MIDDLE WATERWAY SHORE RESTORATION PROJECT
ADAPTIVE MANAGEMENT REPORT
1999 - 2002

Prepared for

THE COMMENCEMENT BAY NATURAL RESOURCE TRUSTEES

Prepared by

U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office

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INTRODUCTION AND OVERVIEW

This report describes the adaptive management actions undertaken at the Middle Waterway Shore Pilot Restoration Project (Project) during calendar years 1999, 2000, and 2001. The Commencement Bay Natural Resource Trustee Council selected the U.S. Fish and Wildlife Service as the project manager for the site (Trustee Council Resolution 1999-05, dated February 9, 1999). The Restoration Technical Subcommittee prepared a work plan outlining the principle tasks for the Project and presented it to the Trustee Council for their consideration. The Trustee Council adopted the work plan in February 1999 (Trustee Council Resolution 1999-03, dated February 9, 1999).

Initial sections of this report describe project history and initial site construction. Project goals and objectives are discussed, with a focus on objectives that had not been met and related adaptive management actions that were taken in an effort to meet those objectives. This report also summarizes monitoring information from Simpson's initial five-year monitoring of the project, further providing the rationale for implementing adaptive management actions.

Additional sections describe adaptive management actions taken and monitoring conducted on those actions. The final section makes recommendations for future actions. The appendices provide more detailed information about the chronology and plantings over time.

PROJECT HISTORY

This Project was developed as a cooperative venture between federal and state agencies and Indian tribes named as Commencement Bay Natural Resource Trustees (Trustees) and industry to restore injured natural resources for the Commencement Bay Natural Resource Damage Assessment (CB/NRDA). In the early 1990's, federal and state agencies and tribal governments initiated the CB/NRDA and restoration planning process. The Trustees represent the interests of the public in assessing damages and restoring the public's natural resources and services. The Trustees for Commencement Bay include the National Oceanic and Atmospheric Administration; the U.S. Department of the Interior, including the U.S. Fish and Wildlife Service (USFWS) and the Bureau of Indian Affairs; the Washington State Departments of Ecology, Fish and Wildlife, and Natural Resources; the Puyallup Tribe of Indians; and the Muckleshoot Indian Tribe.

This Project is one component of the 1991 St. Paul Waterway Agreement. In 1991 the Simpson Tacoma Kraft Company (Simpson), Champion International Corporation (Champion), and the Washington State Department of Natural Resources entered into a natural resource damages settlement with the Trustees regarding the St. Paul Waterway[1]. Under that agreement, Simpson and Champion paid $500,000 in damages and agreed to work with the Trustees in planning and constructing a restoration project utilizing these funds.

[1] United States, et al. v. Simpson, et al., Civ No. C91-5260TC (W.D. Wash., Dec. 13, 1991); Amendment 1, April 1, 1996.

A joint Trustee/industry work group, utilizing project evaluation criteria that were developed for the CB/NRDA Restoration Plan, chose the Project. The Project is located along the southeastern shore, at the head of Middle Waterway, adjacent to one of the largest remaining areas of original intertidal mudflat in Commencement Bay (Figure 1, Photo 1). The Project site contains historic mudflat. At the time of project selection, the adjacent uplands had been utilized for log storage (Figure 2, Photo 2). A detailed description of historic uses at the site can be found in *Project Analysis: Middle Waterway Shore Restoration Project* (Parametrix 1993).

Project Goals/Objectives

The Project has dual goals: to provide 1) estuarine habitat restoration, and 2) to evaluate different restoration techniques to gain more information for planning future restoration projects in the Bay.

Goal 1: Estuarine Habitat Restoration

Specific project objectives for the first goal included:

1. Conversion of approximately 1.5 upland acres from existing industrial use to estuarine intertidal wetland,
2. Increase the length of natural shoreline from 840 to 960 feet along the +9 to +13 foot contour,
3. Establish approximately 1.2 acres of habitat at known high and low salt marsh elevations,
4. Provide a riparian buffer and transition zone between the tide flat and the upland area,
5. 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. (Figure 3).

Goal 2: Evaluation of Restoration Techniques

Evaluations undertaken to implement the second goal included:

1. Natural revegetation of estuarine intertidal emergent vegetation on pumped Puyallup River sands,
2. Natural revegetation of estuarine intertidal emergent vegetation on pumped Puyallup River sands top-dressed with salvaged mudflat soils,
3. Effectiveness of hand-planting to establish intertidal salt marsh vegetation,
4. Effectiveness of salvaging onsite salt marsh vegetation.

Design and Construction

Goal 1: Estuarine Habitat Restoration

Objectives 1, 2, 3, & 5
Under a cooperative agreement between the Trustees and Simpson, Simpson obtained the needed permits and assumed responsibility for initial project construction. In June of 1995,

approximately 1.5 acres of industrial fill was excavated to create estuarine habitats (Photo 3). Site construction fulfilled objectives 1, 2 and 5, and fulfilled the basic intent of objective 3, to "establish approximately 1.2 acres of habitat at known high and low salt marsh elevations" by excavating portions of the site to between 9.5 and 12.5 feet MLLW, providing the known elevations for establishment of both low and high salt marsh communities in the Bay (Photo 4).

Objective 4

In October of 1995, trees, shrubs and groundcover were planted in the riparian zone, implementing project objective 4. A few days prior to the initial volunteer[2] riparian planting date, it was discovered that the intended supplier had not filled the order. Over a hundred volunteers were coming to the site, so the planting plan was slightly altered so that plants could be obtained on short notice from local nurseries. A few plants were not the desired species and had lower survival than hoped (Appendix B). To compensate for the altered planting and to take advantage of the results of plant establishment, additional plantings were conducted on October 16 and 23, 1996 (Appendix A&B, Photo 5). A supplemental upland planting[3] was conducted May of 1998, furthering project objective 4 (Appendix B, Photo 6). These actions, in conjunction with site stewardship, have resulted in establishment of a riparian buffer. Site stewardship has occurred through funding from Simpson Tacoma Kraft[4] and volunteer activities coordinated by Citizen's for a Healthy Bay.

Goal 2: Evaluation of Restoration Techniques

To implement goal two of the project, "to provide the opportunity to study various restoration techniques," several methods were attempted to establish salt marsh vegetation on the site. During the initial construction in June of 1995 several techniques were executed.

- Evaluation of natural revegetation on Puyallup River sands

  Fill on the northern end of the project was excavated to form a wide peninsula at elevations between 10.5 and 12.5 feet MLLW for establishment of salt marsh vegetation (Photo 7). To reduce project costs historic fill material (Puyallup River sand) was retained on-site (Photo 8). One of the assessments was evaluating the ability of plants to colonize and grow in this substrate.

- Evaluation of natural revegetation on Puyallup River sands top-dressed with native sediment

  One-half of the newly constructed middle lobe was top-dressed with native sediment from adjacent excavated areas (Figure 3, Photo 9). Another of the assessments was evaluating whether plants were more likely to colonize and grow on this substrate and whether there was a seed bank within the native sediments.

[2] Citizens for a Healthy Bay coordinated volunteers in conjunction with the Trustees and Simpson
[3] Coordinated by People for Puget Sound
[4] David Adams has been employed by Simpson as the site steward since 1995

- Evaluation of hand planting salt marsh vegetation

  In May of 1996 additional areas were hand-planted with a variety of low and high salt marsh plants (Figure 4, Photo 10). A further assessment was evaluating the effectiveness of this planting.

- Evaluation of salvaging fringing marsh vegetation

  Prior to site construction, a band of salt marsh vegetation existed along the edge of the fill material (Photos 11,12). The dominant species growing above approximately 10 feet MLLW were *Distichlis spicata* (saltgrass) and *Salicornia virginica* (pickleweed). Also present were small numbers of *Jaumea carnosa* (fleshy jaumea) and *Spergularia marina* (saltmarsh sandspurry). At lower elevations, the intertidal mudflats were covered by *Eleocharis parvula* (small spikerush) and various filamentous algae (Parametrix 1994b). Existing areas of saltgrass and pickleweed were salvaged and placed at similar elevations to what they were growing prior to construction along the newly constructed habitat areas at the northern end of the project (Photos 13-17). This provided an additional experimental method to review for establishment of marsh vegetation.

POST CONSTRUCTION SITE CONDITIONS

PROJECT MONITORING

The *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan* outlined a five-year monitoring program (Parametrix 1994a). This five-year monitoring program was coordinated and funded by Simpson and Champion. The first year of monitoring was conducted in September of 1996, fifteen months after project construction and four months after planting salt marsh vegetation. Monitoring was then conducted yearly through the summer of 2000. A detailed description of these monitoring activities can be found in the individual monitoring reports (Parametrix 1996b, 1997, 1998, 2002).

As stated above, site construction fulfilled objectives 1, 2, and 5, and fulfilled the basic intent of objective 3, to "establish approximately 1.2 acres of habitat at known high and low salt marsh elevations". Physical monitoring conducted under the five-year monitoring program documented the continued achievement of project objectives 1,2,3, and 5 (Parametrix 1996b, 1997, 1998, 2002).

Review of the first five years of monitoring conducted by Parametrix, Inc. for Simpson and Champion, and additional observations by the Trustees, will be limited to the evaluations conducted relative to the establishment of salt marsh vegetation on the site. The following discussion will pertain to the second project goal to, "evaluate different restoration techniques to gain more information for planning future restoration projects in the Bay."

The first year of monitoring for establishment of salt marsh vegetation was conducted in September of 1996, four months after planting of nursery stock and fifteen months after project

construction and salvage of on-site saltgrass and pickleweed, and was referred to as the Year 0-1 report. Ensuing monitoring was conducted in late summer of 1997, 1998 and 2000 (Parametrix 1997, 1998, 2002).

Transects were established the first year within four general vegetation zones: low marsh, high marsh, mudflat, and marsh top-dressed with salvaged soils. Limited areas of the site had been planted. Transects were established within various planted areas, and corresponding to each planted area, a control was established to evaluate natural colonization (Figure 5).

Vegetation was monitored by visually estimating percent cover within 1-m^2 quadrats established along each transect (Parametrix 1997). In ensuing years, vegetation was reported by species as a cover range along the transect. This information is depicted in Figure 6 utilizing a bar graph. In those instances where the bar graph begins above the zero point, all quadrats sampled along the transect had cover values at or above the lowest position of the bar, for example, all plots along transect 10 in year 2000 recorded *Deschampsia cespitosa* (tufted hairgrass) at a minimum cover of 75 %.

EXPERIMENTAL STUDY REVIEW

Evaluation of natural revegetation on Puyallup River sands

Transect 1 was located at the northern end of the project where the site was excavated to elevations between 10.5 and 12.5 feet MLLW and where historic Puyallup River sand fill material was left on-site. Some planting was conducted in this area and is discussed below. The planted area had a wildlife excluder for several years, reducing impacts of grazing by geese. Natural revegetation in this area was minimal. By 1998 there was some cover by saltgrass (2%) noted in one of the quadrats (Parametrix 1998). Visual observations also noted that there was minimal colonization in 1996 by pickleweed and *Atriplex patula* (fat hen), but by 1998 the area was basically devoid of vascular plants (Photos 18, 19).

Evaluation of natural revegetation on Puyallup River sands top-dressed with native sediment

Transect 14 was located on the northern end of the middle peninsula and spanned elevations for colonization by both low and high salt marsh plants, from 12.5 to 10 feet MLLW. This area had been top-dressed with native sediments during 1995 construction activities. During the five years that Simpson conducted monitoring there was no colonization by vascular plants noted in the area.

Transect 13 was located below 10 feet MLLW in the area top-dressed with native sediments. This transect was very similar to the control transects (11 &12), dominated by microalgae (*Vaucheria* sp., diatoms) and macroalgae (*Enteromorpha* sp., *Rhizoclonium* sp.) (Parametrix 2002). Transect 13 differs from the control transects in monitoring years two and three by having a relatively high cover (55% and 75% respectively) of small spikerush. This difference cannot be attributed directly to top-dressing the area with native sediments and may be related to other site conditions. Small spikerush was not noted along transect 13 during the first year of

monitoring. However, that years report noted, "*Eleocharis palustris*[5] has begun to colonize 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" (Parametrix 1997). The distribution of small spikerush may be related to other site conditions as it was noted in other areas of the project site, and was common prior to construction (Parametrix 1994b).

