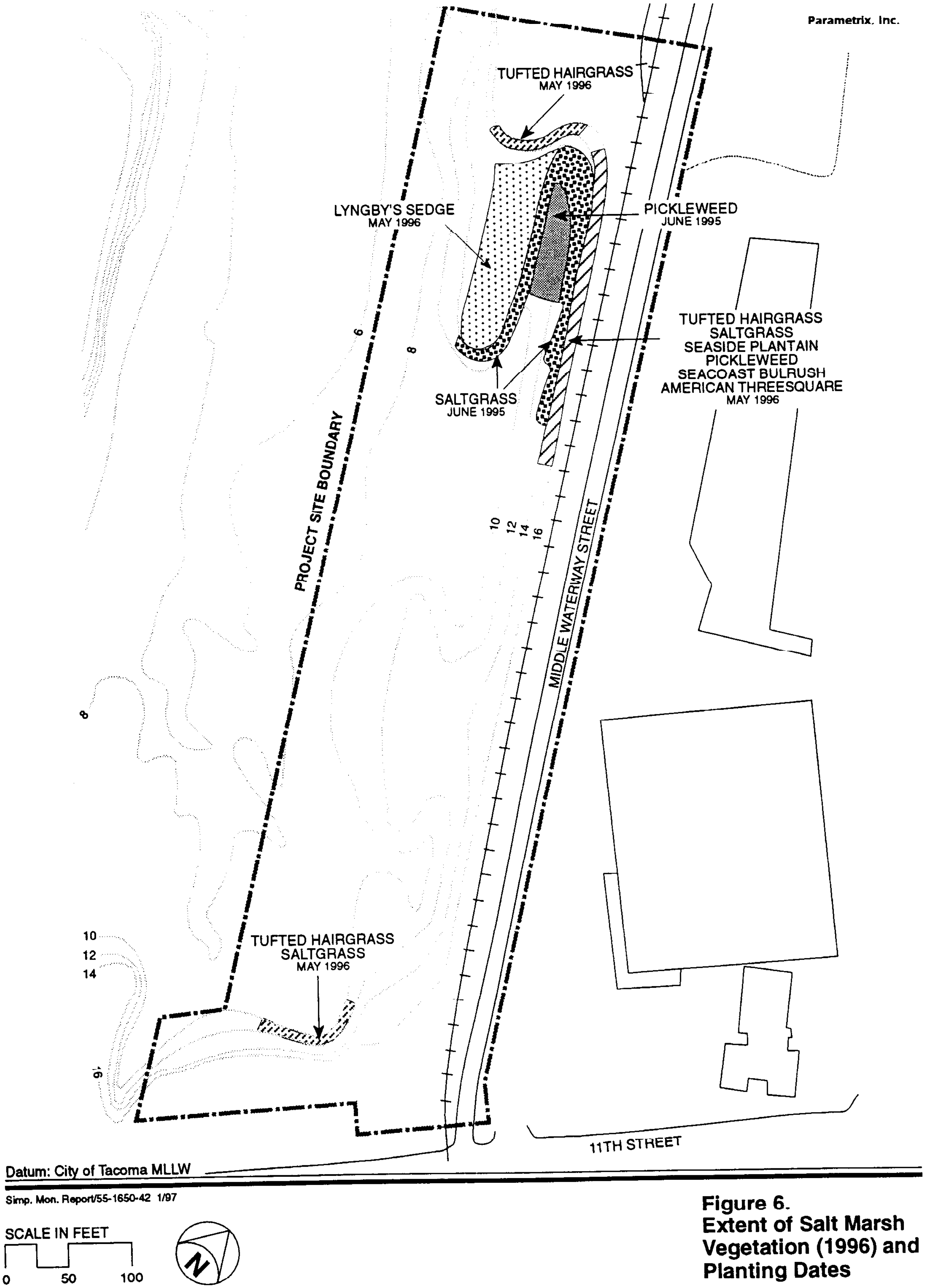
SCALE IN FEET

0 50 100

N

High Salt Marsh
Low Salt Marsh
Mud Flat
Sediment Topdress
Upland Buffer
Sampling Stations
Limit of Activity

Figure 5.
Marsh Zones, Buffer, and Interstitial Water Stations



Simp. Mon. Report/55-1650-42 1/97

**Figure 6.
Extent of Salt Marsh
Vegetation (1996) and
Planting Dates**

summer vegetation surveys were postponed as long as practical, to allow transplanted vegetation more time to establish. Thus (for this year only), vegetation surveys were conducted September 12, 17, and 25.

