

Final Habitat Monitoring Report City of Tacoma Middle Waterway Restoration Project



Photo point LM3B

December 2005

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Final Habitat Monitoring Report

City of Tacoma Middle Waterway Restoration Project

1.0 Introduction

The City of Tacoma (City) performed a habitat restoration on 1.9 acres of vacant industrial property at the head of Middle Waterway in Tacoma, Washington. The property is located near the intersection of East F Street and East 11th Street. The primary objectives of the restoration action were to lower the grade of the properties to salt marsh elevations, cover the surface with clean habitat material, and vegetate the salt marsh and its bordering riparian buffer zones.

This restoration action was conducted as part of the City's settlement of alleged natural resource damages with the Commencement Bay Natural Resource Trustees¹ (Trustees). This monitoring report is being provided to the Trustees as a part of that settlement.

Restoration activities included construction (excavation, backfilling, grading, slope stabilization, fencing, and installation of an irrigation system) performed by RCI Environmental, Inc. between July 21 and September 29, 2000; planting of all the riparian areas by the City and citizen volunteers on November 4, 2000; and planting of salt marsh areas on May 26, 2001.

The City has conducted fourteen monitoring events since completion of construction (field notes available upon request):

- Year 0-1 - December 21, 2000; March 29, 2001; June 26, 2001; and August 15, 2001;
- Year 1-2 - December 11, 2001; March 21, 2002; June 14, 2002; August 20, 2002;
- Year 2-3 - January 21, 2003; April 4, 2003; June 12, 2003; September 9, 2003;
- Year 4 - August 30, 2004, and
- Year 5 - August 30, 2005.

The methods and frequency of these monitoring events were detailed in the "Monitoring and Adaptive Management Plan (MAMP)" (Hart Crowser, February 25, 2000) prepared for this site. Quarterly monitoring events are required for the first two years. The remaining three years of required monitoring include annual monitoring events performed in late summer of each year. The monitoring in August 2005 fulfills the City's 5-year maintenance and monitoring requirement under the Consent Decree (p15, P.21e).

¹ Commencement Bay Natural Resource Trustees consist of the following entities: National Oceanic and Atmospheric Administration; U.S. Fish and Wildlife Service; Washington State Department of Ecology; Washington State Department of Fish and Wildlife; Washington State Department of Natural Resources; The Puyallup Tribe of Indians and Muckleshoot Indian Tribe.

2.0 Qualitative Monitoring & Results

Qualitative monitoring results are based upon observations of trained personnel during site visits. Qualitative observations were taken of vegetation, sedimentation, wildlife, and other local environmental conditions. For the City of Tacoma, this person is Desiree Pooley, Senior Environmental Specialist. The City has retained David Adams as a site steward, and his observations are also included.

2.1 Physical Site Description

The site is composed of three general areas: the City parcel, the DNR parcel and the 11th Street Right of Way (ROW).

The City parcel is approximately 1 acre and is situated adjacent to the substation along East "F" Street. The riparian area (elevation > 14 ft MLLW) lines three edges in this portion of the site and is sloped at 4:1 (horizontal: vertical). The riparian soil is all imported sandy loam. There is a broad flat upper salt marsh area (elevations between 12 and 14 ft MLLW) and the substrate is native sands and silts/clays that were uncovered when the excavation got to the project grade. The lower salt marsh area (elevations between 12 ft MLLW down to the project boundary, which is approximately 9 ft MLLW) consists predominantly of imported silty sand.

The 0.7-acre DNR parcel follows the irregularly shaped project boundary on the waterside and is bordered by the substation and King Salmon Marine (formerly known as Port Yacht Basin) on the upland side. All the substrate on this parcel is imported material. The riparian has some broad flat areas in addition to the transitional sloping portion that leads to the salt marsh. Owing to the limiting project boundaries in this area, the upper and lower salt marsh areas are narrow bands following the project boundary. All three elevation ranges converge at a relatively steep slope along side King Salmon Marine.

The 11th Street ROW is approximately 0.2-acre strip of riparian area that starts at the end of the Port Yacht Basin Property and stretches along East 11th Street. The soil here is imported riparian topsoil.

2.2 Photo Points

Photo points were established as described in the MAMP and depicted in Figure 1. The location of each point was marked by a stake and surveyed. A photo with a digital camera was taken from each photo point during each monitoring event. Appendix A presents photos from each late summer monitoring event over the 5-year monitoring period.

The photos of the riparian areas show the general good health and vigor of the riparian plantings, as well as the development of volunteers, which are quite extensive in most areas. In general, riparian areas have complete ground coverage.

It was previously noted that few volunteer plants were establishing in the salt marsh areas. After review of Year 5 photos and field notes, the pickleweed continues to spread in mass and by seed. The salt marsh has also attracted volunteer native species including goose-tongue (*Plantago maritima* ssp. *juncooides*) and sea arrow grass (*Triglochin maritimum*). Overall, ground coverage in the salt marsh areas is nearing 80%.

It should be noted that while the riparian area experienced significant growth between years 2-3, the salt marsh areas were more productive later between years 3-5.

2.3 Vegetation

Several general trends continue to be observed:

- Nootka rose, alder, and willow species continue to thrive.
- Pickleweed is forming mats in the lower salt marsh and reseeding itself in areas outside the goose exclusion areas.
- Upper salt marsh species, salt grass and tufted hair grass in the upper salt marsh continue to spread beyond the confines of the goose exclusion devices.
- Volunteer vegetation is noted in all areas of the project site.
- Annual maintenance has successfully controlled invasive species.
- Previously noted erosion prone areas are becoming colonized with vegetation.

2.4 Sediment

Certain areas of the restoration site have experienced limited sediment loss since construction was completed. The transitional area between the upper and lower salt marsh appears to have equalized. Past data continues to suggest the overall sediment trend is slow accretion of sediment rather than erosion. This could be attributed to the increase in vegetative ground cover. Isolated erosion prone areas are now colonizing with vegetation.

2.5 Wildlife

Many animals have been visiting the site. Direct observations and/or evidence of the following animals have been documented:

- Salmon fry
- Spotted sandpiper
- Crow
- Canada geese
- Seagulls
- Rabbit
- Raccoon
- Violet-green swallow
- Song sparrow
- Widgeon
- Great Blue Heron
- Killdeer
- Coyote

2.6 Local Environment

In Spring 2005, Washington State Department of Natural Resources (DNR) completed the planting of the access area that was used during the 2004 cleanup of the sediments at the head of Middle Waterway. Construction activities were located adjacent to our site and included excavation, sediment sampling, dewatering and capping. A portion of the 11th Street right-of-way was used for construction access. Please contact Tim Goodman, DNR, at (360) 902-1057 for project information. Post-construction, the access area experienced erosion when road runoff from 11th street crossed the site and entered the waterway near Outfall 200. The City resolved this issue by installing a concrete curb that now intercepts the water before it crosses the site.

The Middle Waterway restoration site continues to be toured for educational purposes. In August 2005, University of Washington Tacoma students walked the site and learned about site history, construction, and lessons learned.

It is anticipated that the City's mitigation projects located along the eastern bank of the Middle Waterway will be completed by Spring 2006. These City projects as well as others located around Commencement Bay are associated with the Foss Waterway Superfund cleanup mitigation requirements and will contribute to the synergy of all Commencement Bay restoration efforts.

Also related to the Foss cleanup, the hydraulic dredge pipeline that runs from the Foss Waterway to the CDF area in the St. Paul Waterway was installed in July 2005. It runs east parallel to and adjacent to the 11th Street right-of-way and takes a 90-degree left hand turn paralleling the Simpson log yard access road and terminates at the CDF facility (formerly know as the St. Paul Waterway). The pipeline route is adjacent to our project site and the excavated material unearthed during the installation of the pipeline has been stockpiled nearby (Appendix B, Photo 1). The pipeline is currently being disassembled and the stockpile will be used as backfill. Please contact Mary Henley (253) 502-2113 for Foss project details.

Ms. Jeanne Hughes and Dr. Kern Ewing with University of Washington's Center for Urban Horticulture are conducting "A Study of Intertidal-Wetland Restoration in Puget Sound". The City's Middle Waterway site is one of their project sites. Please see Appendix C for a summary and contact information.

Citizens for a Healthy Bay "Adopt-a-Wildlife Area" volunteers continue to monitor the Middle Waterway site on a regular basis. Contact Citizens for a Healthy Bay, (253) 383-2429 for more information and/or monitoring results.

Summer 2005, a complaint was received from King Salmon Marine, adjacent property owner, regarding the density of fence line vegetation (mainly red alder) and its propensity to attract thieves. Thinning the alders addressed the safety concern and allowed more sunlight to reach underlying conifers.

Simpson's log haul out area was relocated from the St. Paul Waterway to the east side of the Middle Waterway near the mouth to the Bay. This change in location resulted in an accumulation increase of large woody debris and small bark debris along the shoreline at the head of the waterway. This was noted during the August 2005 monitoring event (Appendix B, Photo 2). This observation was relayed to Simpson via David Adams and they are taking measures to reduce this impact.

3.0 Quantitative Monitoring Methods

Quantitative monitoring involves collection and analysis of numerical data concerning habitat features such as vegetation, sedimentation, and sampling of groundwater seeps (if present). City of Tacoma employee, Desiree Pooley, collected the 2005 quantitative monitoring data.

3.1 Vegetation

Quantitative vegetation monitoring for Year 5 was conducted on August 30, 2005. Transects and quadrats established during Year 0-1 (illustrated in Figure 1) were again monitored.

Twenty-eight sample plots (quadrats) were established at random along the transects. The riparian area contained 8 quadrats (R1: 1-4 and R2: 1-4) and ten quadrats were established for both the upper (U 1-10) and lower (L 1-10) salt marsh areas. Five quadrats L-4, L-5, and L-6 (lower salt marsh) and U-5 and U-7 (upper salt marsh) are located outside the planted areas. The exact location of quadrats U-5, L-5, L-4, R2-2, R2-1, R1-2, and R1-1 were estimated in the field. Quadrats R1-3 and R1-4 were both affected by the DNR access for the 2004 cleanup. The original vegetation planted in these areas was transplanted on-site to provide access and the area has since been replanted with new plants. See Section 2.6 for more information. The data collected from these areas are presented but not used in calculation of the performance goals.

For each quadrat, the Daubenmire cover class (i.e. 0-5%, 5-15%, 15-25%, 25-50%, 50-75%, 75-95% or 95-100%) was estimated for each plant species found within that quadrat as well as the amount of bare substrate. Each cover class corresponds to a Daubenmire cover class midpoint values (i.e. 2.5%, 12.5%, 20.5%, 35%, 65%, 85%, or 97.5%). Plants were categorized as "native" according to Plants of the Pacific Northwest Coast (Pojar & MacKinnon, 1994).

3.2 Sediment

Quantitative sediment monitoring consisted of recording the sediment elevation at each of 8 sediment stakes. The stakes were installed on October 30, 2000 in the areas shown on Figure 1 and initial readings recorded. Each stake was marked in centimeters starting at the top of the stake, however, over time the marks have worn off. During Year 5 monitoring all stakes were read with a tape measure in centimeters from the bottom up.

It should be noted that stake #712 has experienced saltwater corrosion at the top of the stake. Despite the failing stake material and therefore inaccurate readings, visual observations of the area note no significant erosion or accretion.

3.3 Groundwater Seep Sampling

The site was monitored for the presence of seeps during each monitoring event, but no seeps were observed. Therefore, no seep sampling or analysis was conducted throughout the five-year monitoring period. The City does not anticipate seeps to be present in the future.