Evaluation of hand planting salt marsh vegetation

The Project site was planted with high and low salt marsh plants on May 22, 1996. The northern peninsula was planted with 5,400 stems of *Carex lyngbyei* (Lyngby sedge). Lyngby sedge was planted in clumps of three so there were approximately 1,800 planting locations. Four hundred plugs and 400 four-inch containerized plants of tufted hairgrass were planted at the base of the berm in two locations at the north end of the site and at one location at the southern end of the site (Parametrix 1996c). Small amounts of *Plantago maritima* (seaside plantain), pickleweed, saltgrass, *Scirpus maritimus* (Seacoast bulrush), and *Scirpus americanus* (American threesquare) were planted among the tufted hairgrass along the base of the berm along Middle Waterway Street and in the adjacent embayment (Figure 4).

During site planning there was some discussion regarding the appropriateness of Lyngby's sedge for planting in Middle Waterway. Group discussions focused on the pilot nature of the project and it was decided to plant Lyngby's sedge, though it was not currently growing at the site. Lyngby's sedge plantings were not successful at the site. Failure of Lyngby sedge plantings was likely due to a number of factors, however, the most significant factor is the high salinity at the site. Lyngby sedge is absent from marshes where soil salinities above 20 ppt persist for most of the growing season (Hutchinson 1991). Interstitial water was sampled concurrently with vegetation surveys during the five year monitoring period. Salinity ranged from 18 to 29 ppt in 1996, 8 to 29 ppt in 1997, 14 to 30 ppt in 1998, and 25 to 33 ppt in 2000 (Parametrix 1996,1997,1998, 2002). The increase in salinity in the final year of monitoring was possibly attributed to the cessation of riparian irrigation[6] (Parametrix 2002).

Tufted hairgrass plantings were relatively successful at the site. Plants flowered the first year following planting and by the third year were naturally seeding into higher elevations on the site. Transects 2 and 10 are located in areas that were planted with tufted hairgrass. Monitoring results are shown in Figure 6. No data were collected along transect 2 in 1997 as the transect was placed in the wrong location. Plantings along transect 2 were initially successful at this location; however, these plantings are being impacted by erosion along the base of the berm (Photo 20).

Tufted hairgrass plantings at the southern end of the site (transect 10) have been very successful, ranging from 75 to 100 % cover by the fifth year of monitoring (Figure 6). This planting is adjacent to a more gradual slope and has provided an area for natural colonization by pickleweed. The pickleweed first established itself at the edge of the goose excluder. By 2001 it had expanded outside the goose excluder and by 2002 it had increased in area and moved north along the shoreline (Photo 21). An additional area, at the north end of the northern peninsula,

[5] That year *Eleocharis parvula* (small spikerush) was mis-identified as *Eleocharis palustris.*

[6] On-site irrigation was utilized for the first 5 years solely to promote the establishment of riparian plants

was also planted with tufted hairgrass. This planting has also been very successful and has not been impacted by erosion (Photo 22). Since tufted hairgrass was planted in the high intertidal areas all these plantings likely benefited from the adjacent upland irrigation.

Erosion along the base of the berm in the northern embayment may also be the reason for the absence of other species planted in this area, including seaside plantain, pickleweed, and saltgrass. Following planting, tidal waters eroded around plant roots and washed out the plantings (Photo 23). Seacoast bulrush and American threesquare that were planted among the tufted hairgrass along transect 2 may have failed due either to erosion and/or high salinity. Plantings of seacoast bulrush were also conducted within the adjacent embayment. These plantings did not survive. This may have been due to ponding in the area or high salinity. A channel has since formed, more effectively draining the embayment. Over time plants with higher salinity tolerances may be able to move down into this area.

Evaluation of salvaging fringing marsh vegetation

The monitoring conducted by Simpson was not set up to evaluate a very large portion of the plant salvage area. Transect 6 was a very short transect (approximately 11 meters, with 3 quadrats) located within the saltgrass salvage area. Transect 7 was the only other area where salvaged saltgrass plants were monitored. This transect was situated along the interface of the pickleweed and saltgrass salvage plantings and also included an area that was planted with nursery plants. The overlap of different planting methods complicates evaluation of the monitoring data. Transect 5 was located through the center of the salvaged pickleweed plants.

The first year of monitoring the plots along transect 5 had between zero and ten percent cover of pickleweed (Parametrix 1996a). Picklweed was not encountered along this transect in the following four years. Transect 6 had reasonably high cover of saltgrass the first year and none in the following years. Small amounts of pickleweed were found along transect 6 in all but one of the years monitored. Transect 7 had small occurrences of both saltgrass and pickleweed which declined to trace amounts by the end of the monitoring period (Figure 6, Table 1).

The first year of monitoring, in conjunction with visual observations throughout the year, revealed that the above-ground portions of the salvaged vegetation died rapidly (Photos 24, 25). This may have been due to a variety of conditions. The plant material was moved between the middle and end of June, and the weather over the next month was very dry. When the salvaged plants were placed in their new locations the root mass was not dug into the new substrate and plant material was subject to desiccation (Photos 26,27). By the middle of July the above-ground portions of salt grass were mostly brown.

The pickleweed was planted in the embayment adjacent to the northern lobe. Following construction this area was not well drained and there was standing water even at low tide. Constant inundation, not typical of natural marshes, likely had adverse impacts on the salvaged plants. By the following year a channel had formed effectively providing drainage to the area (Photo 28). Some pickleweed was present in the upper portions of this embayment most notably in 1997 (Photo 29). The monitoring report for that year noted clumps of pickleweed, saltgrass, tufted hairgrass and fat hen growing outside of the goose excluders at the head of the channel.

The report also speculated, "The shallow slope and protection from exposure to waves in this area may promote the retention of seeds and organic matter and reduce the exposure of established plants." The report further expressed the difficulty of determining the success of various methods by stating, "It was not clear if the existing plants in the area were new recruits or growth from plantings in 1996" (Parametrix 1998). It is also not clear if the plants might have been from the plant salvage actions in 1995.

Summary

At the end of the third year of monitoring, the report stated, "most of the low and high salt marsh communities lacked vegetation or had extremely low cover by vascular plants". Most of the restoration techniques had very little success establishing marsh vegetation. Natural revegetation on river sand was not effective. Topdressing with native sediments appeared to have no effect. Hand planting of nursery stock had mixed results. Negative results were due to poor plant selection as well as erosive site conditions. Tufted hairgrass plantings were fairly successful and may have benefited from adjacent upland irrigation. Salvage of on-site pickleweed and saltgrass was disappointing. Higher survival may have occurred with more careful planting methods. However, salvage efforts were additionally impacted by transplanting timing and unforeseen site conditions. Following the third year monitoring activities the Trustees decided to implement adaptive management actions.

ADAPTIVE MANAGEMENT ACTIONS

DESIGN

The Restoration Technical Subcommittee's (RTS) 1999 work plan set out primary tasks that included development of an adaptive management plan and conceptual design. The work plan also identified the need for engineering drawings, which were to be provided by Simpson. Adaptive management actions were discussed at the February 2, 1999 Commencement Bay RTS meeting and a final conceptual design was agreed upon. The conceptual plans were provided to Simpson and they provided engineering drawings for use in the permitting process (Figure 7).

A number of elements were seen as important to consider, including providing a more conducive substrate for plant establishment, controlling erosion, and planting appropriate species according to elevation and existing site salinity conditions. Soil amendment plans were initially based on previous work by the Port of Tacoma at the Rhone-Poulenc mitigation site. At the Rhone-Poulenc site imported topsoil was incorporated into a layer of cobble and gravel to stabilize sediments and provide a suitable planting medium. Following the first year of monitoring at the Rhone-Poulenc site, most plants had survived and exhibited good growth (Parametrix 1996a). Initial adaptive management plans for soil amendment included removal of approximately three feet of sand from the northern peninsula, replaced with a one foot layer of quarry spalls covered with approximately two feet of top soil.

The design included placing logs along the outside of the northern berm and in the center of the middle berm to both buffer the areas from erosive elements and provide protected areas for sediments and potentially marsh seeds to settle out and become established. Additional proposed

actions included amending soil by hand along the base of the berm where plants were not yet established, followed by additional plantings of tufted hairgrass, hydroseeding the upland areas with a mix of native grasses and forbs, and amending upland soils at one location adjacent to 11th Street. The focus was on low impact construction methods. The desire was to not impact existing features at the site such as, riparian plants, established high salt marsh tufted hairgrass plantings, or adjacent mudflats.

CONSTRUCTION

Prior to construction the RTS decided that use of quarry spalls at this location was likely unnecessary to alleviate erosion since the site is adjacent to an expansive mudflat without boat traffic and associated boat wake. The placement of logs along the peninsula shoreline would be sufficient to compensate for tidal and wind related erosion. Thus, soil amendment actions at the site were limited to removal of approximately one to two feet of existing Puyallup River sand from the northern peninsula followed by placement of approximately one to two feet of topsoil mix.

This was a cooperative project utilizing assistance from many of our partners in the Commencement Bay area. The City of Tacoma, through our in-kind services agreement, provided site survey assistance and placed cut and fill stakes prior to construction. Simpson provided engineering drawings, site access, logs, and a stockpile area for removed sand.

The Western Washington Fish and Wildlife Office of the U.S. Fish and Wildlife Service, in cooperation with the Nisqually National Wildlife Refuge, provided personnel and equipment to conduct soil amendments and initial log placement during the first two weeks of September 1999. During the first week of September access to the site was constructed. Trees and shrubs growing on the access over the berm were dug and healed in for later replanting. A temporary access road was constructed over the berm and onto the northern peninsula (Photo 30).

During the second week of September sand was excavated from the peninsula and was replaced with 375 yards of pro gro topsoil mix. Topsoil was spread over the site and a swale was constructed through the center of the peninsula to provide an area for potential settling of drift and marsh seeds (Photos 31, 32). Onsite logs were also moved and placed along the shoreline. A trench was dug along the west shore of the peninsula; logs were placed in the trench and then backfilled (Photo 33).

Following fall tides and weather, it was determined that log placement techniques were not adequate. On-site drift logs had been utilized and some were not very substantial. Placing the logs in a trench did not prove sufficient to hold them in place. Even though the Middle Waterway site is not impacted by boat wake, tidal and wind action were enough to move the logs around. Simpson had logs that they were willing to donate to the project. These logs were larger and less decayed than the ones used previously, and Simpson provided further assistance by delivering the logs to the site.

The new logs were placed on the west shore of the peninsula and around the tip. It was decided that logs should be anchored into place providing for longer term site stability. The logs were

anchored in place on January 25, 2000 utilizing contractor installed Manta Ray anchors, with a cabling system around the logs (Photos 34, 35). David Adams, the site steward, has adjusted the cable system on a few instances; otherwise the log anchoring system has remained in place.

Soil amendments proposed on the waterway side of the berm that were to be done by hand proved to be too large of an undertaking to accomplish with volunteers. This portion of the adaptive management actions was not accomplished. Tufted hairgrass plantings appear to be relatively successful at the site so soil amendments, while speculated to be beneficial, do not appear necessary for survival of this species in this location. Protection from erosion is likely a more important consideration for the long-term survival of tufted hairgrass plantings.

PLANTING

A variety of salt tolerant plants were planted on April 1, 2000, utilizing volunteers coordinated with the assistance of Citizens for a Healthy Bay and the Trustees. Both bareroot and containerized plants were used. Bareroot plants included 200 tufted hairgrass, 300 saltgrass, 200 *Juncus balticus* (Baltic rush), 200 *Grindelia integrifolia* (gumweed), and 200 *Aster subspicatus* (Douglas aster). Container plants included 150 seaside plantain, 136 *Triglochin maritima* (seaside arrowgrass), 300 tufted hairgrass, 50 seacoast bulrush, and 26 American threesquare (Appendix C).

All planting areas were protected with a goose excluder that was constructed with jute rope and twine. This method had proved effective at the Rhone Poulenc site (Adams 1999 personal communication). During 2001 monitoring, heavy grazing of plants by rabbits was noted. During late summer of 2001, the goose excluder was modified by attaching chicken wire to the perimeter of the exclosure. This has proved effective at excluding rabbits from the planted areas.

MONITORING

The City of Tacoma, through the Trustees in-kind services agreement, conducted a survey of the site in February of 2001. The survey included generating a topographic map of the total project site and a map of the various plant communities (Figure 8).