Four general types of vegetation zones were identified in the monitoring plan: low salt marsh, high salt marsh, mud flat and marsh top-dressed with salvaged soils (see Figure 5). Only limited areas of the high and low salt marsh areas were planted. Most planted areas were enclosed with string and flagging to exclude geese. Only one area, a north-end low salt marsh bed, was planted without an enclosure. Using field notes, planting notes, survey elevations, site photos, and the aerial photo, the site was divided into nine existing and potential macrophyte beds (based on elevation, plant species, substrate, and protective enclosure) that were mapped (Figure 7).

Corresponding to each planted bed (or "treatment" area), a control bed ("untreated") with similar physical conditions was identified. The physical conditions used to define each control bed included: (1) proximity to the treatment bed (e.g., near the same part of the site), (2) similarity of elevation, and (3) similarity of substrate. Obviously, the control beds did not contain any transplanted vegetation. As specified in the monitoring plan, additional treatment and control beds were identified to measure future vegetation colonization on unplanted soils. The treatment and control macrophyte beds are listed in Table 5 and illustrated in Figure 7.

Table 5. Treatment (T) and control macrophyte beds (C) for vegetation monitoring.

Bed 1	High salt marsh (northwest end), with protective enclosure (T)
Bed 2	High salt marsh (northeast end), with protective enclosure (T)
	High salt marsh (south end), with protective enclosure (T)
Bed 3	High salt marsh control 1 (center) (C)
	High salt marsh control 2 (north end) (C)
Bed 4	Low salt marsh, planted, no enclosure (T)
Bed 5	Low salt marsh (north end), with protective enclosure (T)
	Low salt marsh (south), with protective enclosure (T)
Bed 6	Low salt marsh control (north end) (C)
	Low salt marsh control (center) (C)
Bed 7	Mud flat, unplanted (north end) (C)
	Mud flat, unplanted (south end) (C)
Bed 8	Low mud flat, unplanted, with soil top-dressing (T)
Bed 9	High and low mud flat, unplanted, with soil top-dressing (T)

Vegetation was monitored by estimating percent aerial cover by species along transects in the high marsh, low marsh, and mud flat zones (Figure 8). Percent cover by species was visually estimated within eighty 1-m^2 quadrats established along 14 transects. Transects in macrophyte and control beds, the percent cover by species, and dominant substrate type are presented in Table 6.