4.0 Quantitative Results

4.1 Vegetation

The MAMP established performance goals for both the riparian and salt marsh areas and are presented below. These goals were established for 12 months of growth and development. As of September 2005, when the quantitative data was collected, the riparian plants had been in place for 58 months and the salt marsh plants had been in place for 52 months (2 months and 8 months short (respectively) of the 60 month/5 year performance goal). Table 1 presents the results. Appendix D presents a 5-year look at total vegetative cover and total native vegetative cover by habitat area in relation to the 5-year performance goal. The majority of the Year 5 performance goals have been met. This will be the final monitoring report.

4.1.1 Riparian Area

Total areal cover within each quadrat and mean percent cover are two measures used to evaluate the successful establishment of the project site. Plant growth continues to be successful as presented in previous reports.

The Year 5 performance goals for the riparian area are:

- 1) Total areal cover of native or naturalized non-native plants shall be greater than 60 percent of the total target area and
- 2) Greater than 75 percent average areal cover for all quadrats.

Table 1 shows that all riparian quadrats meet the first goal, with the exception of quadrats R1-3 and R1-4. However, data from these quadrats are not included in our calculations because of the recent DNR cleanup disturbance to the area. The range of areal coverage is 162-194%, far exceeding the goal of 60% or greater. The second performance goal has also been achieved. 169% is the average areal coverage of all riparian quadrats. This number is somewhat skewed by the abundance of grasses, however, it should be noted that as the canopy vegetation increases the percent grass coverage is declining. It is also notable that the average native vegetative cover is 95%, which exceeds the second performance goal as well.

The success of the riparian areas could be attributed to:

- Irrigation during the dry months.
- Aggressive and routine invasive species removal.
- Frequent site visits allowing quick identification of damage or disease.

The riparian areas have exceeded vegetation expectations. No adaptive management is warranted.

4.1.2 Upper and Lower Salt Marsh Areas

Total areal cover within each quadrat and mean percent cover are two measures used to evaluate the successful establishment of the salt marsh as well.

The Year 5 performance goals for the salt marsh areas are:

- 1) Total areal cover of native or naturalized non-native plants in the upper salt marsh and lower salt marsh zones shall be 75%
- 2) Greater than 75% average areal coverage for all quadrats.

Table 1 shows that fourteen of the twenty quadrats (70%) in both salt marsh areas meet the first goal with a range of 85% - 261%. Seven of the qualifying fourteen quadrats are located in the upper salt marsh and the remaining seven are in the lower salt marsh. Six quadrats (L-1, L-5, L-6, U-5, U-6, and U-7) have not met the individual goal with a range of 8% - 68%. Four of the six quadrats (U-6, U-7, L-1, and L-6) fall into the higher end of the range. Of these six, 4 quadrats (U-5, U-7, L-5, L-6) are located outside of the planted areas. See Table 2 below for a detailed chart.

Table 2. Quadrats Not Meeting Year 5 Performance Goals

Quadrat	L-1	L-5	L-6	U-5	U-6	U-7
Percent Cover (%)	67.5	7.5	67.5	37.5	65	65.5
Planted vs Not Planted	P	NP	NP	NP	P	NP

The average areal coverage in the upper salt marsh area is 125% and in the lower salt marsh area it is 81%. These numbers have increased dramatically from the Year 2-3 report of 35% and 46% respectively showing substantial growth and progress. Therefore the second performance goal has been achieved.

The success of the salt marsh areas could be attributed to:

- Entrapment of free seed due to increased vegetative cover
- Aggressive and routine invasive species removal
- Frequent site visits allowing quick identification of damage or disease

4.1.3 Diversity

Species diversity is another measure in the ecological evaluation of this project. The long-term goal is for the project site to have a comparable diversity to the original habitat

it is trying to recreate. The diversity values provided are targets only and are not criteria by which success will be judged.

The riparian zone diversity target is between 10 and 15 species of native or naturalized non-native herbs, shrubs, and trees present and abundant. Abundant is defined as being present in at least 50-60% of the quadrats. Applying this definition to the data in Table 1 shows that the following 12 riparian plants are abundant on the restoration site: red alder, shore pine, nootka rose, horsetail, pearly everlasting, Himalayan blackberry, reed canary grass, butterfly bush, grass, buttercup, dune tansy, and soft rush. The target diversity value for the riparian area has been achieved.

The success of diversity in the riparian areas could be attributed to:

- Irrigation during the dry months
- Aggressive volunteer species
- Bird/animal transportation of seed material

The salt marsh zone diversity target is more than 5 species of native or naturalized non-native grasses, sedges, rushes, succulents, and broad-leaved herbs present. Referring to Table 1, the upper salt marsh far exceeds this goal with 28 different species present and the lower salt marsh area with 11 different species present. Thus the target goal has been met.

This increase in salt marsh vegetation diversity can be attributed to:

- Increase in vegetative cover aids to retain free seed
- Transplanting activities during the DNR cleanup
- Growth of the riparian vegetation into the fringe of the salt marsh areas

4.1.4 Invasive Species

Aerial coverage of invasive species is the final measure used to evaluate the success of this project. As native vegetation matures it is expected to out-compete the invasive species.

The riparian zone performance goal for invasive species is not more than 15% areal coverage of knapweed, Scot's broom and/or Himalayan blackberry. Referring to Table 1, the riparian zone has no knapweed or Scot's broom and Himalayan blackberry has dropped from 2.5% (Year 2-3) to 1.9%. Therefore, this invasive species performance goal has been met for Year 5.

However, there is a need to remove other invasive species present on-site. Butterfly bush, tansy ragwort, Canada thistle, Himalayan blackberry, St. John's wort and any other noxious or obnoxious weeds should be removed and disposed of properly to prevent the spread of seed on-site or off-site.

The salt marsh area performance goal for invasive species is not more than 10% total areal cover of invasive plants considered noxious weeds shall be present (i.e. spartina

alterniflora). Referring to Table 1, the upper and lower salt marsh zones have no signs of spartina alterniflora populations. All non-native species are below the 10% goal except for grass of unknown species (25%). Therefore, this invasive species performance goal has been met.

It should be noted that all invasive species percent cover has declined and can be attributed to targeted invasive species removal and general maintenance of the site.

The adaptive management recommendation under this measurement index is the periodic qualitative monitoring of these areas to ensure native plant dominance and success.

4.2 Sediment

Erosion of salt marsh or riparian soil substrates could cause loss of habitat and vegetation. However, some equilibration of sedimentary regime is to be expected. Sediment stakes were placed in October 2000. Table 3 presents Year 5 sediment stake readings, the net change between years 2 and 5, and provides an opportunity to compare the final readings to the data of years 0 and 1.

The performance goal for sediment erosion is to have less than 1 cm of erosion per year, on average, between Year 2 (2002) and Year 5 (2005) monitoring events. Referring to Table 3, all sediment stakes have met this goal. Please note that the reading of sediment stake #712 is inaccurate due to the failing stake material. Past measurements of the stake #712, show it to be a very stable area. As no significant accretion or adjacent erosion was noted in the field, the net change and average change can be assumed to be fairly accurate and not indicative of any sediment problems.

Sediment accretion and erosion will continue to be monitored periodically on a qualitative basis.

5.0 Maintenance / Adaptive Management

This section presents the maintenance activities that have been completed and the activities that are proposed under the adaptive management process.

5.1 Completed & On-going Activities

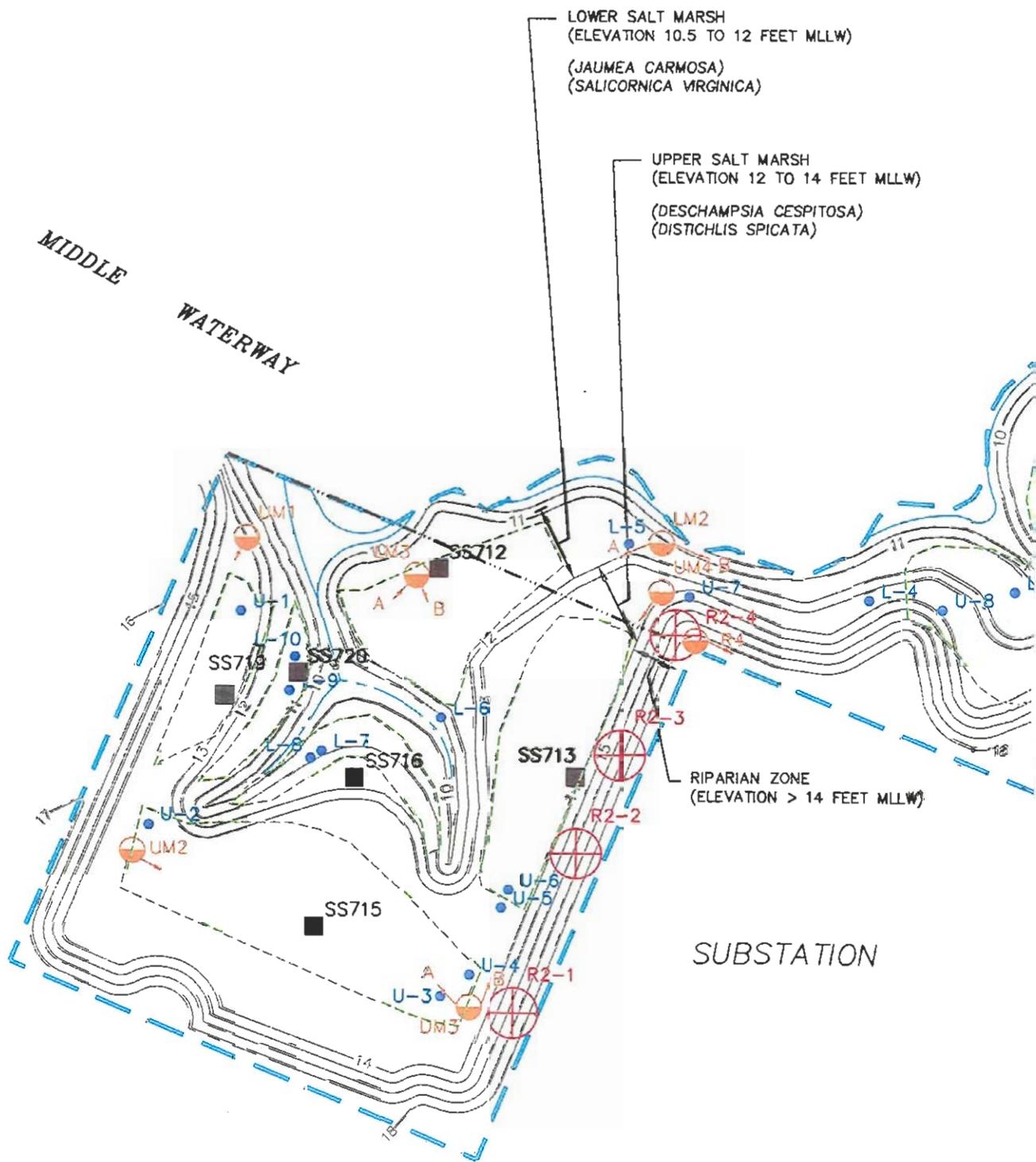
In August and September 2005, maintenance was completed through a partnership with Pierce Conservation District and Tacoma's Urban League crew. Supervised by David Adams, the crew spent 4 days on-site removing Himalayan blackberry, butterfly bush, white sweet clover, and pampas grass as well as thinning red alder (near King Salmon Marine) to encourage conifer growth. The City sponsored Washington Conservation Corps crew continues this maintenance effort during Fall/Winter 2005.