Monitoring the survival of containerized plants has been conducted annually since 2000. Monitoring of tufted hairgrass survival was not reliable in later years due to seeding and germination from established plants, and the inability to distinguish between bareroot and container plants in successive years. Survival of container planted seaside plantain, seaside arrowgrass, seacoast bulrush, and American threesquare was conducted in late summer of 2000, 2001 and 2002, without complications.

Monitoring of bareroot plants was compromised by the inability to acquire accurate as-planted data. Volunteers conducted plantings and it was not always evident where specific species were planted. Many of the bareroot baltic rush and Douglas aster were planted in among the already established tufted hairgrass plantings preventing an accurate count and location. Monitoring of bareroot plants was further compromised by the difficulty of being able to distinguish individual plants of saltgrass and baltic rush in ensuing years. Photo monitoring provides a better picture of

plant establishment of these species. Two species, gumweed and aster, had such low survival rates (none were apparent following the first year of monitoring) that the lack of as-planted information was of no consequence.

ADDITIONAL WORK

Trustee representatives and volunteers anchored drift logs along the base of the berm using commercially available anchors (Photo 36). Logs were those that had floated onto the site and were in locations that would provide benefits to ameliorate erosion along the base of the berm. A goose excluder was also constructed on the middle peninsula to assess plant establishment in a protected area without conducting any planting. These activities were accomplished on March 6, 2001.

Invasive species, particularly butterfly bush (*Buddleja davidii*), were removed from the site in September 2002. This work was accomplished utilizing the Washington Conservation Corps under the supervision of the City of Tacoma under its in-kind services agreement with the Trustees.

RESULTS

Many of the bare root plants did not have high survival. Gumweed and Douglas aster were not evident on the site by the second year following planting. Baltic rush also had very low survival, but plants that have survived were expanding by the third year following planting. Two exceptions were the bareroot plantings of saltgrass and tufted hairgrass. Both of these species are surviving and reproducing.

All of the bareroot plants (with the exception of saltgrass) were planted in the upper intertidal at or above about 12.5 feet MLLW. These plants many have suffered more desiccation than plants lower in the intertidal. Those that survived may have benefited from irrigation of the riparian area later in the summer. A number of factors make it difficult to determine the success of bareroot plantings of tufted hairgrass. These factors include distinguishing between container and bareroot plants, and seedlings establishing from older plantings.

Container plants had various survival rates. Seaside arrowgrass had 98% survival by year three, plantain had 39%, seacoast bulrush 92%, and American threesquare 15% (Figure 9). All of these species had flowering individuals, however, seaside arrowgrass was the only species that clearly showed reproduction (Photo 37). Many of the plants appeared not to have spread much beyond their original root mass. The seacoast bulrush, though flowering, appeared stressed and had expanded only slightly (Photo 38). Though overall, the American threesquare had very low survival, in one location plants have spread via rhizomes and are forming a small patch. One planting of seaside plantain (in area I) has suffered from browse but appears to be recovering. This planting area is located at the head of the north embayment and benefits from longer tidal inundation and is a more sheltered area of the site. The other planting of seaside plantain, in area A, has suffered a 40-50% loss in both years 2 and 3 (Appendix D, Figure 8).

Bareroot plantings of saltgrass have been difficult to quantitatively monitor, however, these plantings are spreading by rhizome. In some areas the saltgrass plantings are expanding outside goose excluders and in most areas the plantings are flowering and appear robust (Photo 39).

DISCUSSION

The success of hand planting of nursery stock has been species dependent. While a number of species have been planted at the site only a few have survived and spread. The site is definitely compromised by higher salinities and with the cessation of irrigation site salinity may be increasing (Parametrix 2002). Some species, such as American threesquare and possibly seacoast bulrush, are likely at the upper end of their salinity tolerance and may be able to survive where they were planted but may not spread. The upper limit for American threesquare is about 15 ppt, though in a subsaline reach of the Fraser River estuary it can tolerate salinities of 20 ppt (Hutchinson 1991). Sampling for the two species of *Scirpus* has noted that plantings appear stressed and plants have brown and yellow foliage (Appendix D). Even though the seacoast bulrush planting had a survival rate 92%, the plantings have only spread minimally.

Seaside plantain had a survival rate of 39%. In some areas the plantings appear stressed and in other areas the plantings appear robust and flowering. There has also been some natural colonization by seaside plantain in the southern embayment. Seaside plantain may favor more protected areas on the site. This species may not be a major component on the site but might remain in smaller numbers. It occupies habitats with a salinity range of 5-25 ppt (Hutchinson 1991). This species was also identified along the adjacent shoreline prior to site construction.

Seaside arrowgrass had a survival rate of 98% by year 3 and plantings appear robust and are flowering. This species was not known in the area from the pre-construction survey, but may form a minor component in the establishing marsh. Hutchinson reports that available field data indicate that this species occupies sites with salinity varying from 0-21 ppt, but that unpublished data suggests that it is found in more saline habitats, and may be able to tolerate hypersaline conditions for brief periods (Hutchinson 1991). Future monitoring could provide new data on the salinity tolerance of this species.

Baltic rush did not have a high survival rate, but in several locations it is spreading and forming small patches. There is a small patch of baltic rush in the high intertidal on the north end of the site that was not altered during construction. While plantings of baltic rush did not have a high survival rate, in several locations it is spreading and forming small patches, and may become another species that forms a minor component of the establishing marsh.

Saltgrass and pickleweed were both dominant plants on the site prior to construction. Plantings of saltgrass are robust and expanding beyond the protection provided by goose exclusion devices. Saltgrass has a salinity tolerance of 50 ppt (Hutchinson 1991). Though no plantings of pickleweed have been conducted (except for salvage attempts) this species is colonizing various areas of the site. Pickleweed has a salinity tolerance of 80 ppt (Hutchinson 1991). Therefore, it is likely that both saltgrass and pickleweed could become a major component in the establishing marsh.

Tufted hairgrass plantings have been fairly successful. However, some of the earlier plantings are being severely impacted by erosion at the base of the berm (Photo 40). Some plantings have set seed and natural reseeding has occurred at a few places higher on the berm (Photo 41).

Natural revegetation on any of the various site substrates appears to be compromised and is only occurring in specific areas. Colonization is occurring within existing protected planting areas, within the unplanted excluder, and in quiescent areas in the southern and northern embayments (Photos 42-45). Typical colonizing species include *Atriplex patula* (fat hen)*, Spergularia sp.* (sand spurry)*,* and pickleweed. Other species are beginning to colonize in smaller numbers, particularly gumweed and seaside plantain in the northern embayment, and seaside plantain in the southern embayment. Colonization (or expansion from adjacent areas) has occurred in the unplanted goose excluder constructed in 2001.

RECOMMENDATIONS

There are several factors that appear to compromise the establishment of an estuarine marsh at the site. Those that appear to be major factors include salinity, erosive forces, wildlife impacts, and invasive species.

Limit future plantings to salt tolerant species

Though there are several factors limiting the establishment of an estuarine marsh at the site, site salinity provides a critical limitation. Prior to site construction, species diversity was limited, with the dominant components of the marsh being saltgrass and pickleweed with smaller numbers of *Jaumea carnosa* (fleshy jaumea) and sandspurry. It is prudent at this juncture to reevaluate the goals for the site at least in regard to species composition. If further plantings are proposed, it is recommended that plantings in the lower intertidal be limited to saltgrass and pickleweed. This recommendation is further supported by Lucinda Tear, coordinator for the Parametrix monitoring. Ms. Tear stated in a September 21, 1998 e-mail, "From what I have been reading, it seems that *Salicornia*, *Distichlis*, and *Atriplex* are probably the only intertidal plants that can be expected to do well at the site unless fresh water is added." A few other species may be appropriate, such as the fleshy jaumea that was found at the site prior to construction or the seaside arrowgrass that has been doing well from previous plantings. However, these species would likely remain as minor components in the marsh. Seaside arrowgrass is already established and reproducing so further planting of this species is not recommended.

During the 1999 planning for adaptive management actions, it was proposed that pickleweed be planted at the site. The supplier for the pickleweed had trouble with their nursery stock and none were available at planting time. If additional plantings occur, adequate time should be allowed to contract with a nursery experienced with propagation of this species. Saltgrass is readily available and additional plantings could help to stabilize areas where site erosion is occurring.

As stated above, if further plantings are proposed, it is recommended that plantings in the lower intertidal be limited to saltgrass and pickleweed.

Evaluate site erosion

A further recommendation would be to evaluate site erosion. Where logs have been adventitiously placed along the base of the berm, erosion has been reduced in localized areas. However, adjacent areas are being impacted by erosion. Erosion has been occurring along the base of the berm since site construction in 1995, but log placement may have exacerbated or localized site erosion. This may also be true for the logs placed along the water side of the northern peninsula in December of 2000. The northern end of the site has been experiencing erosion for years, but was severely impacted by erosion during the winter of 2002/2003 (Photos 46-487). Review by a hydrogeologist would be helpful.

Construct additional excluder devices

Considering how the unplanted goose excluder has colonized in one year's time, it may also be possible to accelerate marsh establishment by simply constructing additional exclosures at prime locations. An additional concern was noted in December of 2002. Saltgrass expanding outside of exclosures was severely impacted by Widgeon grazing (Photo 49). It may be beneficial to expand existing excluders to allow existing marsh areas to expand. If plantings are able to expand and fully cover an area their root mass may be able to withstand grazing by wildlife. If a larger area of the site were covered by salt grass, grazing would be spread over a larger area and plantings might be better able to with stand grazing pressure.

An additional recommendation is to construct additional excluders to accelerate natural colonization of marsh plants.

Monitor for invasive species

The riparian buffer has become well established. Invasive species were removed in August 2002. It is recommended that continued monitoring for invasive species occur, but otherwise the area should continue to fill in without additional planting.

Monitoring for invasive species should also occur in the intertidal zone. *Lepidium latifolium* (perennial pepperweed) has become established along the Hylebos Waterway, and Ruston Way and Marine View Drive shorelines, and a small patch was removed in August of 2002 from the peninsula between Middle and St. Paul Waterways. This plant can invade the upper intertidal, form monotypic stands, and exclude native vegetation. Perennial pepperweed is a class B weed, and its distribution is such that it is designated for control by state law. Under state law, prevention of seed production is required (Washington Administrative Code 16-750). It is recommended that the site be monitored for this species on a regular basis, and if found immediately removed and disposed of in a manner that does not allow spread of seeds.

No action

Another option would be to take no further action and allow the site to develop slowly over time with existing erosive forces and wildlife impacts. Some colonization by native species is

occurring outside of excluder devices and some of these areas have remained unimpacted by wildlife.

This recommendation would take longer for a marsh to establish and may not fulfill the goal "to establish approximately 1.2 acres of habitat at known areas for low and high salt marsh vegetation."

Include site in the Trustees baywide monitoring program

The site was monitored beginning in 2002 under the Trustees *Commencement Bay Natural Resource Damage Assessment (CB/NRDA) Restoration Monitoring Program* (Commencement Bay Natural Resource Trustees 2001). A detailed description of 2002 monitoring activities can be found in *Year 1 (2002) Monitoring Report for Commencement Bay Habitat Restoration Sites* (Ridolfi 2003).

Annual monitoring should be continued at this site. If problems occur decisions can be made regarding mid-course corrections or other alternative actions, including modification of goals.

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United States, et al. v. Simpson, et al., Civ No. C91-5260TC (W.D. Wash., Dec. 13, 1991); Amendment 1, April 1, 1996.