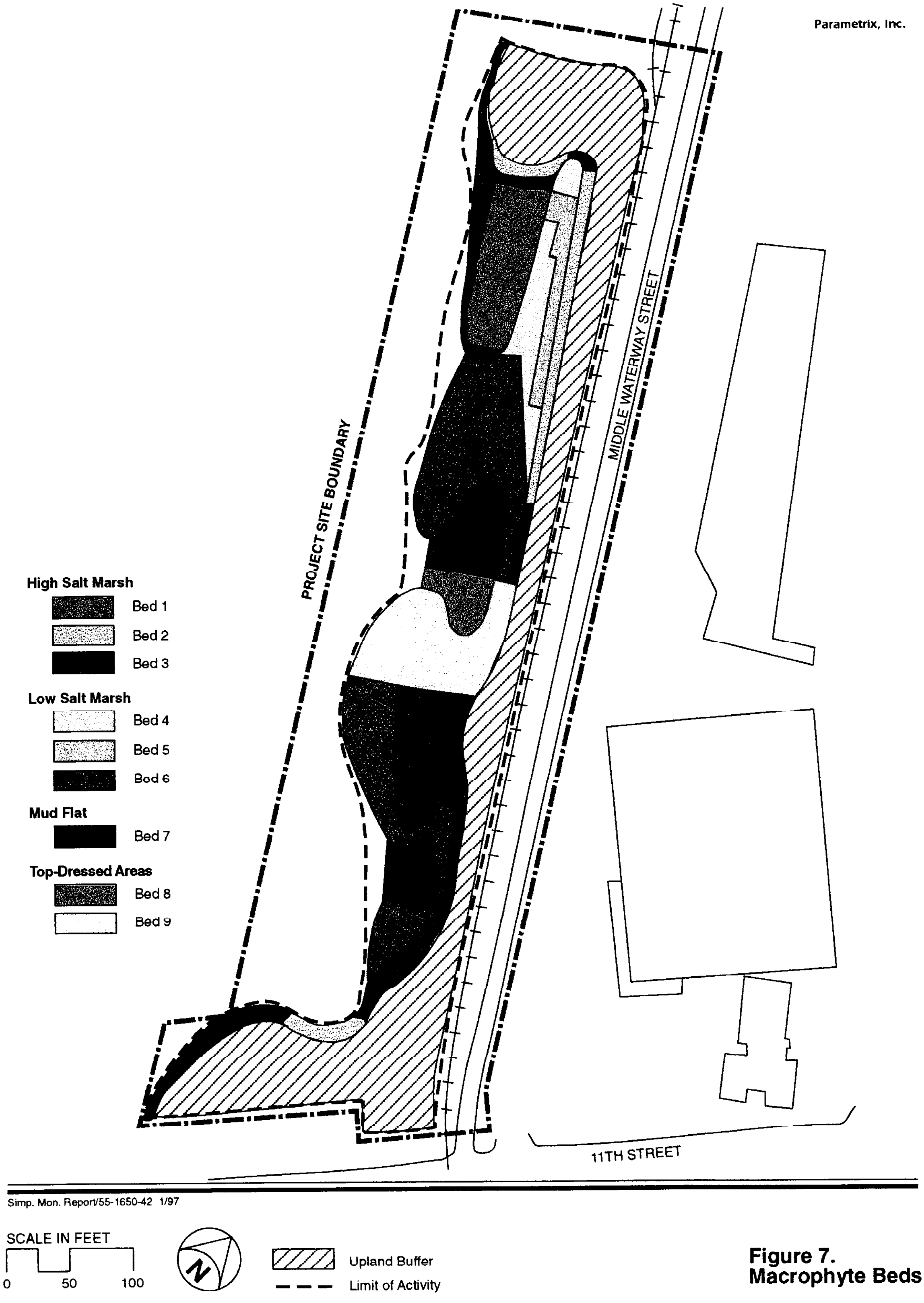


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Figure 7.
Macrophyte Beds

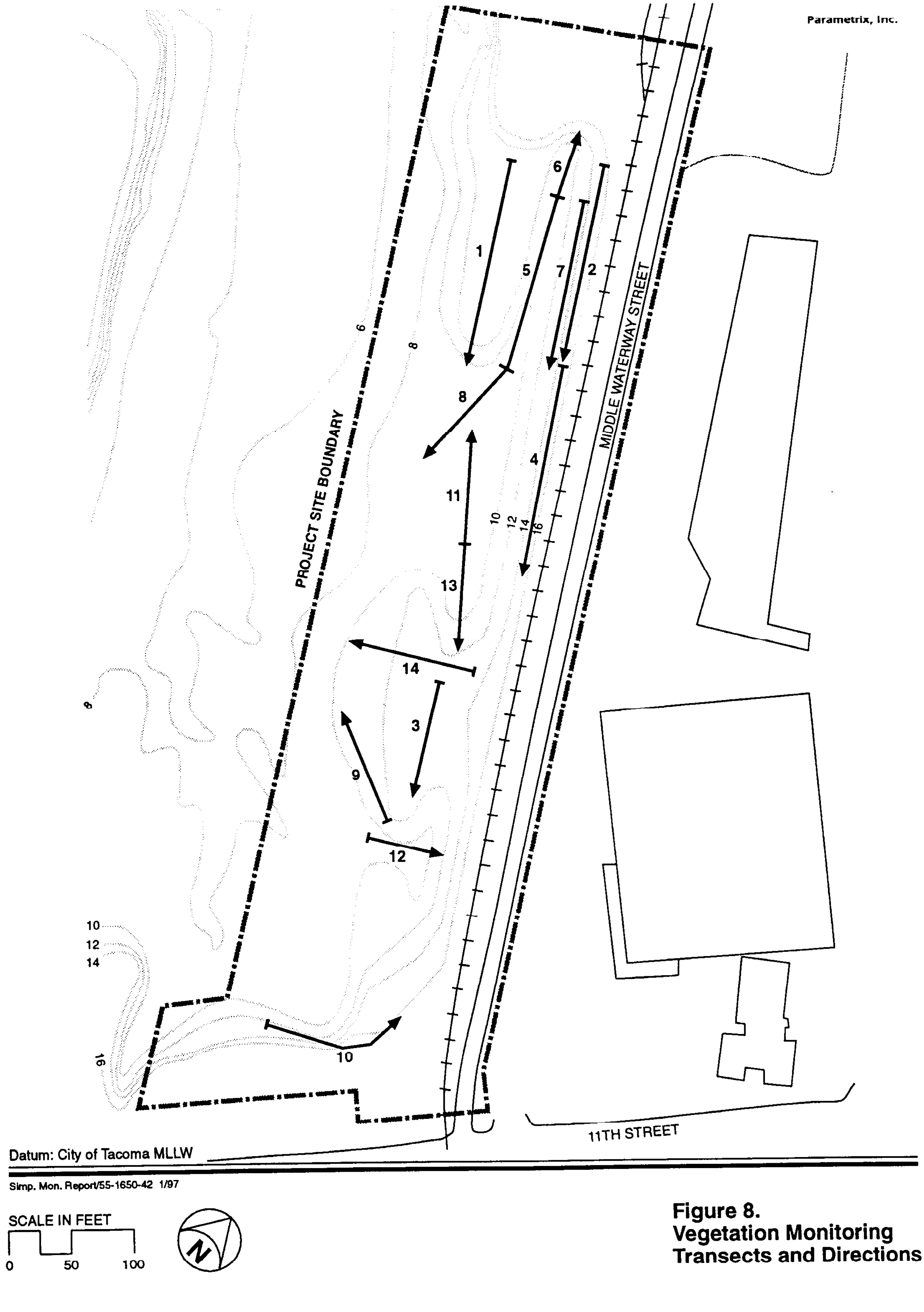

Figure 8.
Vegetation Monitoring Transects and Directions

Table 6. **Vegetation species, percent cover, and dominant substrate characteristics of macrophyte beds, 1996.**

Bed #	Transect #	Endpoints	Species	% Cover (Range)[1]	Dominant Substrate (>50%)[2]
1	1	A, A1	*Carex lyngbyei* (Lyngby sedge)	0.5-4	<u>sand</u>, mud, leaves
1	2	B, B1	*Deschampsia cespitosa* (tufted hairgrass)	1-4	litter (wood, leaves), <u>sand</u>
			Atriplex patula (salt weed)	0-18	
3	3	C, C1			<u>sand</u>, litter
3	4	D, D1	*Atriplex patula* (salt weed)	0.5-6	litter (leaves), <u>sand</u>, trash (plastic bag)
4	5	E, E1	*Vaucharia* sp. (yellow-green algae)	0-95	litter, <u>mud</u>
			Enteromorpha flexuosa (green algae)	0-3	
			Salicornia virginica (pickleweed)	0-10	
			Eleocharis palustris (spike rush)[3]		
5	6	F, F1	*Vaucharia* sp. (yellow-green algae)	0-6	litter (leaves), <u>mud</u>
			Enteromorpha flexuosa (green algae)	1-40	
			Scirpus maritimus (seacoast bulrush)	0-2	
			Distichlis spicata (saltgrass)	5-50	
			Salicornia virginica (pickleweed)	0-1	
5	7	G, G1	*Distichlis spicata* (saltgrass)	1-2.5	litter, <u>sand</u>
			Atriplex patula (salt weed)	0-33	
			Salicornia virginica (pickleweed)	0-2.5	
			Jaumea carnosa (fleshy jaumea)[3]		
			Plantago maritima (seaside plantain)[3]		
6	8	H, H1	*Vaucharia* sp. (yellow-green algae)	0.5-4	litter, <u>mud</u>
			Enteromorpha flexuosa (green algae)	0-63	
6	9	I, I1	*Vaucharia* sp. (yellow-green algae)	0-23	litter, mud, <u>sand</u>