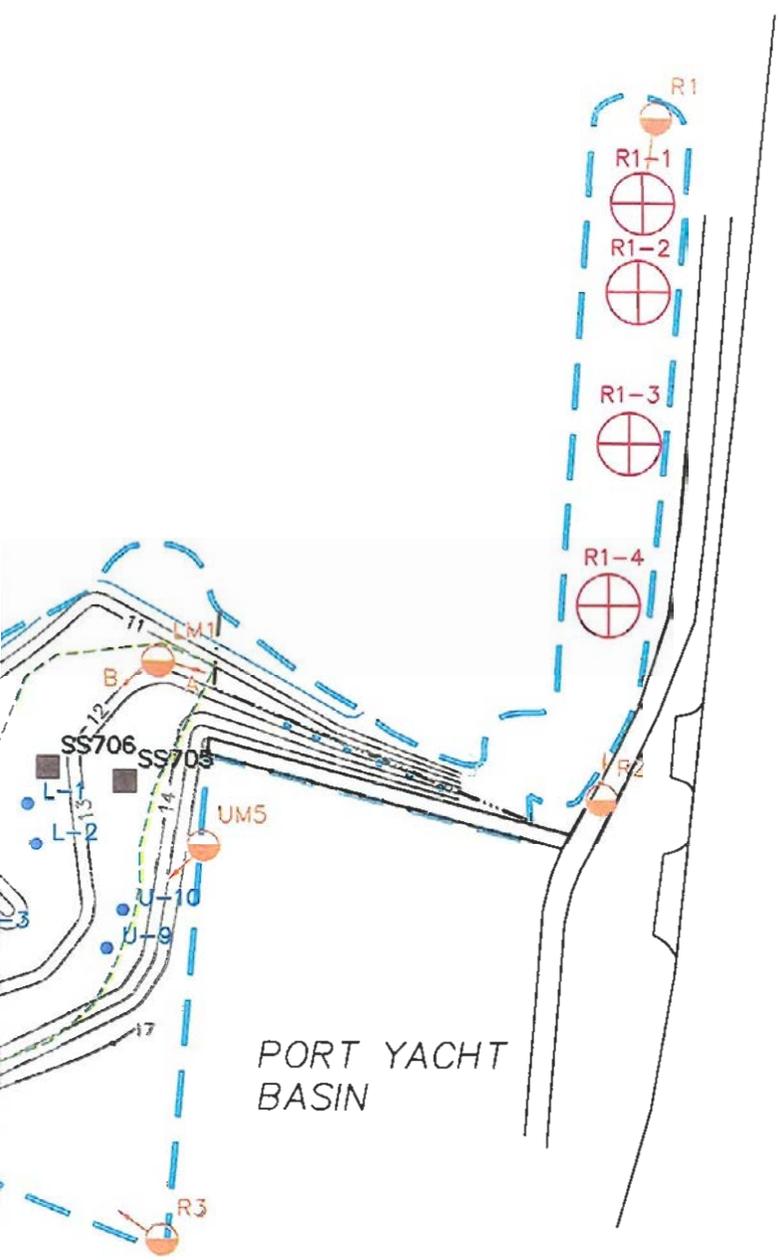
David Adams (site steward under City contract), frequently visited the site, removed noxious weeds as necessary, and gathered pertinent information on the condition of the site. David also provided advice and expertise on adaptive management options.

5.2 Recommended Adaptive Management Activities

The overall health and vigor of the vegetation at this restoration site is very good. The vegetation has shown much progress over the last five years. As this ends the City's five-year monitoring and maintenance commitment, we no longer intend to perform the vigilant monitoring and maintenance activities. However, the City will make periodic site visits to qualitatively assess the site and perform maintenance on an as needed basis.

FIGURE 1





LEGEND

-  RIPARIAN QUADRANTS 28.3 m
-  SALT MARSH QUADRANTS 0.25 m
-  SEDIMENT STAKES
-  PHOTO POINTS
-  SALT MARSH PLANTED AREAS WITH GOOSE EXCLUDER
-  PROJECT BOUNDARY



CITY OF TACOMA DEPARTMENT OF PUBLIC WORKS		
MIDDLE WATERWAY RESTORATION PROJECT		
DATE	SCALE	
10-12-01	1"=30'	
DES	MANAGER ENGINEERING DIVISION	
JOL		
DR	CITY ENGINEER	
REG		
CK	DIRECTOR OF PUBLIC WORKS	SHEET 1 of 1
JGP		YEAR-0.DWG DWG NAME

**Table 1
Quantitative Vegetation Monitoring Results**

Transsect	Riparian 1 (11th Street ROW)				Riparian 2 (North of Substation)				Riparian 2 (North of Substation)				Year 5 Avg Cover %	Year 5 Frequency		
	R1-1*	R1-2*	R1-3	R1-4	R2-1*	R2-2*	R2-3	R2-4 ²	R1-1	R1-2	R1-3	R1-4			R2-1	R2-2
Quadrat #	Daubenmire Cover Class				Daubenmire Cover Class				Daubenmire Midpoints							
Other																
Bare substrate	0	0-5	0	0-5	0	0	25-50	0	0.0	2.5	0.0	2.5	0.0	0.0	35.0	0.0
* Location of quadrat estimated in the field																
† Similar looking to phlox																
* Storage box for NWT-SC sampling equipment located in this quadrat (approximate size 4.5' x 2.25')																
Indicates data not used for calculations due to DNR disturbance of area.																
Bold - Indicates plants that were planted as per the planting plan on November 4, 2000																
<u>Underline</u> - Indicates plants that are on the Pierce County or Washington State Noxious or Obnoxious weed list																

Table 1 Continued
Quantitative Vegetation Monitoring Results

Transect:	Upper Salt Marsh Transect										Year 5 Avg Cover/ Frequency %													
	Quadrat #	U-1	U-2	U-3	U-4	U-5	U-6	U-7	U-8	U-9		U-10												
Native Species	Daubenmire Midpoints																							
<i>Scientific name</i>	<i>Common name</i>																							
<i>Deschampsia cespitosa</i> ssp. beringensis	5-15	0	25-50	50-75	5-15	25-50	0	0	0-5	0-5	0-5	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	20%	
<i>Distichlis spicata</i> var. <i>spicata</i>	50-75	5-15	0-5	0	0	0	0	25-50	50-75	50-75	0	65.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5	70%
<i>Equisetum arvense</i>	0	0-5	0	0	0	0	0	0	0	0	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60%	
<i>Plantago maritima</i> ssp. juncooides	0	0	0	0	0-5	0-5	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Salicornia virginica</i>	0	0	0	0	5-15	0	0	0	0-5	50-75	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30%	
<i>Triglochin maritimum</i>	0	0	0	0	0	0	0	0	0	0-5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Spergularia macrotheca</i>	0	0	0	0	0-5	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Atriplex patula</i>	0	0	0	0	0	0	0-5	0	0-5	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20%	
<i>Fragaria chiloensis</i>	0	0	0	0-5	0	0-5	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20%	
<i>Salix sitchensis</i>	0-5	0-5	0	5-15	0	0-5	25-50	5-15	25-50	75-95	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80%	
<i>Populus balsamifera</i> ssp. trichocarpa	0	0	0	0	0	0	0	0-5	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Fraxinus latifolia</i>	0	0	0	0	0	0	0	0	0	0-5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Alnus rubra</i>	0	0-5	0	0-5	0	5-15	15-25	0	5-15	15-25	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60%	
<i>Anaphalis margaritacea</i>	0	0	0	0	0	0	0-5	0	0-5	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
Total Native Vegetative cover												80.0	20.0	37.5	82.5	30.0	55.0	60.5	50.0	120.0	243.0		77.9	
Non-native species	Daubenmire Midpoints																							
<i>Scientific name</i>	<i>Common name</i>																							
<i>Senecio</i> sp.	0	0	0	0-5	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Medicago lupulina</i>	0	0	0	0	0	0-5	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Epilobium watsonii</i>	0	0	0	0-5	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Hypochaeris radicata</i>	0	0-5	0	0	0	0	0	0	0	0	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Plantago lanceolata</i>	0-5	5-15	25-50	5-15	0-5	0-5	0-5	5-15	0	0	0	2.5	12.5	35.0	12.5	2.5	2.5	2.5	12.5	0.0	0.0	0.0	8.3	60%
<i>Juncus effusus</i>	0-5	0	0-5	0	0	0	0	0	0-5	5-15	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40%	
<i>Phalaris arundinacea</i>	0	0-5	0	0-5	0	0	0	0	0-5	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Lupinus arcticus</i>	0	0	0	0	0	0	0	0-5	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Rumex crispus</i>	0	0	0	0-5	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
<i>Vicia villosa</i>	0	5-15	0	0	0	0	0	5-15	0	0	0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20%	
<i>Rubus discolor</i>	0	0	0	0	0	0	0	0-5	0	0-5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20%	
<i>Trifolium repens</i>	0	0	15-25	5-15	0-5	0-5	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40%	
<i>Trifolium dubium</i>	0	0-5	0	0	0	0	0	15-25	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20%	
<i>Grass</i>	0-5	75-95	75-95	25-50	0-5	0-5	0-5	25-50	0	0	0	2.5	85.0	85.0	35.0	2.5	2.5	2.5	35.0	0.0	0.0	0.0	25.0	80%
<i>Unknown 1</i>	0	0-5	0	0	0	0	0	0	0	0	0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10%	
Total Vegetative cover												85.0	142.5	178.0	155.0	37.5	65.0	65.5	135.5	122.5	260.5		124.7	
Other												2.5	2.5	0.0	2.5	65.0	35.0	85.0	0.0	0.0	0.0	0.0	21.3	
Bare substrate																								

Bold - Indicates plants that were planted as per the planting plan on May 26, 2001
Underline - Indicates plants that are on the Pierce County or Washington State Noxious or Obnoxious weed list

Table 3. Sediment Stake Readings for Year 5

Sediment Stake ID	Year 0 Installation	Year 1 2001**	Year 2 2002	Year 5 2005	Year 2-5 Net change (x)	Average Change (x/3)
705	60	61	60.2	59.4	-0.8	-0.27
706	50	50	50.5	49.5	-1.0	-0.33
*712	50	50	50.1	48	-2.1	-0.70
713	61	61	60.8	60	-0.8	-0.27
715	51	52	50.8	50	-0.8	-0.27
716	51	52	51.6	51.2	-0.4	-0.13
719	50	51	49.3	47.3	-2.0	-0.67
720	50	49	48.6	46.4	-2.2	-0.73

*The top most metal portion of the stake has begun to corrode due to the saline environment.

** Average of quarterly readings for year

Readings are in centimeters from the top of the stake to the sediment surface.

Positive net change means the sediment surface is getting further from the top of the stake = erosion.

Negative net change means the sediment surface is getting closer to the top of the stake = accretion.