Figure 1: Vicinity Map [7]

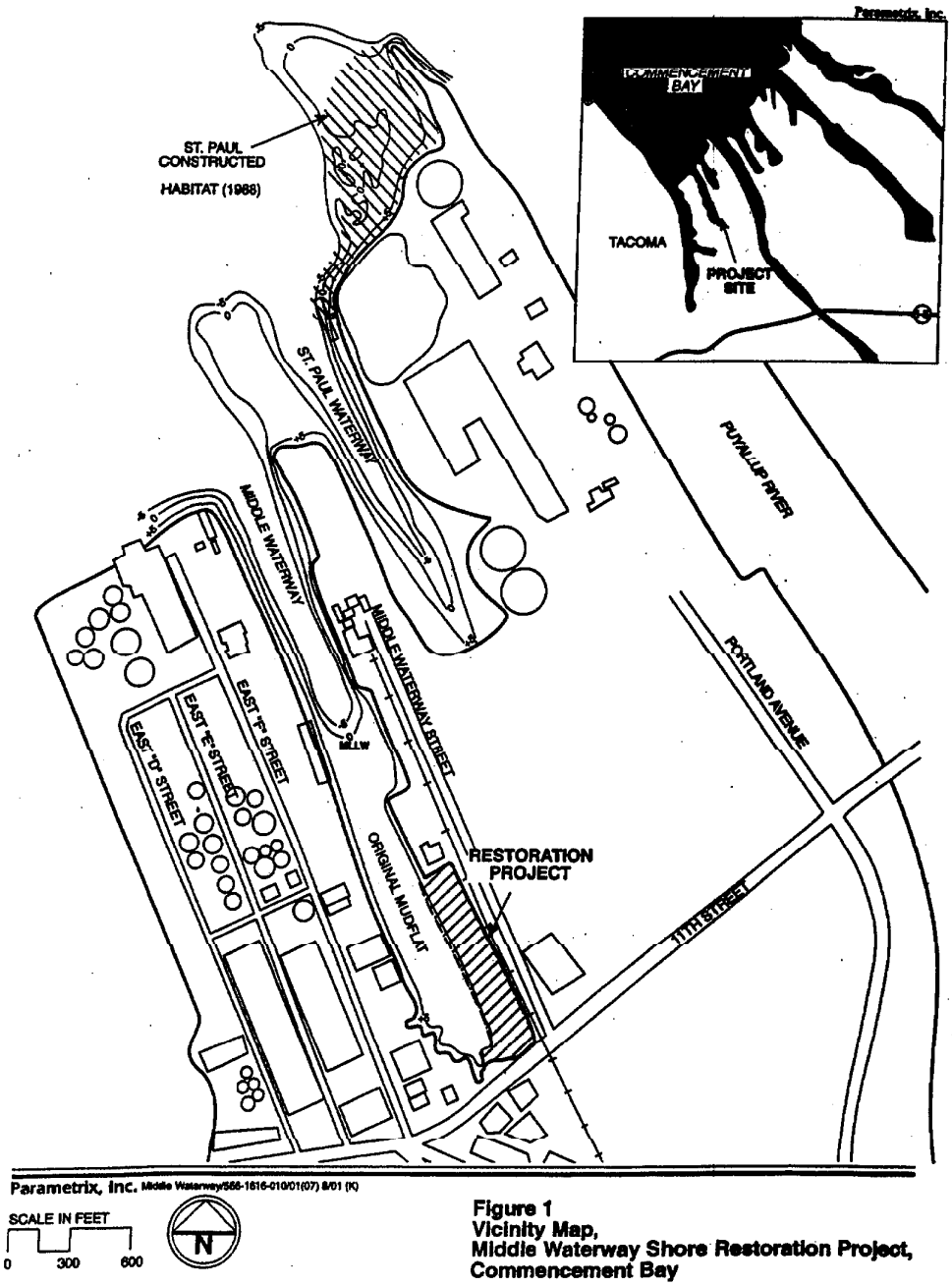


Figure 1
Vicinity Map,
Middle Waterway Shore Restoration Project,
Commencement Bay

[7] From: Parametrix, Inc. 2002. Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan data report, post-construction (Year 5).

Figure 2: Pre-project conditions[8]

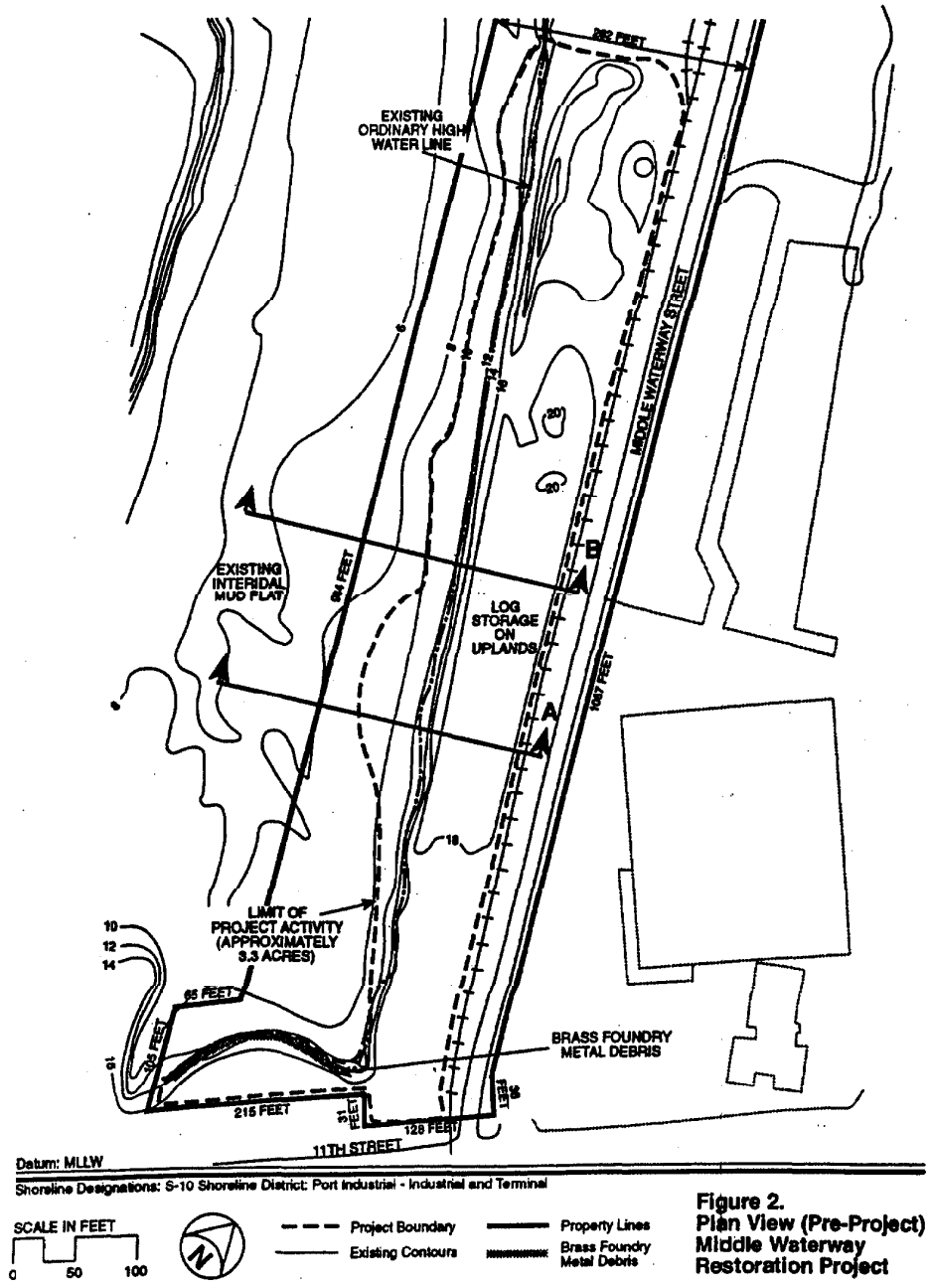


Figure 2.
Plan View (Pre-Project)
Middle Waterway
Restoration Project

[8] From: Parametrix, Inc. 1993. Project Analysis: Middle Waterway Shore Restoration Project - Project Overview, SEPA Environmental Checklist, Technical Appendices

Figure 3: Initial Site Plan[9]

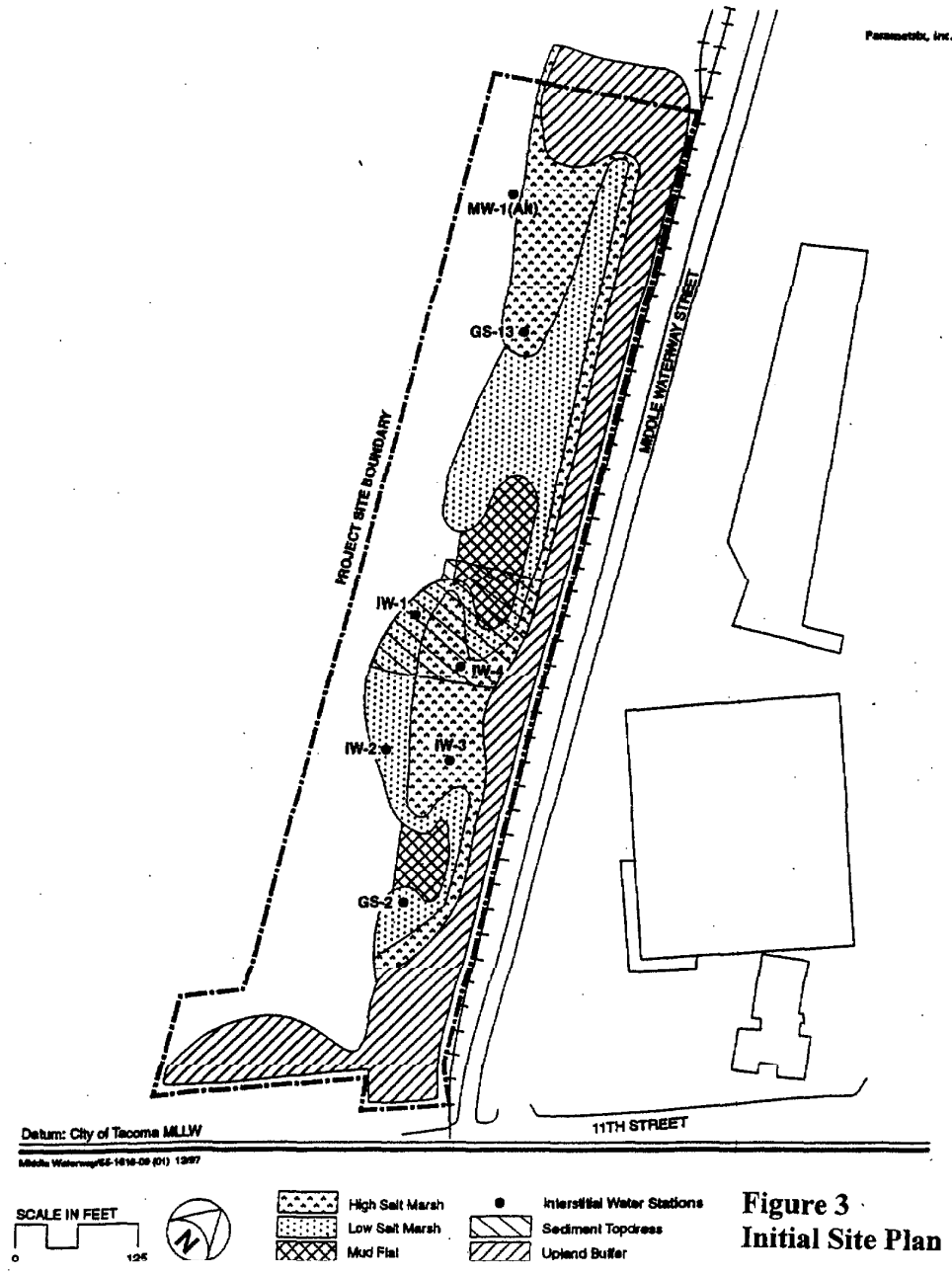


Figure 3
Initial Site Plan

[9] From: Parametrix, Inc. 1997. Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan data report, post-construction (Year 2).