			Enteromorpha flexuosa (green algae)	0-13	
2	10	J, J1	*Deschampsia cespitosa* (tufted hairgrass)	1-6	litter, <u>sand</u>
			Fragaria chiloensis (coastal strawberry)	0-0.5	
			Atriplex patula (salt weed)	0-50	
7	11	K, K1	*Vaucharia sp.* (yellow-green algae)	1-93	<u>mud</u>, litter
			Enteromorpha flexuosa (green algae)	<1-68	
7	12	L, L1	*Enteromorpha flexuosa* (green algae)	0.5-5	<u>mud</u>, litter
			Vaucharia sp. (yellow-green algae)	0-<1	
8	13	M, M1	*Vaucharia* sp. (yellow-green algae)	0-8	<u>mud</u>, wood
			Enteromorpha flexuosa (green algae)	3-91	
			Eleocharis palustris (spike rush)[3]		
9	14	N, N1	*Enteromorpha flexuosa* (green algae)	0-1	<u>sand</u>, stones, litter, mud

[1] Cover estimates comprise live plants; dead plants were included as litter under the substrate heading.
[2] Underlined substrate is dominant; other substrates were present.
[3] Observed along transect, but not in sample plots.

To determine the location and distribution of sampling points within each macrophyte or control bed, the bed area was estimated or measured, and a maximum transect length and width was determined that would cover the entire area. A random number generator function (Excel® 4.0) was used to establish random points along each transect and random distances to the left or right of the transect for each plot. The lower corner of the quadrat closest to the transect was placed at that point and percent cover by each species was visually estimated and recorded on data sheets. Plants that appeared dead, without any tissue color, were recorded as litter. Copies of vegetation monitoring data sheets and sample point coordinates are in the Data Appendix.