Appendix A:

**Middle Waterway Monitoring Photos
5 year summary**

Middle Waterway Restoration Project
Photo Point R1





Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: R1



Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: R1



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: R1



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: R1

Middle Waterway Restoration Project
Photo Point R2

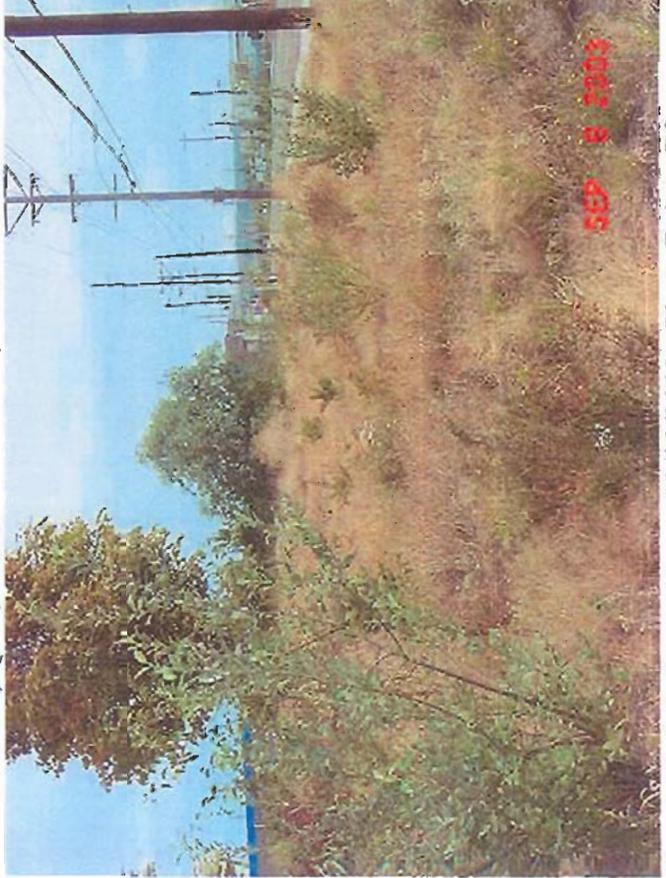




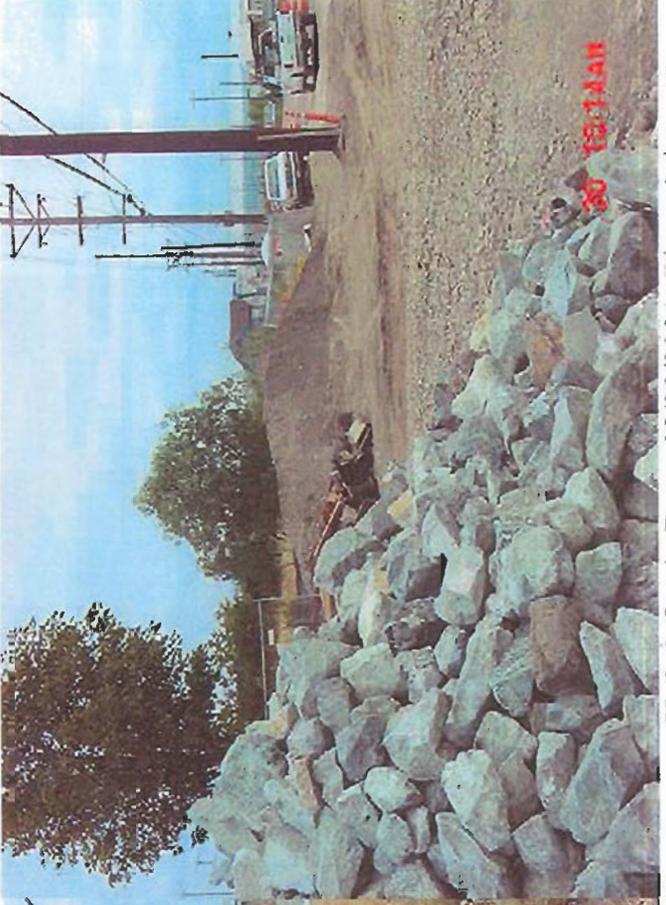
Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: R2



Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: R2



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: R2



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: R2

Middle Waterway Restoration Project
Photo Point R3





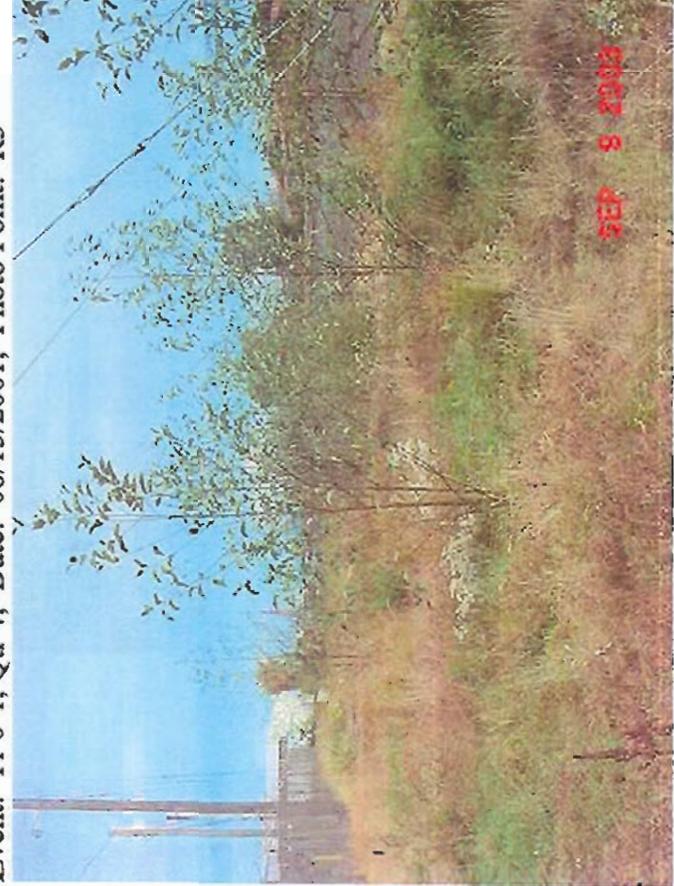
2001 8 15

Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: R3



2002 8 20

Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: R3



SEP 9 2003

Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: R3



2004 8 30

Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: R3

Middle Waterway Restoration Project
Photo Point R4





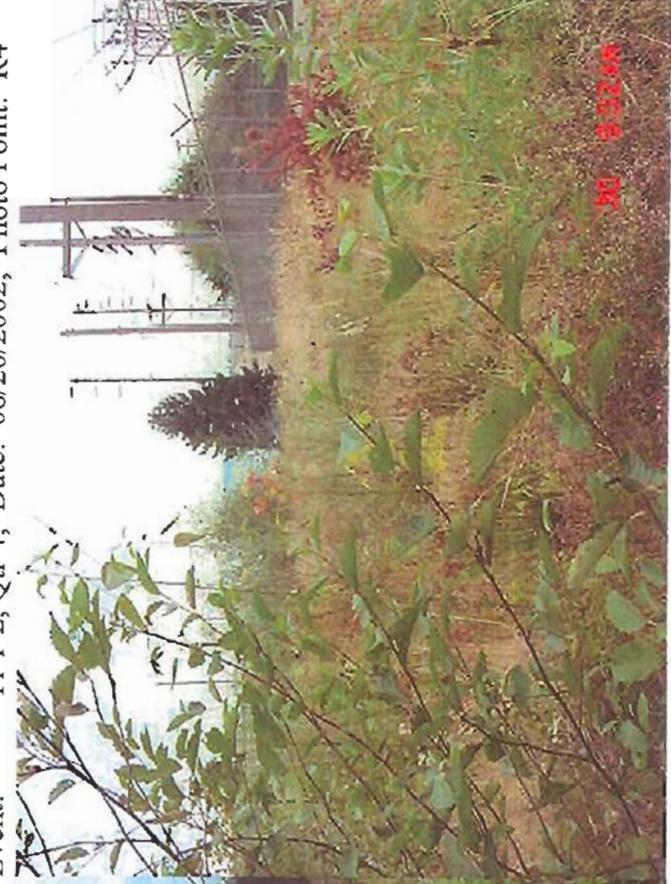
2001 8 15

Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: R4



2002 8 20

Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: R4



SEP 9 2003

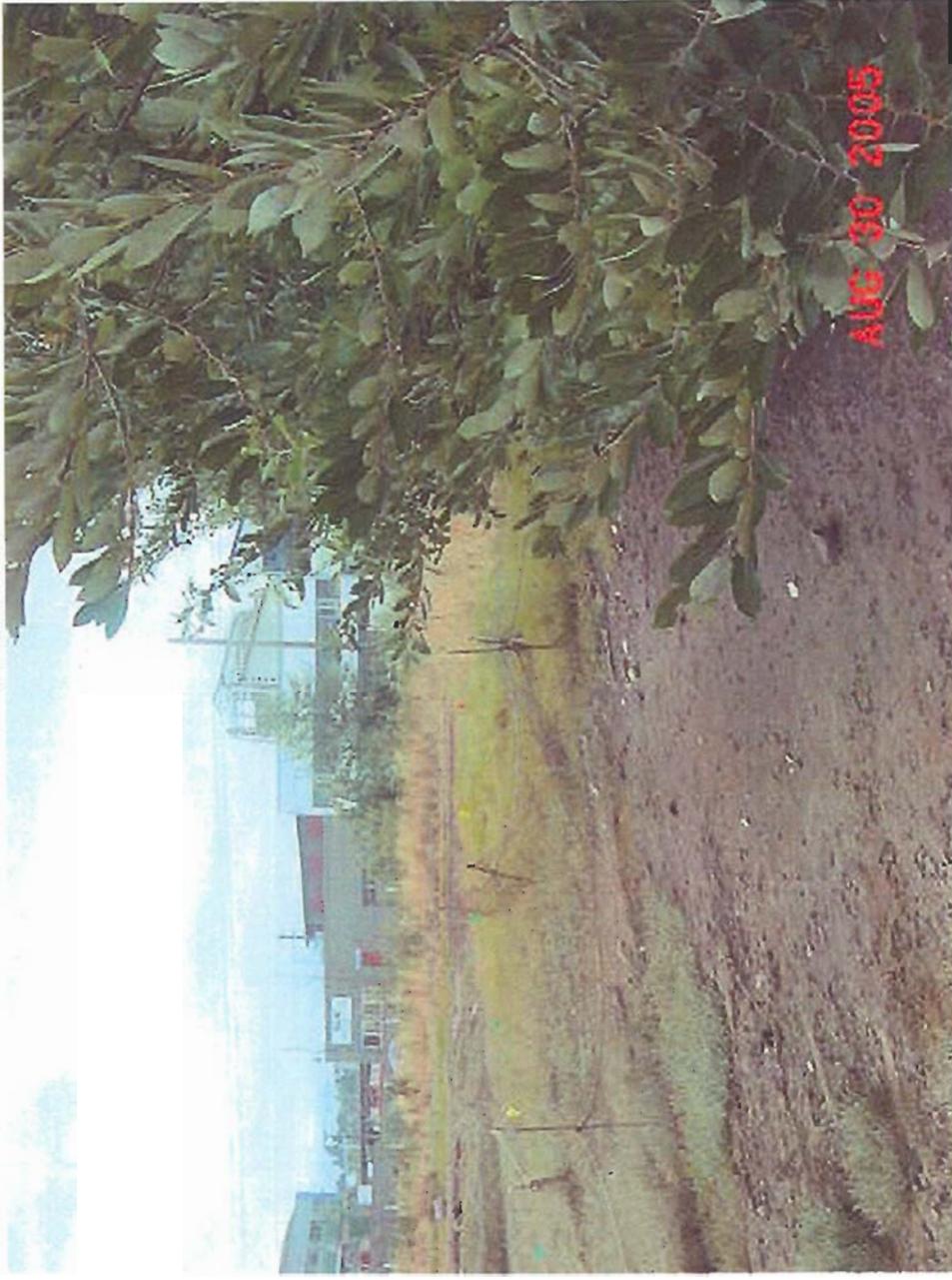
Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: R4