Figure 4: Extent of Salt Marsh Vegetation[10]

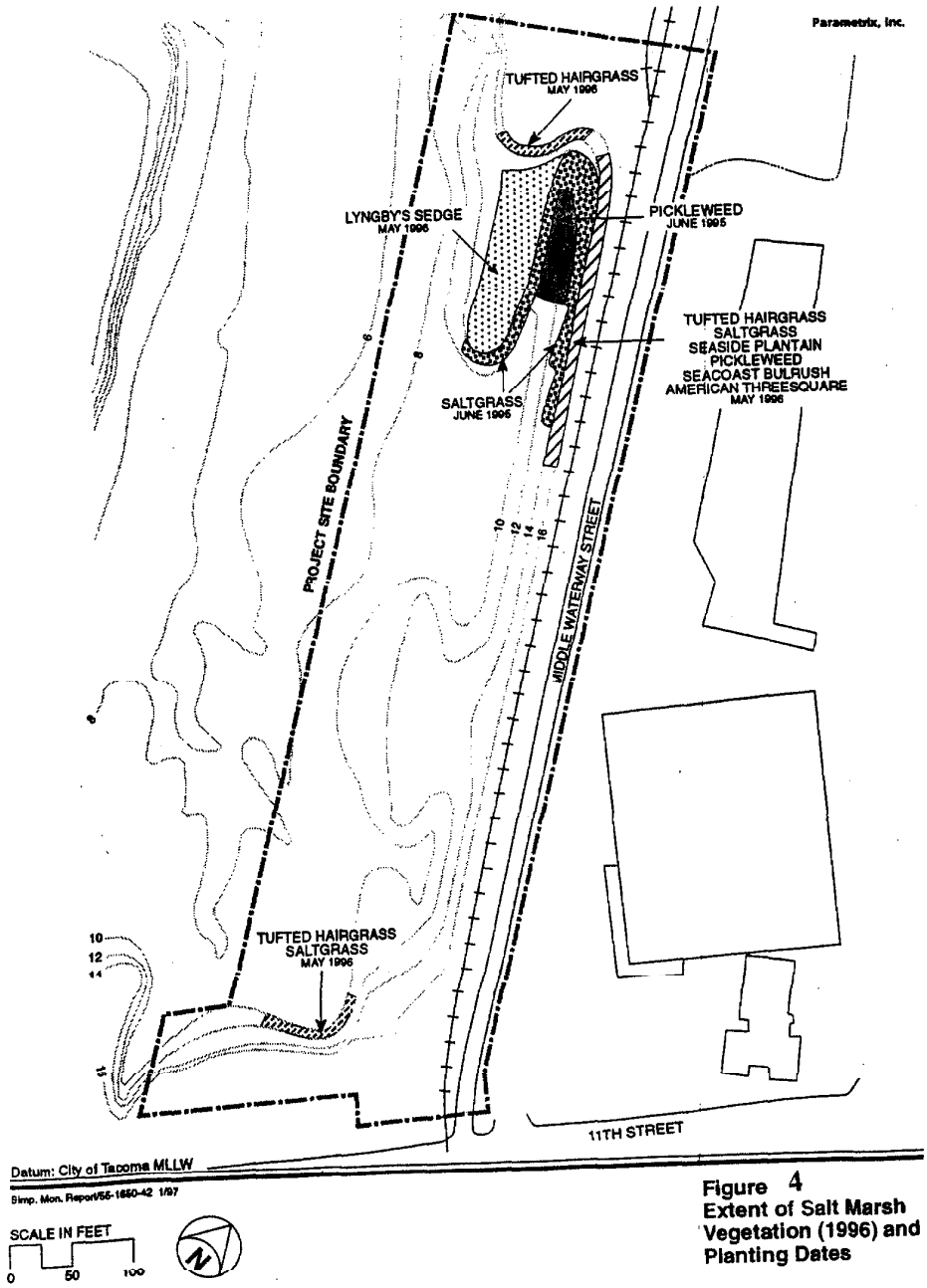
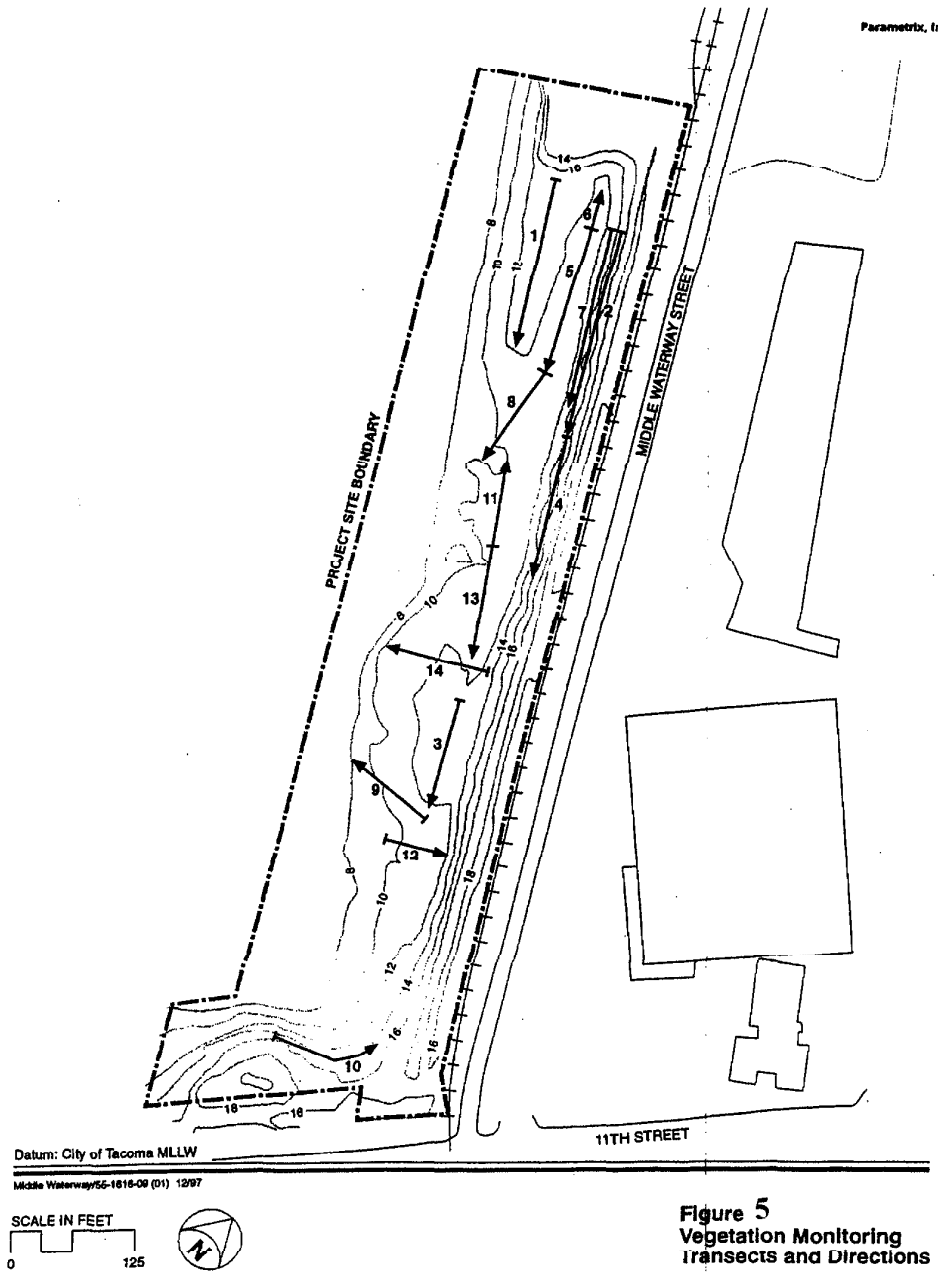


Figure 4
Extent of Salt Marsh Vegetation (1996) and Planting Dates

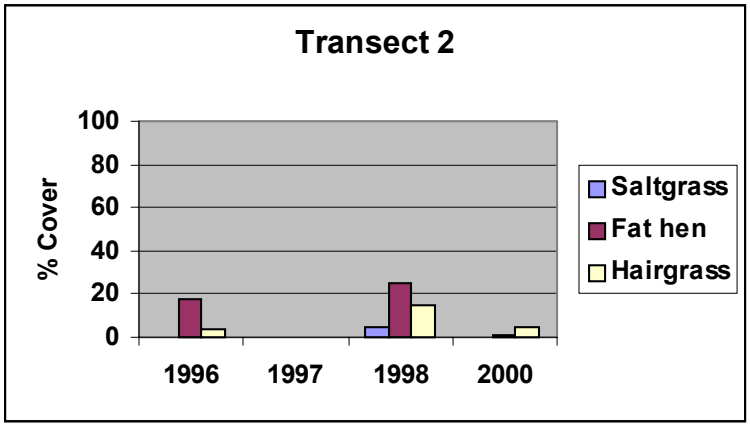
[10] From: Parametrix, Inc. 1996b. Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan data report, post-construction (Year 0-1).

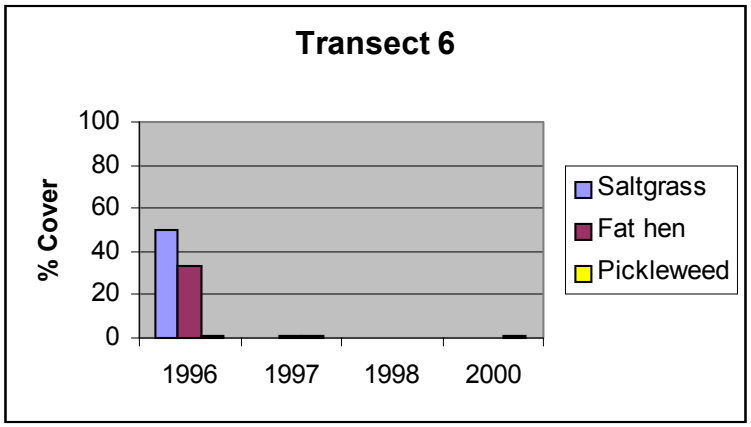
Figure 5: Vegetation Monitoring Transects[11]

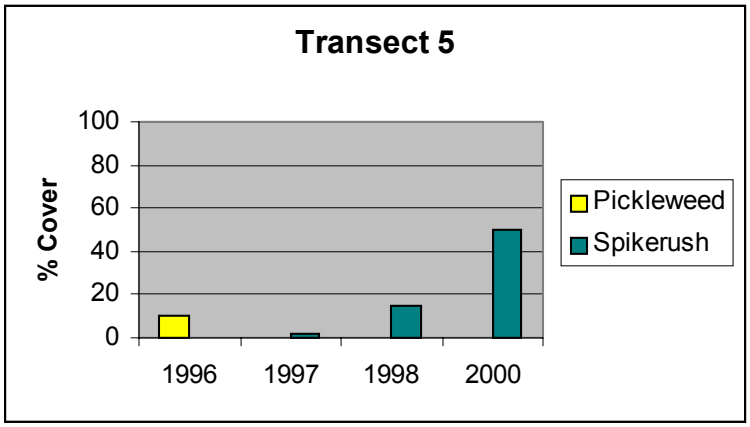


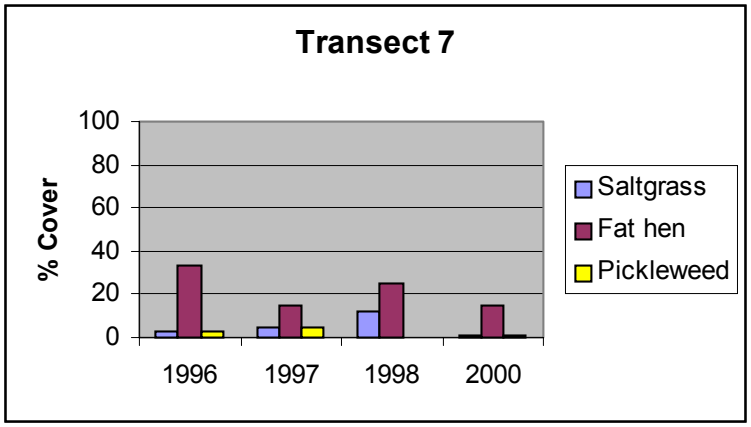
[11] From: Parametrix, Inc. 1997. Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan data report, post-construction (Year 2).