Following monitoring plan protocols, a minimum of 10 sampling points was established in each type of marsh zone. For further analytical comparisons, a minimum of 10 sampling points was established for each treatment and each control bed.

The location of each vegetation sample point along each transect was recorded on data sheets (see Data Appendix). The transect starting endpoint and compass direction were also noted. Transect endpoints were permanently marked with rebar and labeled with plastic nursery tags. (Initially, aluminum plant tags were used, but the connecting wires quickly corroded and broke.) The monitoring plan specified that each sampling point be permanently marked. Because numerous stakes would snag floating debris and alter circulation patterns, the stakes could have artificially altered natural plant colonization and distribution. Therefore, instead of installing permanent pieces of rebar at each sampling location, sampling points will be re-established annually along the transects using the locations recorded on the data sheets.

Vegetation monitoring revealed that a majority of the newly installed plant materials had not increased in size (percent cover) or produced new shoots or seeds. *Deschampsia cespitosa* appeared to be the healthiest and most vigorous, followed by *Fragaria chiloensis*, *Jaumea carnosa*, *Plantago maritima*, *Distichlis spicata*, *Carex lyngbyei*, and *Scirpus maritimus* respectively. Most of the *Deschampsia cespitosa* had produced seeds, and the *Fragaria chiloensis* had long runners with small rooting plantlets. Neither *Carex lyngbyei* nor *Scirpus maritimus* appeared to be particularly healthy or vigorous.

A majority of the unplanted mud flat, low salt marsh, and high salt marsh lacked vegetation, but several species of plants were colonizing these areas in low numbers. Five vascular plant species were colonizing the intertidal portion of the wetland. *Atriplex patula* and *Salicornia virginica* were sparsely colonizing the shoreline edge between 11 ft and 13 ft MLLW. *Eleocharis palustris* has begun to colonized several areas between 9.5 ft and 10.5 ft MLLW, apparently where seeps are present and the fine-grained sediment of the original tideflat has been exposed. Seedlings of *Jaumea carnosa* and *Plantago maritima* also occurred between 11 ft and 12 ft MLLW. Two algal species (*Vaucharia* sp. and *Enteromorpha flexuosa*) were observed colonizing the mud flat below about 9.5 ft MLLW.

Plants protected by the string enclosures did not appear to be grazed by geese (shoot tips and blades appeared intact). Low salt marsh species (e.g., *Jaumea carnosa* and *Plantago maritima*) outside of the string enclosures also appeared ungrazed.

During construction in June, 1995, *Distichlis spicata* and *Salicornia virginica* were mechanically dug from the construction area as sods and planted in the salt marsh (see Figure 6). The above-ground portions of the salvaged plants died rapidly. However, many sods continued to support a few live shoots. In some cases, the sods supported seedlings of colonizing plants. The sods placed on the steeper slopes between the high and low marsh fringe have also provided erosion control.

Vegetation in the upland buffer (planted during November 1995) has been monitored by Judy Lantor (USFWS). Generally, plant survival exceeded 85% and most species exhibited good health and vigor during the 1996 growing season. Specific monitoring results and recommendations are reported in the Data Appendix.

Soil Nutrient Status Sampling

Interstitial water was sampled concurrently with vegetation surveys on September 25, 1996, at four stations for soil nutrient status (see Figure 5). Sampling was conducted on an ebb tide, on a day without rainfall. Additional salinity data, collected on July 24, 1996 by Judy Lantor (USFWS), is provided in the Data Appendix.

Station IW-1 was located in the top-dressed low mud flat bed. Sample IW-2 (at the approximate location of GS-5) was located in the nearby low salt marsh control bed. Sample IW-3 (at the same location as GS-6) was located in the adjacent high salt marsh control bed. Sample IW-4 (at the same location as GS-8) was located in the top-dressed high mud flat bed. Samples were collected by digging a hole to a depth that incorporated the root zone of most plants (i.e., 12- to 14 in) and allowing interstitial water to seep in. The seep water was then collected into clean 1-L jars and filtered, via a peristaltic pump, through 0.45-μm filters into clean, labeled, 50-ml sample containers. Each station had separate, clean, dedicated equipment, including pump hosing and filters.

The monitoring plan called for the use of a vacuum pump and a porous ceramic filtering device (i.e., lysimeter) for interstitial water collection. This sampling device was rejected for several reasons. First, at several stations, the lysimeter probe would have allowed overlying water to run down the outside housing and fill the sample container faster than interstitial water. Second, to grout the lysimeter in place would have added artificial clay material to the site where subsequent grain size and sediment chemistry samples will be collected. Third, the lysimeter would have necessitated leaving the device in the intertidal area for 24 hours, which would have left it unprotected from the large logs that were resting on site nearby. Fourth, the laboratory supply house would not guarantee that the lysimeter would function properly in a sandy intertidal area. Finally, because the chemical compounds chosen for analysis are stable when exposed to air, the vacuum extraction method was unnecessary. The alternate method was simple, fast, and obtained comparable data of potentially better quality.