NOV 9 2004

Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: R4

Middle Waterway Restoration Project
Photo Point UMI

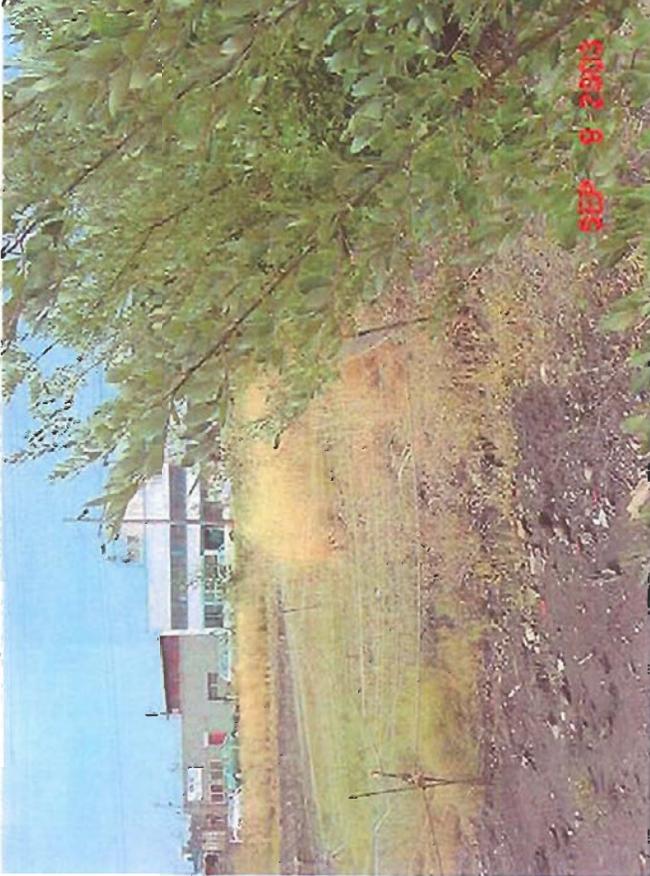




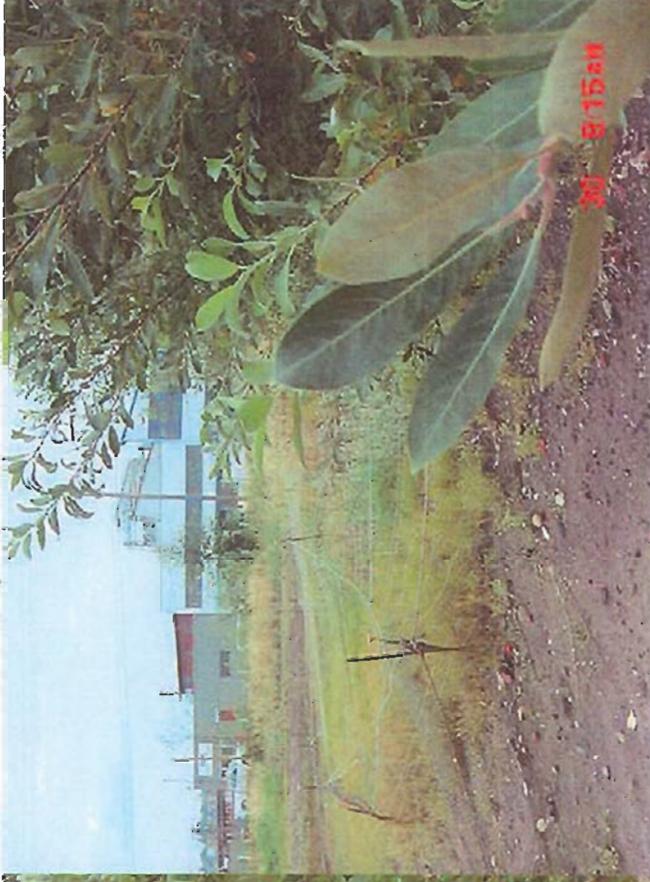
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Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UMI



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UMI



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UMI

Middle Waterway Restoration Project
Photo Point UM2





Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: UM2

2001 08 15



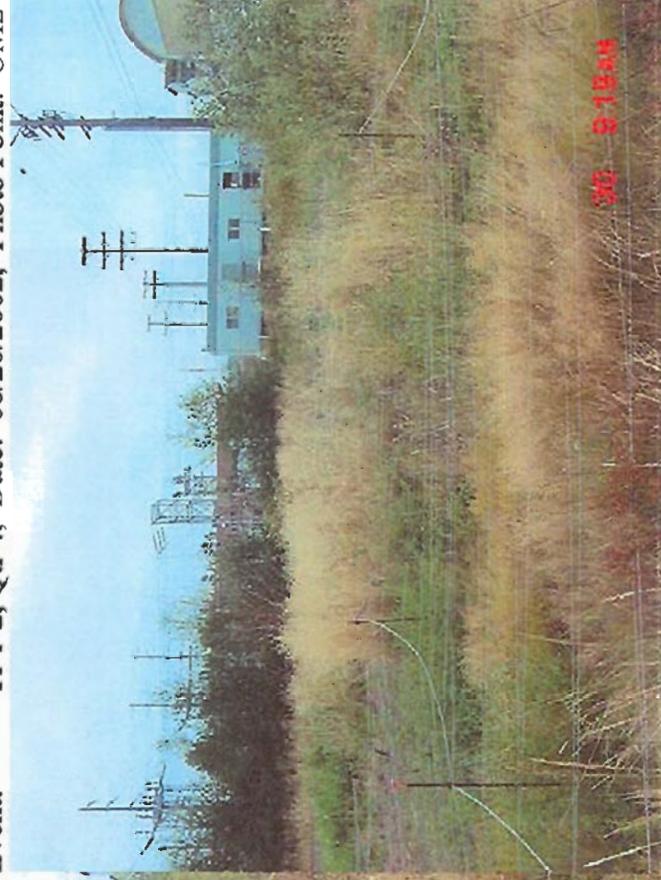
Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UM2

2002 08 20



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UM2

SEP 9 2003



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UM2

2004 08 30

Middle Waterway Restoration Project
Photo Point UM3A

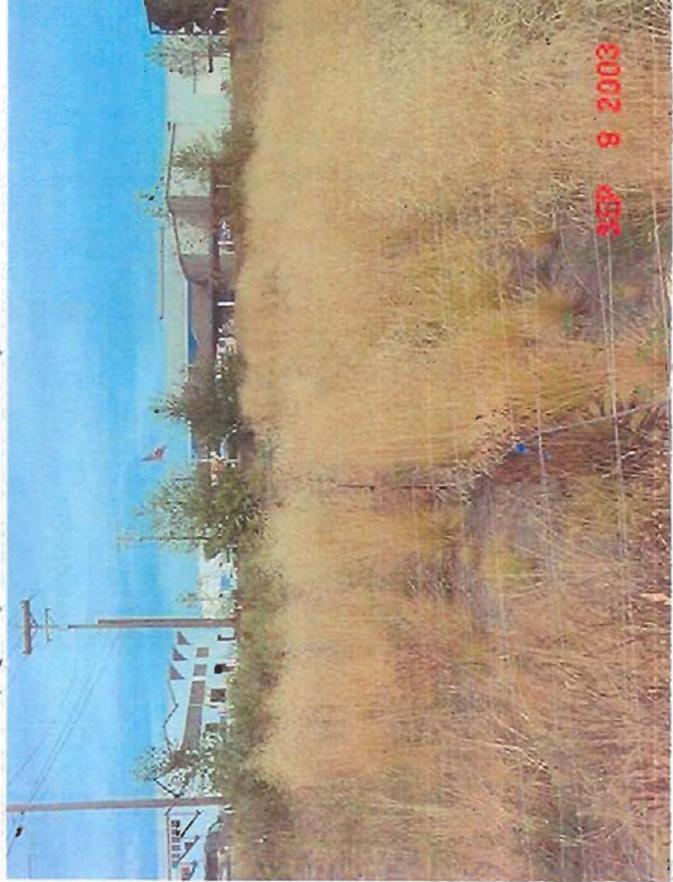




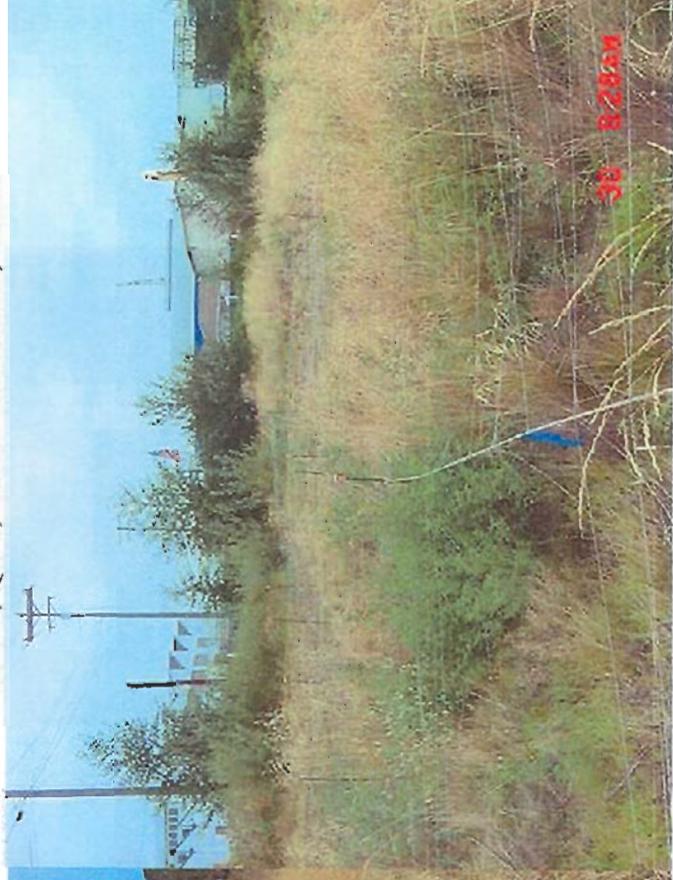
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Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UM3A



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UM3A



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UM3A

Middle Waterway Restoration Project
Photo Point UM3B





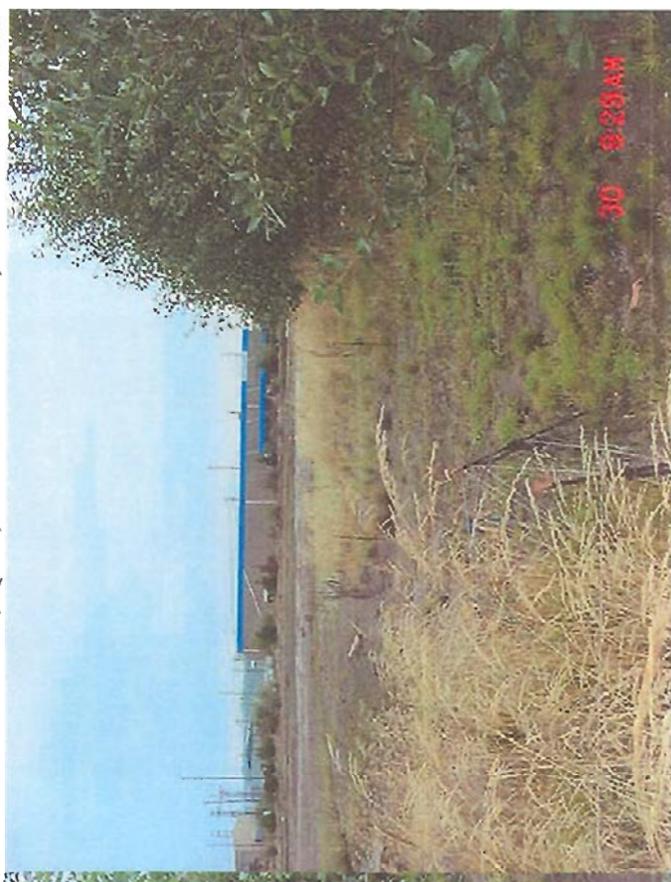
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Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UM3B