Figure 6
Vegetation Percent Cover 1996-2000









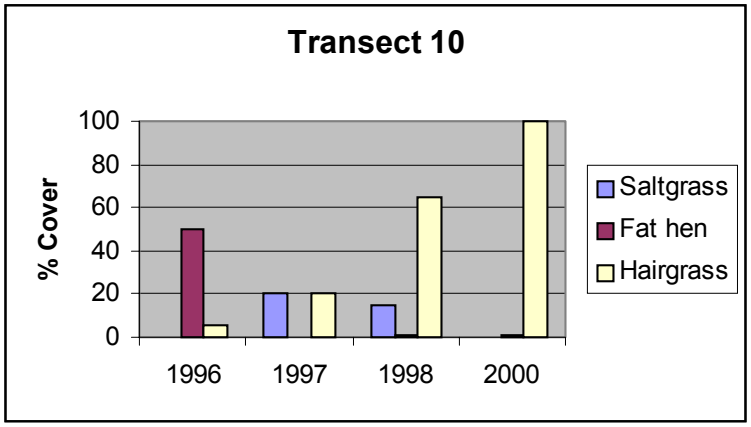


Figure 7: Adaptive Management Proposed Actions

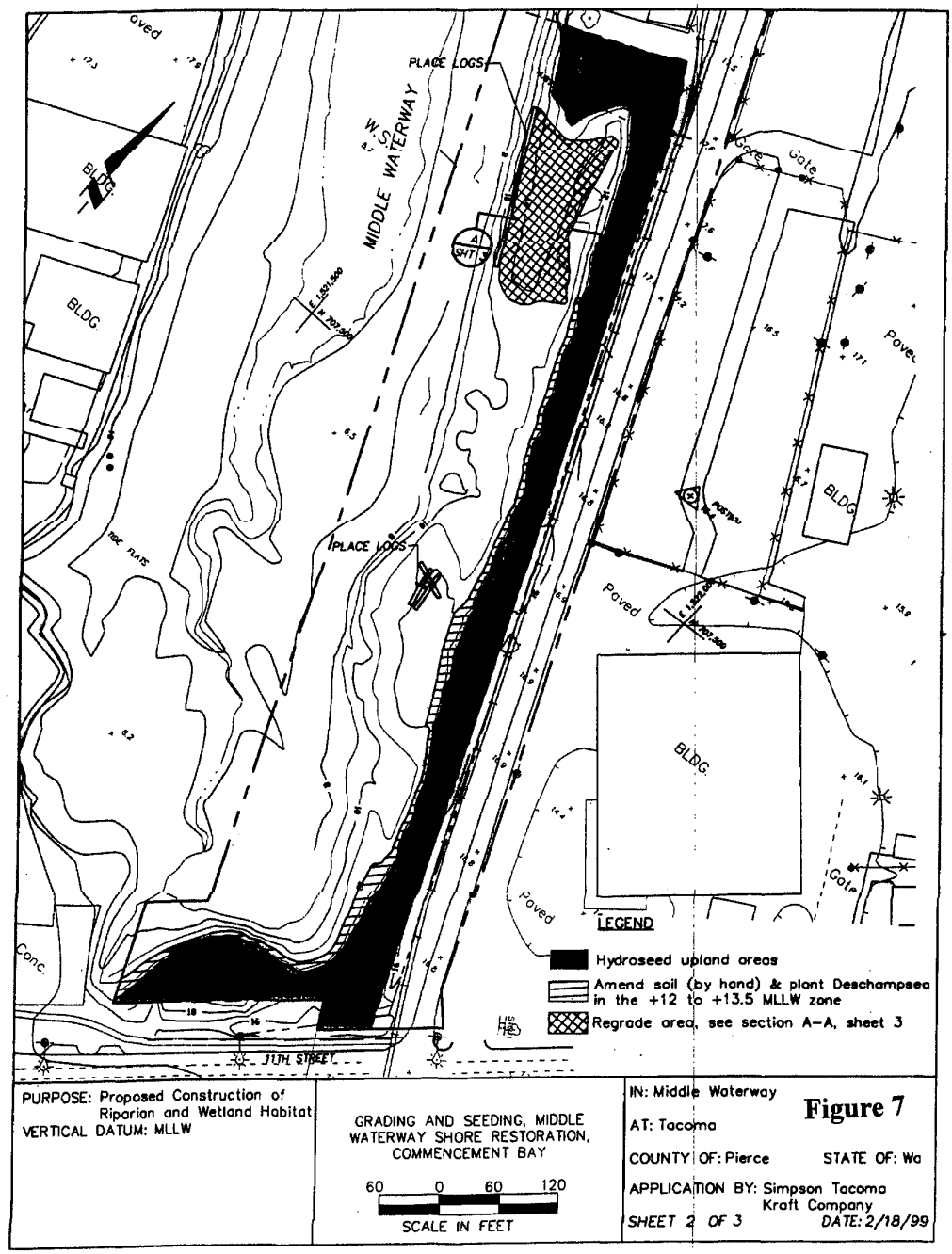


Figure 8: 2001 Site Survey / Planting Areas

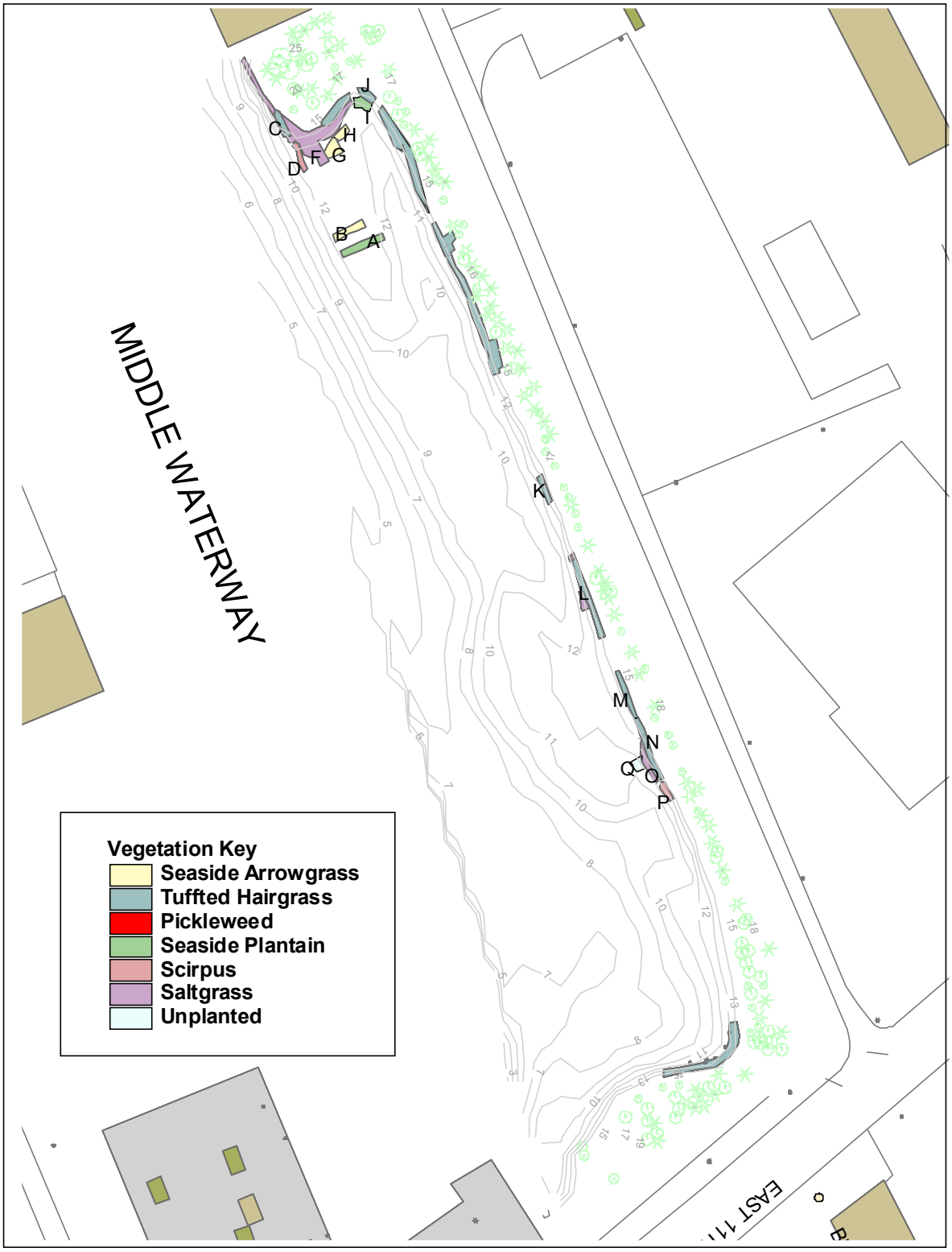
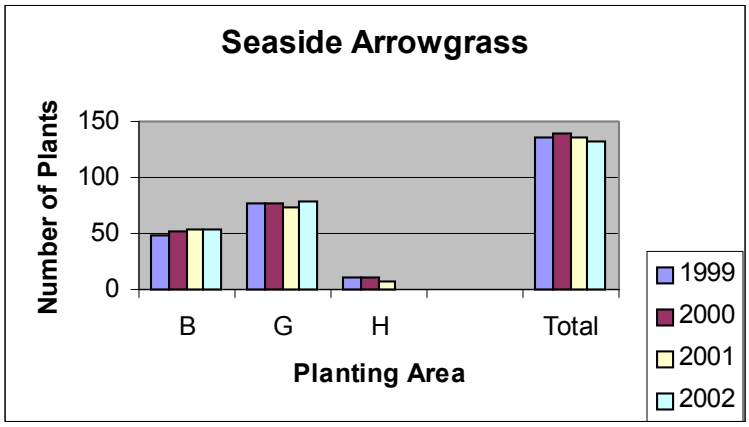
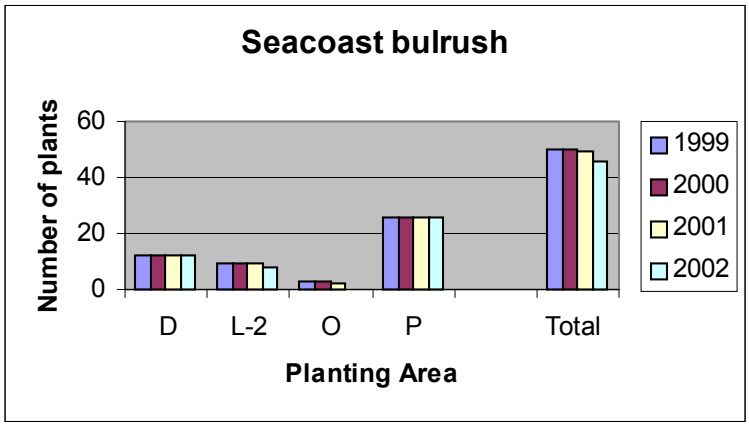
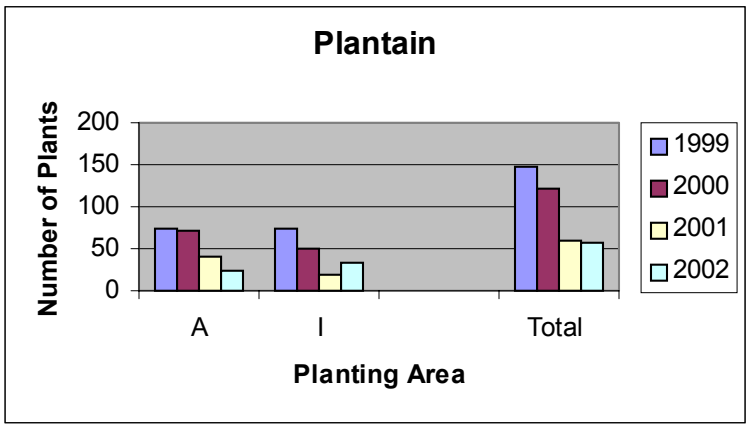