The sample containers were stored on ice in a cooler and delivered to the analytical laboratory (Aquatic Research, Inc.) within 24 hours, accompanied by a chain-of-custody record.

Interstitial water samples were analyzed for salinity, total nitrogen, total phosphorous, and potassium. Temperature, pH, and oxygen reduction potential (redox) were measured *in situ* using electronic meters (Corning® and Orion® pH/ISE Model 250A) (Table 7). The probes were inserted directly into the saturated soil near the bottom of each hole. Probe measurements were recorded within 30 minutes of collecting each interstitial water sample. Sampling conditions and methods were consistent between all stations.

Redox potential ranged from a high of 8.5 mV to a low of -250 mV. Soil redox potential is an indicator of the oxygenation of the soil. In a marsh, extremely low potentials (< -250 mV) are good indicators of anaerobic conditions (Ewing 1983, Armstrong 1967). Roots of well-established wetland species oxygenate saturated soils, thus increasing the redox potential.

Laboratory results indicated that laboratory quality control measures for interstitial water analysis were followed and that percent recovery and relative percent difference (PRD) were within acceptable ranges. Total nitrogen ranged from 4.89 mg/L to 7.90 mg/L. Total phosphorus ranged from 0.006 mg/L to 0.062 mg/L. Potassium ranged from 198 mg/L to 298 mg/L. As would be expected, the two highest concentrations of potassium were reported at the two most saline stations.

Table 7. Interstitial water chemistry results, September 25, 1996.

Station	Max. Depth (cm)	Time	Temp. (°C)	pH	Redox (mV)	Salinity (ppt)	Phosphorus (total, mg/L)	Nitrogen (total, mg/L)	Potassium (mg/L)
IW-1	30	1810	14.4	6.31	-42.5	28.45	0.018	4.89	298
IW-2	35	1830	14.9	6.86	-190.2	29.70	0.062	5.81	249
IW-3	30	1710	15.3	6.61	8.5	19.62	0.006	6.20	198
IW-4	30	1720	15.7	5.78	-61.0	18.69	0.006	7.90	215

WILDLIFE OBSERVATIONS

Biologists collecting vegetation data on September 17, 1996, observed four glaucous-winged gulls (*Larus glaucescens*) and two great blue herons (*Adrea herodias*) in the mud flats immediately adjacent to the site. When the biologists became clearly visible, the herons flushed and moved across the waterway. Two killdeer (*Charadrius vociferus*) were observed along the in the high salt marsh and throughout the south end of the waterway. In the north end of the upland buffer, numerous small, irregular-shaped holes (roughly 10 cm diameter and less than 15 cm deep) had been dug along the slope. Small animal tracks were noted, but no clear prints were distinguishable in the dry sand. A sample of the filamentous green algae *Enteromorpha flexuosa* was collected and later observed under a dissecting microscope. The hollow filaments and surrounding tissue were filled with harpacticoid copepods, which are an important food resource for salmon.

A biologist conducting interstitial water sampling during high tide on September 25, 1996, observed numerous small shore crab (*Hemigrapsus* sp.), a pigeon (*Columba livia*), and a foraging belted kingfisher (*Ceryle alcyon*).

No other wildlife observations were reported during other monitoring activities. Additional wildlife observations on the restoration site will be recorded by a local volunteer wildlife expert and submitted separately.