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UM3B



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UM3B

Middle Waterway Restoration Project
Photo Point UM4

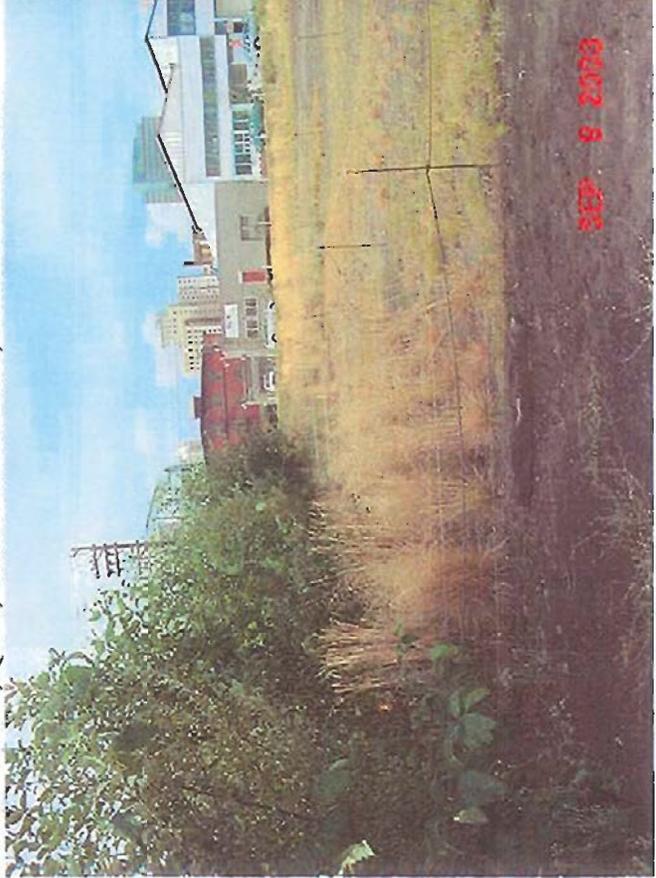




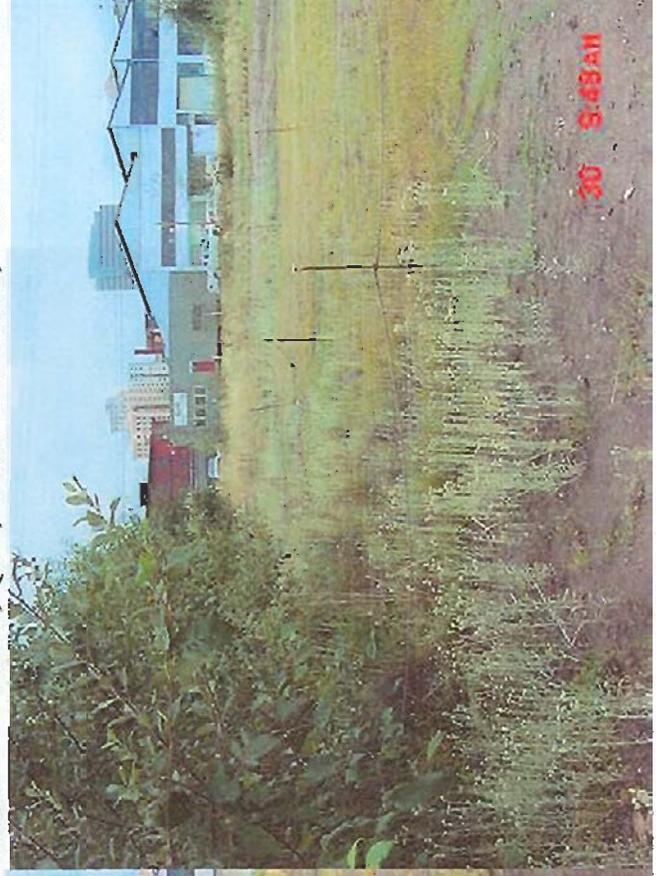
Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: UM4



Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UM4



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UM4



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UM4

Middle Waterway Restoration Project
Photo Point UM5





Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: UM5



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: UM5



Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: UM5



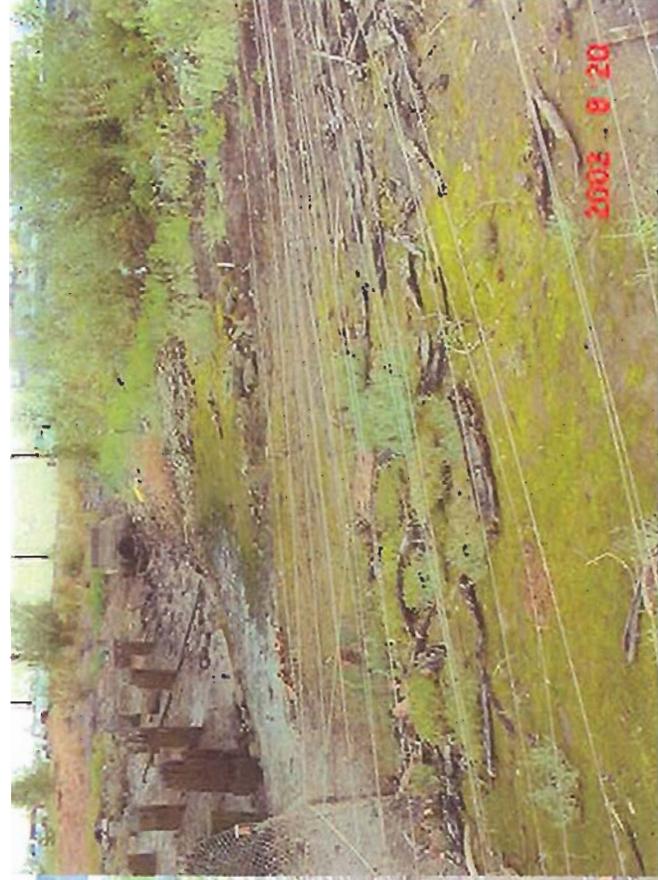
Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: UM5

Middle Waterway Restoration Project
Photo Point LMIA





Event: Yr 1, Qtr 4; Date: 08/15/2001; Photo Point: LM1A



Event: Yr 2, Qtr 4; Date: 03/29/2001; Photo Point: LM1A



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: LM1A



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: LM1A

Middle Waterway Restoration Project
Photo Point LM1B





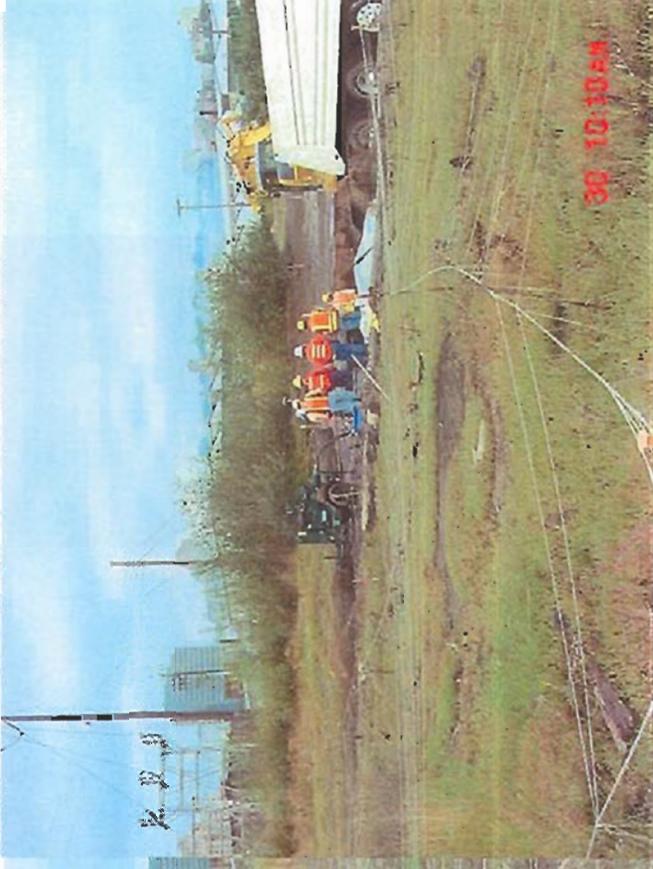
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Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: LM1B

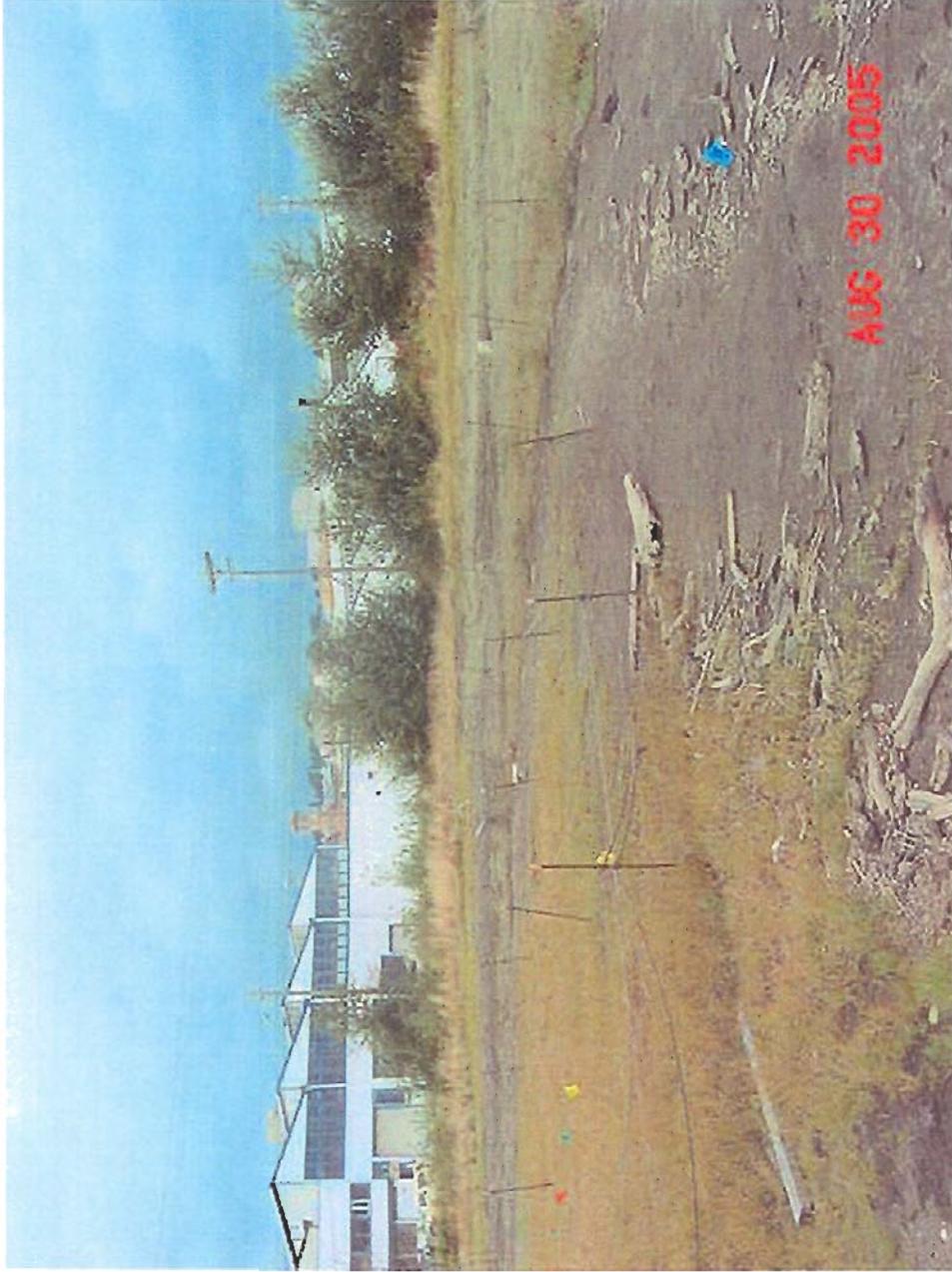


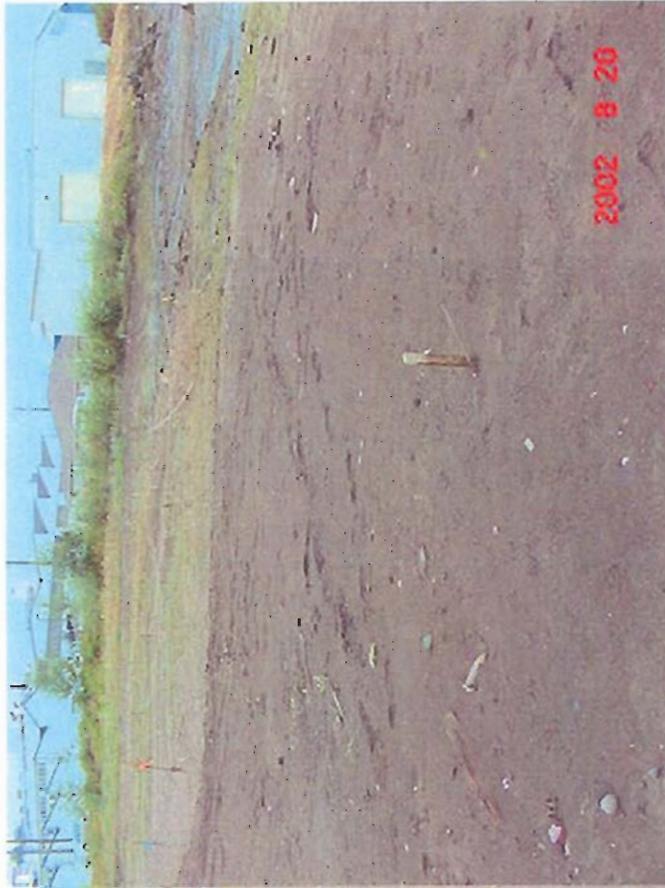
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Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: LM1B