Figure 9
Plant Survival 2000-2002







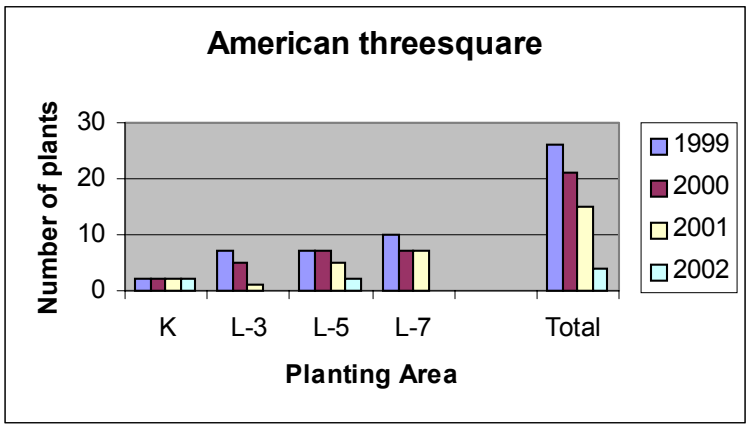


Table 1: Percent Cover by Species 1996-2000

	Species	Year 0-1	Year 2	Year 3	Year 5	Notes
Transect 1	*Carex lyngbyei*	.5-4				1996 planting of *Carex lyngbyei*
	Atriplex patula			0-7	trace	
	Vaucheria sp.		0-99		90	
Transect 2	*Deschampsia cespitosa*	1-4		0-15	trace-5	1996 planted with *Deschampsia cespitosa*
	Atriplex patula	0-18		0-25	trace	
Transect 5	*Salicornia virginica*	0-10				Plant salvage area
	Vaucheria sp.	0-95	0-75	0-100	Trace-90	
	Eleocharis parvula	*	0-2	0-15	0-50	
Transect 6	*Scirpus maritimus*	0-2				Combination of salvage and planted 1996 w/ small quantities of *Scirpus maritimus*
	Distichlis spicata	5-50				
	Salicornia virginica	0-1	0-1		trace	
	Vaucheria sp.			0-40	0-90	
Transect 7	*Distichlis spicata*	1-2.5	1-5	0-12	trace	Combination of salvage and planted 1996 w/ small quantities of *Jaumea carnosa* and *Plantago maritima*
	Salicornia virginica	0-2.5	0-5		trace	
	Atriplex patula	0-33	0-15	0-25	10-15	
	Jaumea carnosa	*				
	Plantago maritima	*				
Transect 10	*Deschampsia cespitosa*	1-6	5-20	0-65	75-100	Planted 1996 w/ *Deschampsia cespitosa*
	Atriplex patula	0-50	trace	0-1	trace	
	Distichlis spicata		0-20	0-15		
	Fragaria chiloensis	0-.5	0-20	0-4	trace	
	Aster subspicatus		0-5			

* noted along transect but not within quadrat

APPENDIX A

CHRONOLOGY OF EVENTS

DATE	ACTIVITY
December 13, 1991	St. Paul Waterway Natural Resource Damage settlement agreement
Spring 1993	Selection of the Middle Waterway Shore site as the location for development of a Pilot project to fulfill the 1991 NRD settlement agreement
1993-1994	Project planning / Collection of baseline data
April 1994	Monitoring and Adaptive Management Plan
June 1995	Site construction / Salvage of onsite salt marsh plants
October 21, 1995	Riparian planting (see Appendix B)
April 1996	Initiation of post-construction site monitoring (continued annually through 2000). See individual monitoring reports for monitoring schedules.
May 26, 1996	Initial salt marsh planting / installation of goose excluder (see Appendix C)
October 16 & 23, 1996	Additional riparian planting (see Appendix B)
May 1998	Supplemental riparian planting by People for Puget Sound (see Appendix B)
February 1999	USFWS selected as Middle Waterway adaptive management project manager
February 1999	Restoration Technical Subcommittee's 1999 work plan set out primary tasks applicable to the Project.
	Conceptual plan
	Engineering drawings provided by Simpson
September 1999	Removal of approximately one foot of sand from the north peninsula and placement of 375 yd^3 of pro gro topsoil mix. Placement of drift logs along the outer perimeter of the peninsula.
January 25, 2000	Anchoring and log placement along the outer peninsula perimeter
April 1, 2000	Salt marsh planting and installation of goose excluder (see Appendix C)
July 2000	Initiated survival monitoring of salt marsh plants. Conducted annually through
February 2001	Topographic survey conducted by the City of Tacoma
March 6, 2001	Anchor drift logs along base of berm. Install goose excluder on unplanted middle peninsula
Late summer 2001	Goose excluders modified with chicken wire to exclude rabbits
September 2002	Invasive plants removed from the riparian buffer planting by WCC

APPENDIX B

RIPARIAN PLANTING

1995 Plant Order and Year One Survival Rates

The original plant order not filled by the supplier and was revised on short notice with plants available from the local area. Column # on plan, refers to the original planting plan developed by Simpson's contractor (Parametrix), with input from the Trustees. The # ordered was the amended order based on what was available from local suppliers on short notice.

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

Species	# on plan	# ordered	Nursery	***# Dead 9/9/96***	*# Stressed 9/9/96*	% Survival
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:

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 were amended on the planting sheet.

The huckleberry that was planted in 1995 was not *Vaccinium ovatum,* evergreen huckleberry the species ordered from the nursery, 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.

1996 Additional Riparian Plant Order

Species	Quantity	Size	Nursery
Acer circinatum (Vine Maple)	15 6 10	2 gal 5 gal 3 gal	SNP SNP WB
Amelanchier alnifolia (Serviceberry)	25	#1 container	WB
Arbutus menziesii (Pacific Madrone)	3	1 gal	SNP
Arctostaphylos uva-ursi (Kinnikinnik)	200	4”	PN
Corylus cornuta (Beaked Hazelnut)	5	1 gal	SNP
Fragaria chiloensis (Strawberry)	500	4”	PN
Fraxinus latifolia (Oregon Ash)	3	#1 container	WB
Holodiscus discolor (Oceanspray)	30	1 gal	SNP
Mahonia aquifolium (Tall Oregon grape)	20	#1 container	WB
Osmaronia cerasiformis (Indian Plum)	10	#1 container	WB
Picea sitchensis (Sitka Spruce)	7 6	5-6’ 4-6’	WB WB
Pinus contorta (shore pine)	10 15 9	1 gal 2 gal 3 gal	SNP WB WB
Pseudotsuga menziesii (Douglas fir)	10	3 gal (4’)	WB
Ribes sanguineum (Red flowering currant)	30	#1 container	WB
Symphoricarpos albus (Snowberry)	30	1 gal	SNP
Tsuga heterophylla (Western hemlock)	3	2 gal	SNP
Thuja plicata (Western red cedar)	5 5	2 gal 2 gal	SNP WB
Vaccinium ovatum (Evergreen huckleberry)	20	#1 container	WB

PN = Pacific Natives, Woodenville (Bothell), Rob & Patty
SNP = Sound Native Plants, Olympia, Susan Buis
WB = Woodbrook Nursery, Gig Harbor

Notes: Planting of trees and shrubs conducted on October 16, 1996. Planting of groundcover conducted on October 23, 1996.

1998 Supplemental Riparian Planting

Species	Quantity	Size	Nursery
Picea sitchensis (Sitka Spruce)	10	1 gal	WB
Pseudotsuga menziesii (Douglas fir)	10	1 gal	WB
Crataegus douglasii (Western Hawthorn)	10	1 gal	WB
Holodiscus discolor (Oceanspray)	10	1 gal	WB
Ribes sanguineum (Red flowering currant)	30	1 gal	WB
Symphoricarpos albus (Snowberry)	30	1 gal	WB
Fragaria chiloensis (Strawberry)	50	4”	WB

WB = Woodbrook Nursery, Gig Harbor

Notes:
Planting conducted by People for Puget Sound on 5/6/98.

APPENDIX C

SALT MARSH PLANTING

Initial Salt Marsh Plantings

May 22, 1996 Planting

Species	Common Name	Quantity	Size	Nursery
Carex lyngbyei	Lyngby sedge	5,400	sprigs	W&BG
Deschampsia cespitosa	Tufted Hairgrass	400 400	Plugs 4”	W&BG
Plantago maritima	Seaside plantain			W&BG
Distichlis spicata	Saltgrass			W&BG
Salicornia virginica	Pickleweed			W&BG
Scirpus americanus	American threesquare			W&BG
Scirpus maritimus	Seacoast bulrush			W&BG

Wave and Beach Grass Nursery, Florence, Oregon

Adaptive Management Salt Marsh Plantings

April 1, 2000 Planting

Species	Common Name	Quantity	Size	Nursery
Aster subspicatus	Douglas Aster	200	Bareroot	FC
Deschampsia cespitosa	Tufted Hairgrass	300 200	4” bareroot	KCD FC
Distichlis spicata	Saltgrass	300	Bareroot	FC
Grindelia integrifolia	Gumweed	200	Bareroot	FC
Juncus balticus	Baltic rush	200	Bareroot	FC
Plantago maritima	Seaside plantain	150	4”	KCD
Scirpus americanus	American threesquare	40	4”x5”x5” plug	KCD
Scirpus maritimus	Seacoast bulrush	50	1 gal	KCD
Triglochin maritima	Seaside arrowgrass	130 20	4” 4”x5”x5”	KCD KCD

FC= Fourth Corner Nurseries, Bellingham WA
KCD = King Conservation District, Renton WA

APPENDIX D

DATA SHEETS
Survival of 1999 Salt Marsh Planting

Planting Area A

Species	1999	2000	2001	2002
Plantago maritima	**73**	**72 (30 flowering)**	**40 (heavily cropped)**	**24**
colonizing species		Atriplex patula	Atriplex patula	Atriplex patula, Spergularia sp., Salicornia virginica

Planting Area B

Species	1999	2000	2001	2002
Triglochin maritima	**49**	**52 (6 flowering)**	**54 (44 flowering)**	**54 (all flowering)**
colonizing species		Atriplex patula	Atriplex patula	Atriplex patula, Spergularia sp., Plantago maritima

Planting Area C

Species	1999	2000	2001	2002
Deschampsia	**54**		**45 (some very dry)**	**28 (upper plants very dry, dead?) Area eroding**
colonizing species				Distichlis spicata

Planting Area D

Species	1999	2000	2001	2002
Scirpus maritimus	**12**	**12 (5 flowering)**	**12 (grazed)**	**12 (stressed, maintaining but not spreading)**
colonizing species				lower portion Atriplex patula, Spergularia sp., Distichlis spicata

Planting Area E

Species	1999	2000	2001	2002
Grindelia	**25**	**7**	**0**	**0**
colonizing species				

Planting Area F

Species	1999	2000	2001	2002
Distichlis spicata	**too difficult to count #'s**	**taking hold**	**continuing to spread**	**covers approximately 80% of area, flowering**
colonizing species				

Planting Area G

Species	1999	2000	2001	2002
Triglochin maritima	**77**	**77 (8 flowering)**	**74 (many flowering)**	**79 (Includes area H, no longer distinct) All flowering**
colonizing species			Atriplex patula, Salicornia virginica	Atriplex patula, Salicornia virginica (expanding) Distichlis spicata(makes counting difficult)

Planting Area H

Species	1999	2000	2001	2002
Triglochin maritima	**10**	**10 (2 stressed)**	**8**	**included in area G**
colonizing species				

Planting Area I

Species	1999	2000	2001	2002
Plantago maritima	**75**	**~50 (difficult to count due to severe cropping by rabbits and colonization by Atriplex)**	**~20 (heavily grazed, difficult to find among colonizing plants)**	**~34 (well protected, appears to be expanding)**
colonizing species		Atriplex patula	Atriplex patula, Salicornia virginica, Distichlis spicata, Deschampsia)	Atriplex patula, Spergularia sp., Salicornia virginica, Distichlis spicata, Deschampsia, Grindelia, Rose

Planting Area J

Species	1999	2000	2001	2002
Deschampsia 4"	**35**	**35**	**34**	**31**
Deschampsia bareroot	21	0	0	0
Deschampsia seedlings			2	
Juncus balticus	18	few (difficult to tell individual plants)	few	few

Planting Area K

Species	1999	2000	2001	2002
Deschampsia 4"	**36**	**36**	**36** + seedlings	**36** + seedlings
Deschampsia bareroot	6	0		
Scirpus	2	2 (1 stressed)	2 (1 flowering is americanus)	2 (both stressed)
Grindelia	4	0	0	0

Planting Area L-1

Species	1999	2000	2001	2002
Deschampsia 4"	**86**		**76**	66 (a few stressed)
Aster	20	1	0	0

Planting Area L-2

Species	1999	2000	2001	2002
Scirpus maritimus	**9**	**9** **(8 inside enclosure robust and flowering, 1 outside cropped)**	**9** **Note: enclosure not functioning** **(8 robust and flowering)**	**8**

Planting Area L-3

Species	1999	2000	2001	2002
Scirpus americanus	**7**	**5 (stressed)**	**1**	**0**

Planting Area L-4&6

Species	1999	2000	2001	2002
Distichlis spicata	**55**	**taking hold**	**taking hold**	continuing to expand; some growing outside excluder/plants within flowering

Planting Area L-5

Species	1999	2000	2001	2002
Scirpus americanus	**7**	**7 (lower browning, upper plants green)**	**5 (heavily cropped)**	**2 (1 flowering)**

Planting Area L-7

Species	1999	2000	2001	2002
Scirpus americanus	**10**	**7 (some covered by drift)**	**7 (cropped)**	plants indistinguishable small area flowering and expanding by runners