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SALINITY AND UPLAND BUFFER VEGETATION DATA

United States Department of the Interior

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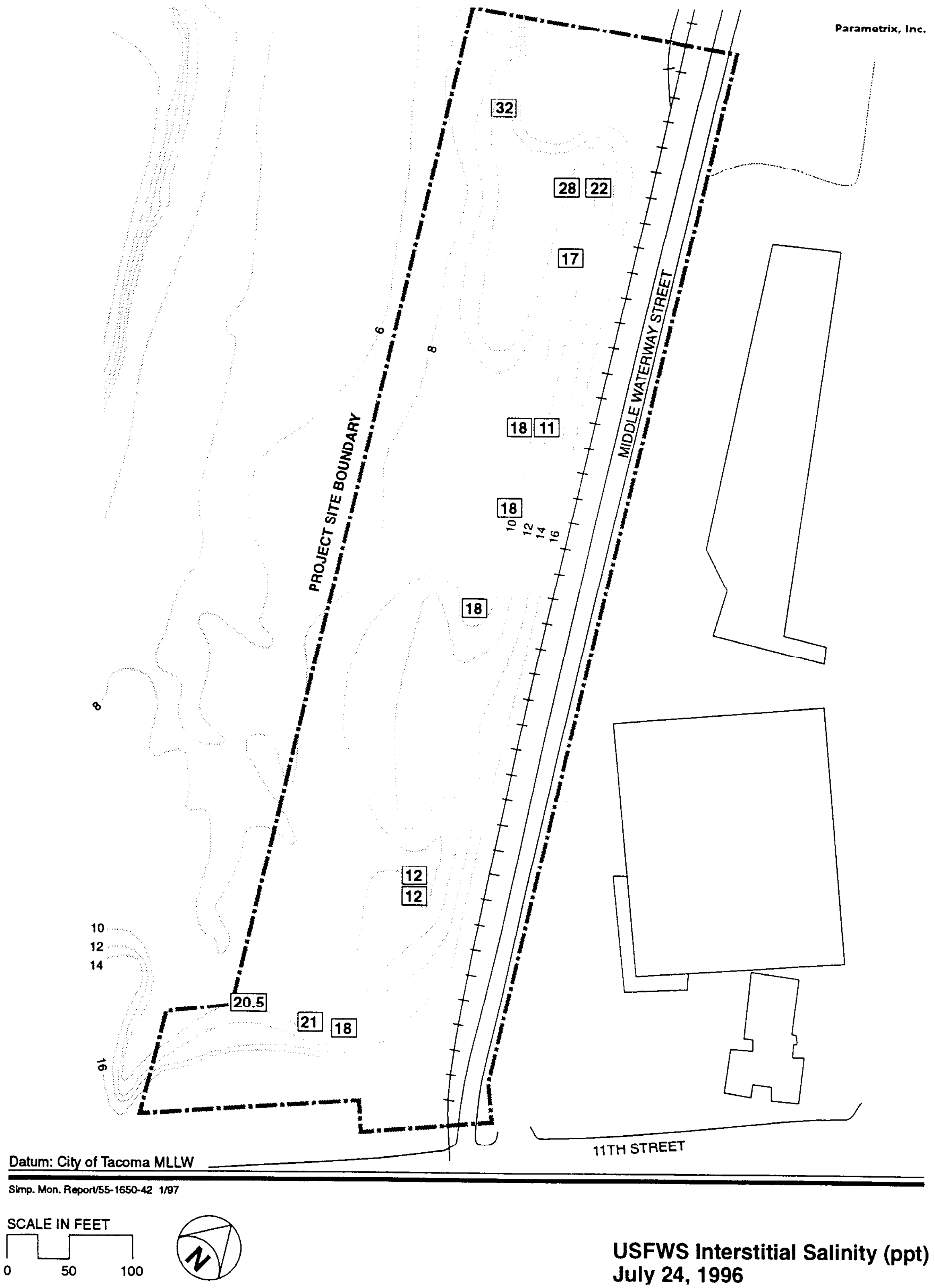
December 19, 1996

Memorandum

TO: Jim Kelley, Parametrix
From: Judy Lantor, US Fish & Wildlife Service Judy
RE: Middle Waterway Monitoring

Per our discussions at the December 6, 1996 monitoring meeting for Middle Waterway, I am sending you information on the upland planting survival rates and the salinity measurements taken on July 24, 1996. I have not done a write-up for the salinity measurements, so I am sending you copies of my field notes. The hand drawn maps on page one show the locations where measurements were taken. The upper map shows the northern peninsula and embayment where salvaged plants were located. The lower map shows both the northern and southern embayments and the southern end of the site bordering 11th Ave. Unless otherwise noted measurements on page one refer to soil salinity measurements. Soil was placed in filter paper inside a syringe and the water was squeezed onto the refractometer. On page 2, soil samples are designated sediment H_20. Channel, seep and pooled water is designated as such. One sample from Hylebos and 11th, on page 3, was a surface water sample taken at high tide. If you have any questions please give me a call. My direct line is 306-753-6056.



USFWS Interstitial Salinity (ppt)
July 24, 1996

To: Files

Date: September 23, 1996

Re: Middle Waterway Shore Restoration - upland planting one year survival rates
Recommended additional plantings

On September 9, 1996 a field review of plant survival of upland buffer plantings was conducted by Judy Lantor. Several plants had been misidentified during the initial inventory of plantings conducted on November 21, 1995. This misidentification was likely due to the late date of inventory and the fact that many of the deciduous plants had already dropped their leaves. Several plants were also missed during the 1995 inventory. These discrepancies have been amended on the planting sheet.