Middle Waterway Restoration Project
Photo Point LM2A





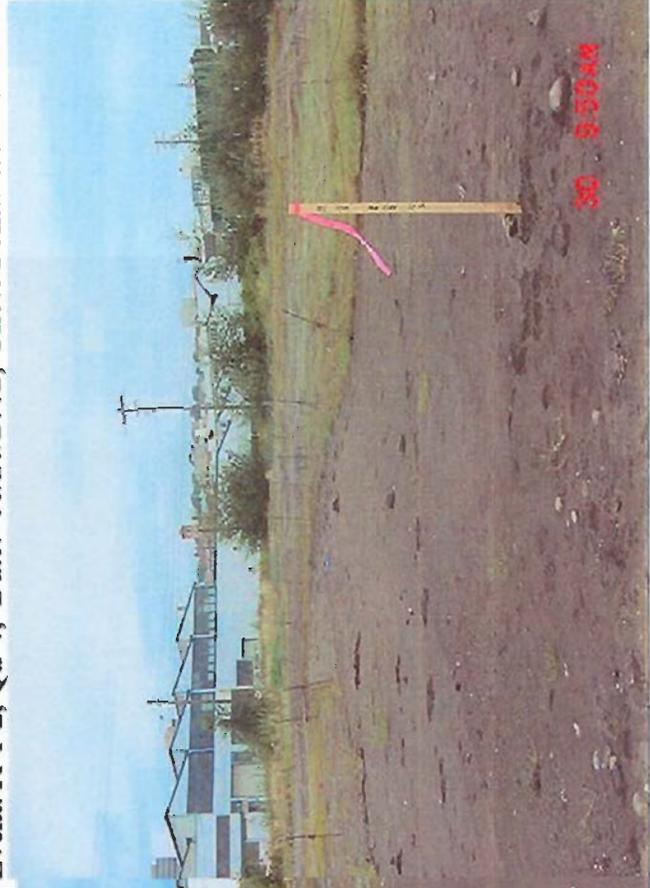
2002 8 20

Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: LM2A



2001 9 15

Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: LM2A



30 9 30 2004

Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: LM2A



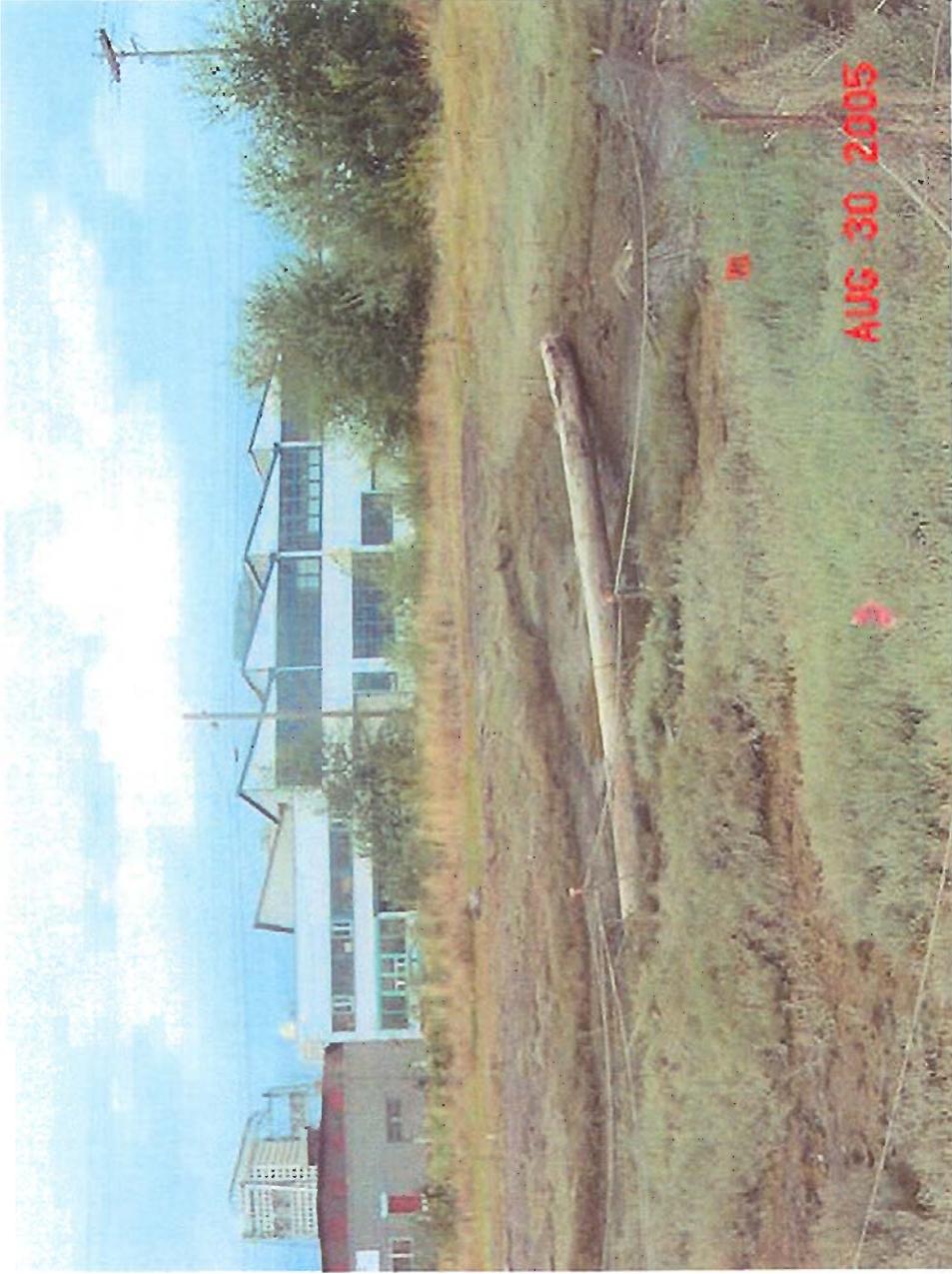
SEP 9 2003

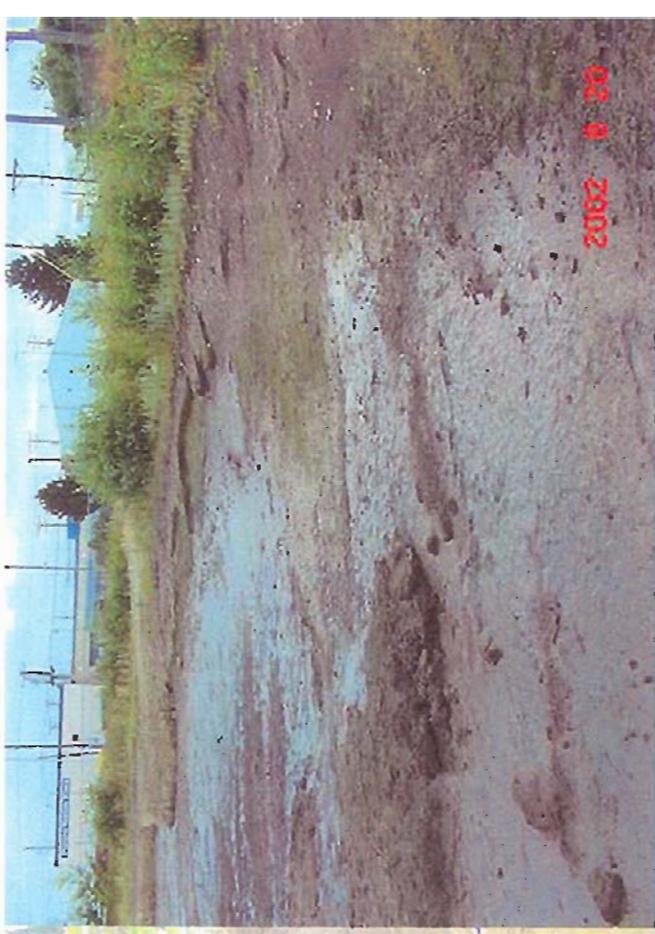
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Middle Waterway Restoration Project
Photo Point LM2B



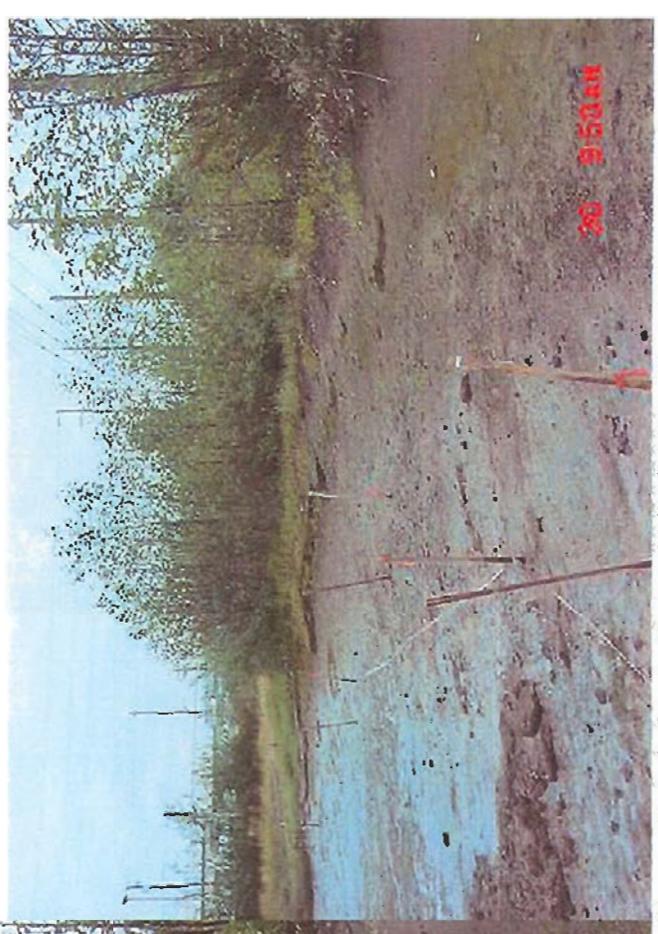
Middle Waterway Restoration Project
Photo Point LM3A