Planting Area M

Species	1999	2000	2001	2002
Deschampsia 4"	**23**			
Deschampsia bareroot	64			
Deschampsia total	87			71 (difficult to tell origin of plants, whether 4", bareroot or new seedling)
Aster	10	0	0	0

Planting Area N

Species	1999	2000	2001	2002
Deschampsia 4"	30	30		
Deschampsia bareroot	104	104		
Aster	12	0	0	0
Distichlis	66	taking hold (Unable to discern individual plants)		Expanding

Planting Area O

Species	1999	2000	2001	2002
Deschampsia 4"	36	36		
Scirpus maritimus	3	3 (stressed)	2 (very stressed)	0 (area colonized by Distichlis; 100% cover)
Juncus balticus	32	few(difficult to discern #)		few (expanding by rhizomes)
Aster	9	0		
Distichlis		Colonizing? (Note: could have been bareroot planting missed in initial inventory)	Very robust	Robust (note: also growing below enclosure)

Planting Area P

Species	1999	2000	2001	2002
Scirpus mix of maritimus and americanus	26	26	26 (healthy; 1/3 flowering)	26 (some yellow)
Juncus balticus	~40	few	few	two patches, upper southern end of enclosure & upper middle
Salicornia				colonizing, mid to low elevation
Distichlis				N. end colonizing (expanding from area O); flowering

Area Q - unplanted Excluder

Species	1999	2000	2001	2002
Atriplex			colonizing	
Salicornia				colonizing
Spergularia				colonizing

Notes: Monitoring conducted on July 31, 2000
Monitoring conducted on July 9, 2001
Monitoring conducted on August 5, 2002

APPENDIX E
PHOTOS

Photo 1 1994 Site prior to construction
(photo courtesy Simpson)

Photo 2 1994 Uplands prior to construction
(photo courtesy Simpson)

Photo 3 1995 Construction
(photo courtesy Simpson)

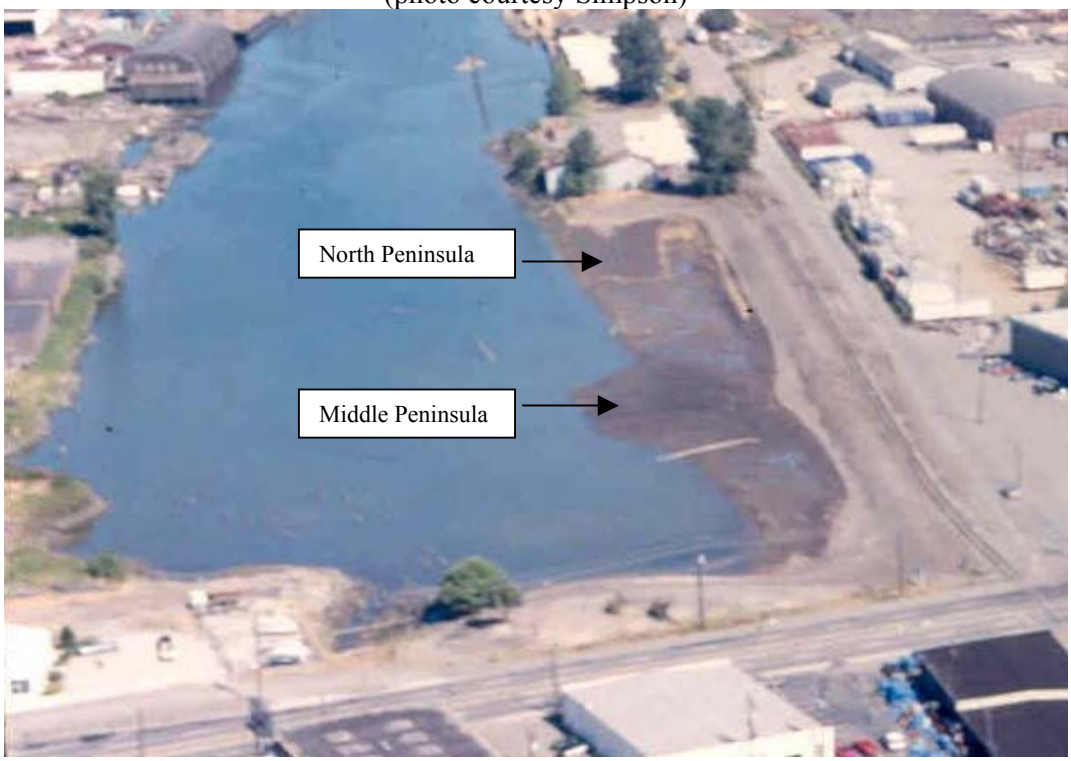


Photo 4 July 1995

Photo 5 Riparian planting October 1996

Photo 6 Supplemental planting conducted May 1998

Photo 7 Construction of North Peninsula 1995

Photo 8 Historic fill, Puyallup River Sand

Photo 9 Middle Peninsula top-dressed with native sediments

Photo 10 Salt marsh planting May 1996

Photo 11 Construction June 1995
(photo courtesy Simpson)

Photo 12 Existing saltgrass

Photo 13 Saltgrass salvage

Photo 14 Saltgrass salvage

Photo 15 Saltgrass & pickleweed

Photo 16 Existing pickleweed

Photo 17 Pickleweed salvage

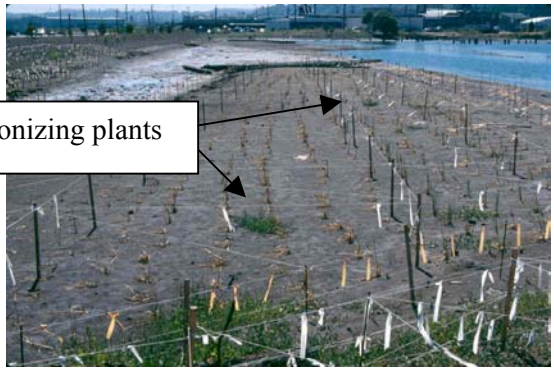


Photo 18 August 1996
Dead Carex, colonizing pickleweed
and fat hen

Photo 19 March 1998
Only flagging remains on peninsula

Photo 20 January 2003
Erosion @ base of berm

Photo 21 July 2000

Photo 22 August 1997

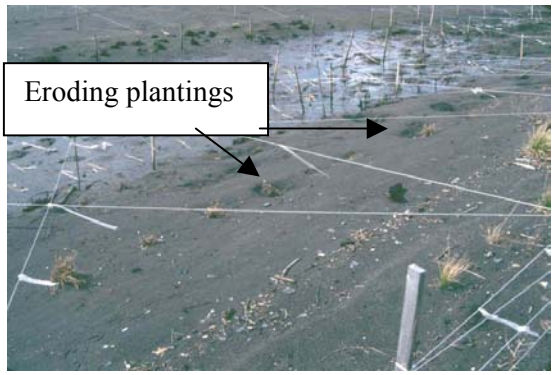


Photo 23 Spring 1997

Photo 24 June 1995 Salvage in progress

Photo 25 July 1995

Photo 26 pickleweed salvage June 1995

Photo 27 saltgrass salvage July 1995

Photo 28 July 1996 (courtesy NOAA)

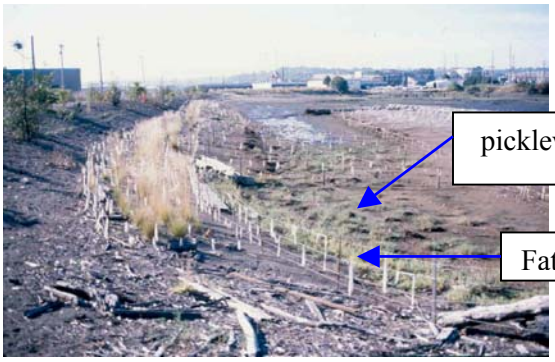


Photo 29 August 1997

Photo 30 September 1999

Photo 31 September 1999

Photo 32 September 1999

Photo 33 September 1999 Log placement

Photo 34 January 2000

Photo 35 January 2000

Photo 36 March 2001

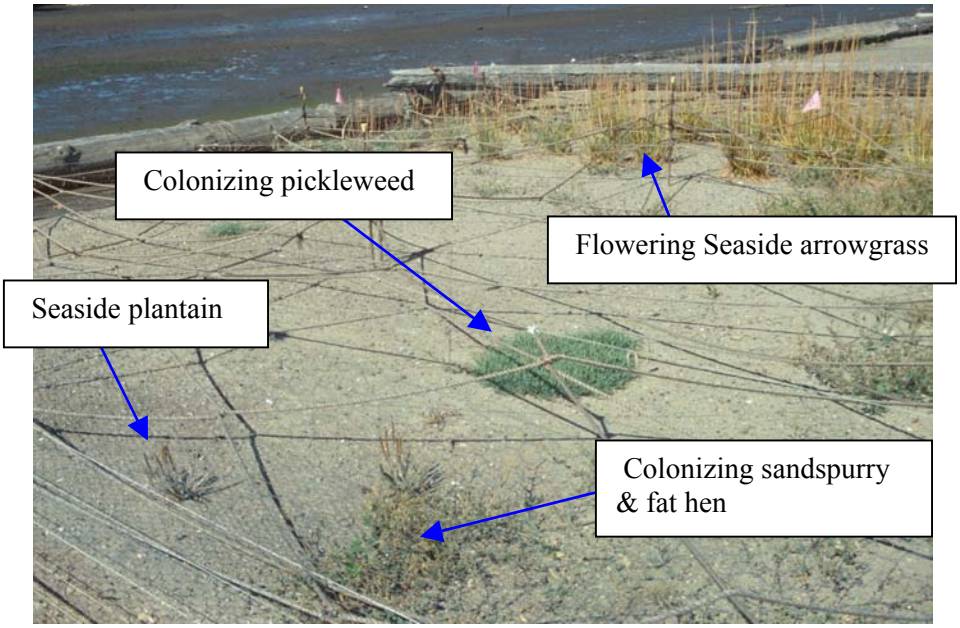


Photo 37 September 2002 planting areas A & B

Photo 38 August 2002 Seacoast bulrush

Photo 39 Saltgrass expanding and flowering August 2002

Photo 40 January 2003

Photo 41 tufted hairgrass naturally reseeding January 2000

Photo 42
Colonizing pickleweed August 2002

Photo 43
Unplanted excluder August 2002

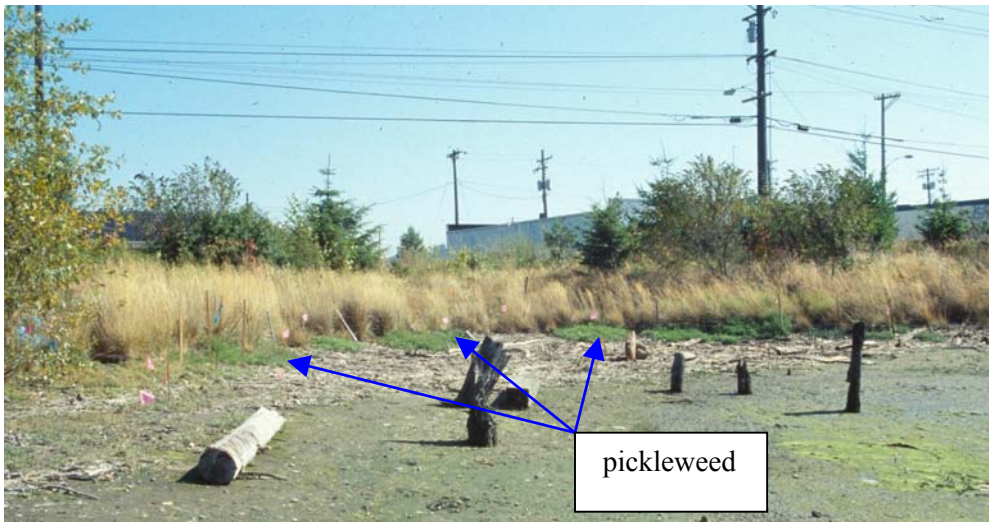


Photo 44 Southern embayment Colonizing pickleweed outside planting enclosure

Photo 45 Northern embayment Colonizing pickleweed, fat-hen, sandspurry and gumweed

Photo 46 2000

Photo 47 January 2003

Photo 48 January 2003

Photo 49 January 2003