The following table provides a record of one year survival by species based upon the number of plants ordered:

Species	# on plan	# ordered	Nursery	***# Dead 9/9/96***	*# Stressed 9/9/96*	% Survival
Vaccinium ovatum (huckleberry)	86	70 - 1gal	N NW	29	3	59
Mahonia nervosa (Oregon Grape)	96	86- 1gal	SNP	24	1	72
Sambucus racemosa (Elderberry)	36	24 - 5 gal 60 - 1 gal	PN SNP	9	4	89
Symphoricarpos albus (Snowberry)	84	84 - 1gal	SNP	4	2	95
Amelanchier alnifolia (Serviceberry)	40	40 - 1gal	N NW	4	4	90
Prunus emarginata (Bittercherry)	20	20 - 1 gal	SNP	2		90
Thuja plicata (Cedar)	25 - 4-5' 27 - 6-7"	25 - 4-5' 27 - 7-8'	N NW ON	17	1	67
Pyrus fusca (W.Crabapple)	20	20 - 1gal	SNP	2	1	90
Arctostaphylos uva-ursi Kinnikinnik	90	200 - 4"	PN	3	6	99
Lonicera involucrata (Twinberry)	10	40 - 1gal	SNP	5	4	88

Rosa nutkana *(Rose)*	96	52 - 2gal 50 - 2gal	SNP PN	4		96
Fragaria chiloensis *(Strawberry)*	90	200 - 4"	PN		4	100
Pseudotsuga menziesii *(Douglas Fir)*	13 - 3-4' 12 - 4-5' 13 - 6'	12- 3-4' 12 - 3gal 13 - 6-7'	N NW	3		92
Acer circinatum *(Vine Maple)*	48	24- 3' BB	N NW	2		92
Pinus contorta *(shore pine)*	45	10	N NW			100
Fraxinus latifolia *(oregon ash)*	3	0				

N NW = Natives Northwest, Mossyrock, Chris Aldrich
PN = Pacific Natives, Woodenville (Bothell), Rob & Patty
ON = Olympic Nursery
SNP = Sound Native Plants, Olympia, Susan Buis

Notes:
The huckleberry that was planted in 1995 was not *Vaccinium ovatum,* evergreen huckleberry, but was a deciduous variety. This probably accounts for the low survival rate. Evergreen huckleberry would have a greater likelihood of surviving the harsh conditions (sandy soils, no overstory) at the project site. I would recommend planting evergreen huckleberry.

The oregon grape also had a lower survival rate. This is also probably due to the harsh site conditions. Additional plantings of this species should be delayed until an overstory is established.

The elderberry didn't show stress until later in the season. The survival rate is adequate. Due to the numerous 1995 plantings, further planting of this species is not recommended.

Snowberry, serviceberry, bittercherry, rose, and crabapple had high survivability and were planted according to the planting plan or in slightly greater numbers (rose). Additional plantings are not recommended at this time. However, snowberry and/or rose would be good species for increasing the understory planting.

Twinberry had adequate survivability. It was to be a test planting to see how well the species would grow under these site conditions. It was planted in greater numbers that the original plan and is not recommended for additional plantings.

The taller cedar trees, purchased from Olympic Nursery, had a small rootball for the size of tree. This may account for the low survival rate, but the survival rate may also be due to site conditions.

The douglas fir had good survivability and was planted according to plan. Additional plantings of this species could be utilized to fill in for other overstory evergreen species.

Shorepine had good survivability. It was planted in much smaller quantities than the original plan and would be recommended for additional plantings.

Both groundcovers, kinnikinnik and beach strawberry, had high survival rates. In some areas the kinnikinnik was showing signs of stress. In areas showing signs of erosion, these species would be recommended for additional plantings.

The vine maples had a good survival rate. The dead vine maples appeared to be a result of impacts from the watering truck rather than site conditions or conditions of nursery stock. Only half the number as originally planned were planted in 1995. Additional plantings of this species would be recommended.

Oregon ash was proposed as a test planting. No plants were available for the 1995 planting. They would still provide an interesting test planting.

Other species that might be planted on the site include: *Holodiscus discolor* (oceanspray), *Oemleria cerasiformis* (Indian plum), *Corylus cornuta* (hazelnut), *Picea sitchensis* (Sitka spruce), *Ribes sanguineum* (red flowering currant), *Tsuga heterophylla* (hemlock) and beach grass.

Conclusion:
A planting plan should include additional evergreen tree species to provide a good overstory component. A diversity of understory species should be planted to fill out the site. Groundcover plantings would be helpful along the waterward side of the berm and at both ends of the site to control erosion and stabilize the berm.