2002 08 20

Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: LM2B



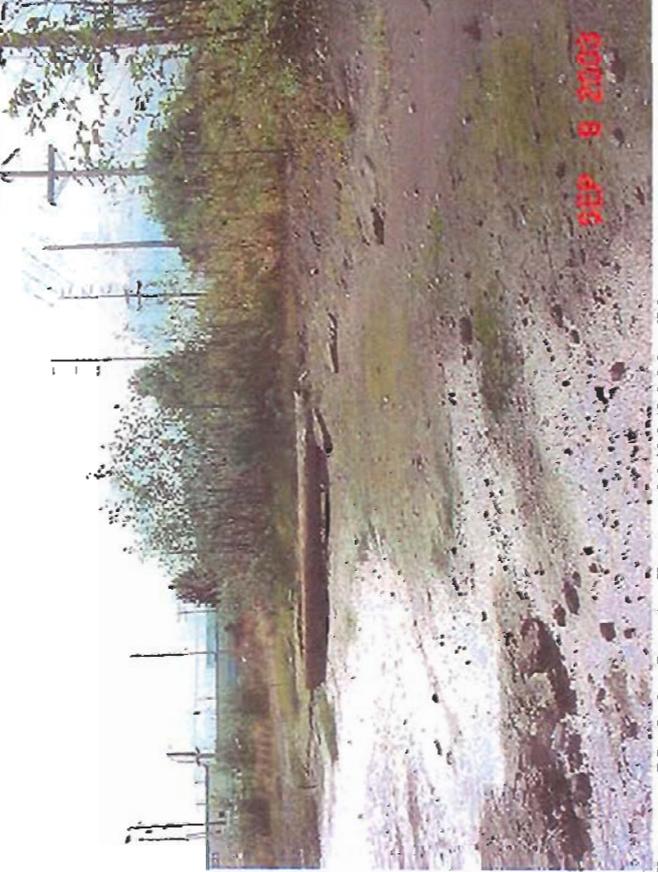
2004 08 30

Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: LM2B



2001 08 15

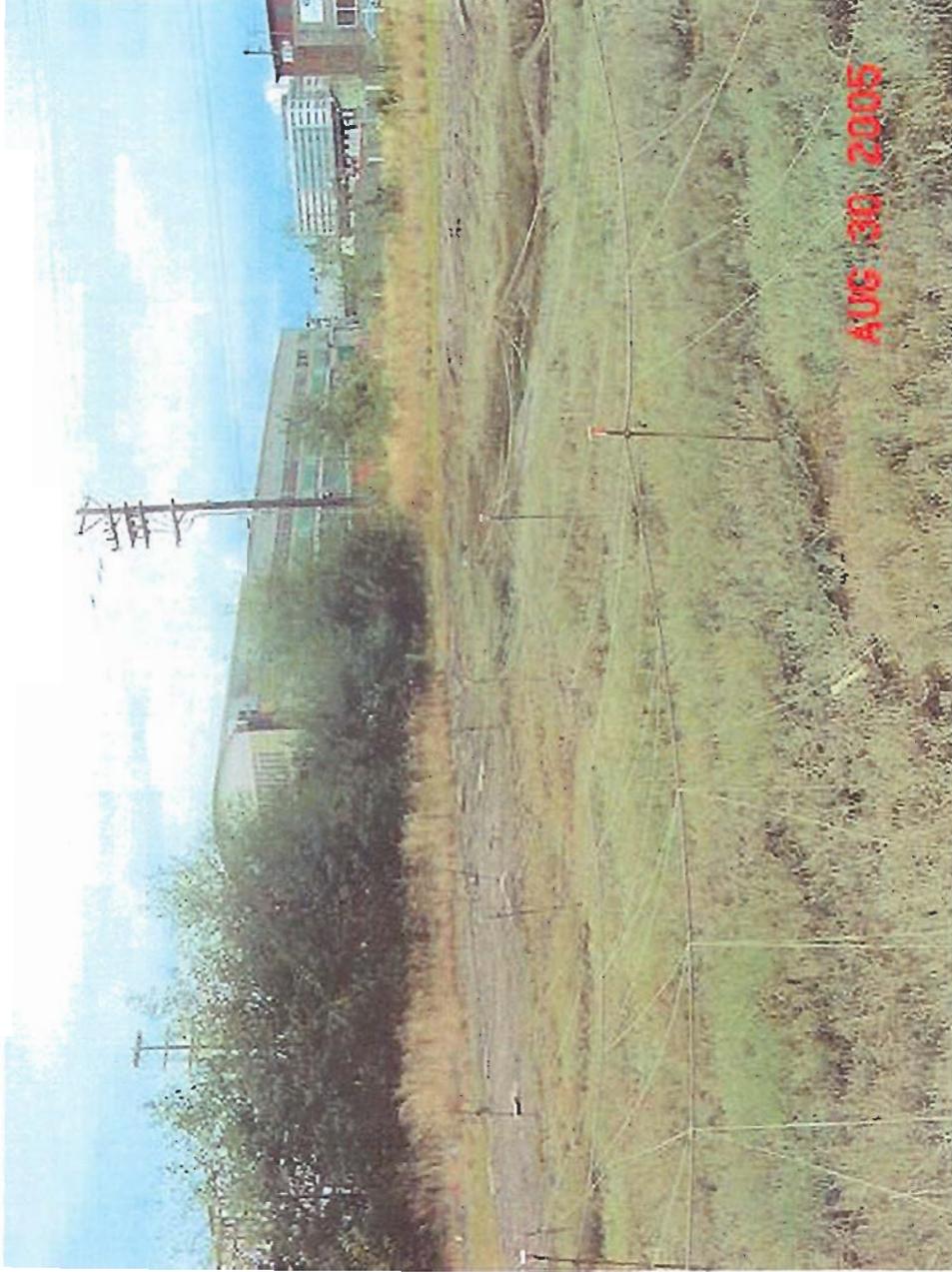
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2003 09 09

Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: LM2B

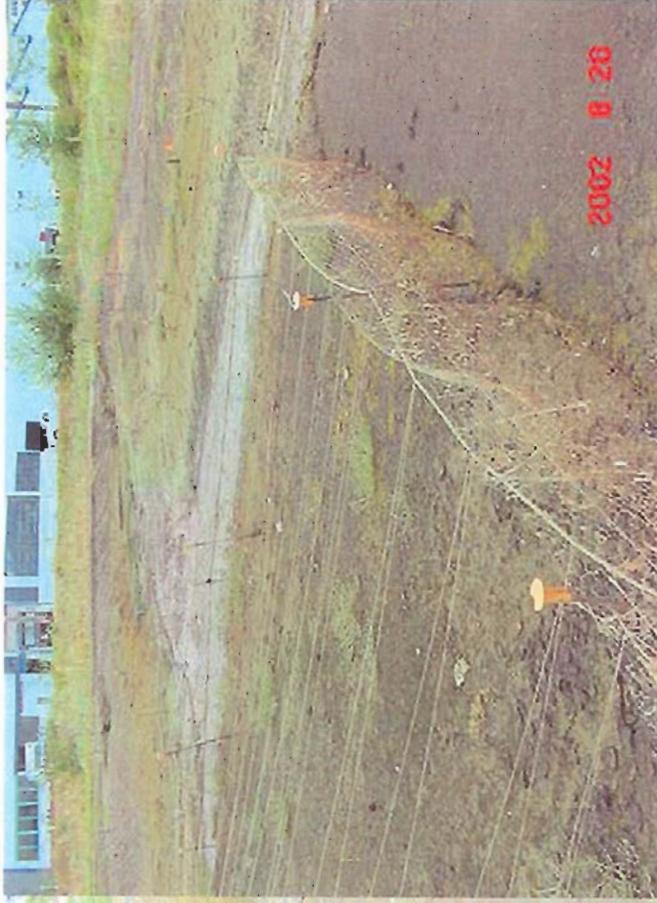
Middle Waterway Restoration Project
Photo Point LM3B





2001 8 15

Event: Yr 0-1, Qtr 4; Date: 08/15/2001; Photo Point: LM3A



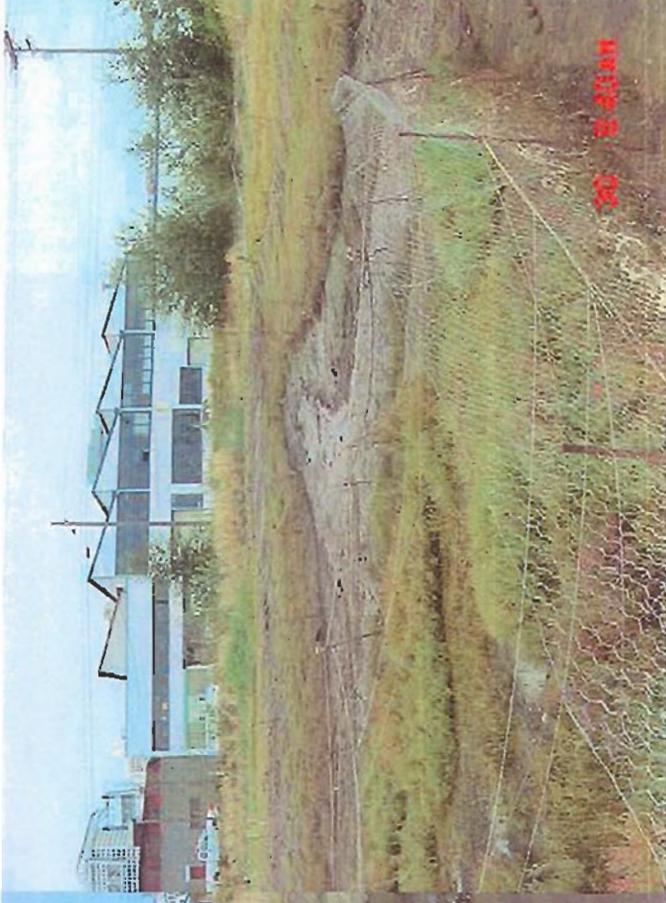
2002 8 20

Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: LM3A



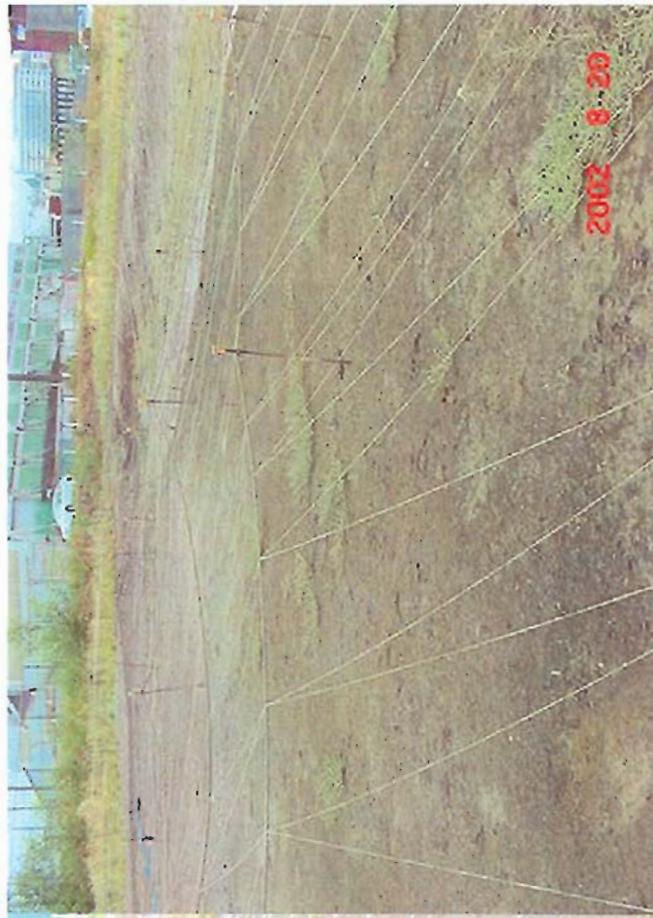
2003 8 2003

Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: LM3A

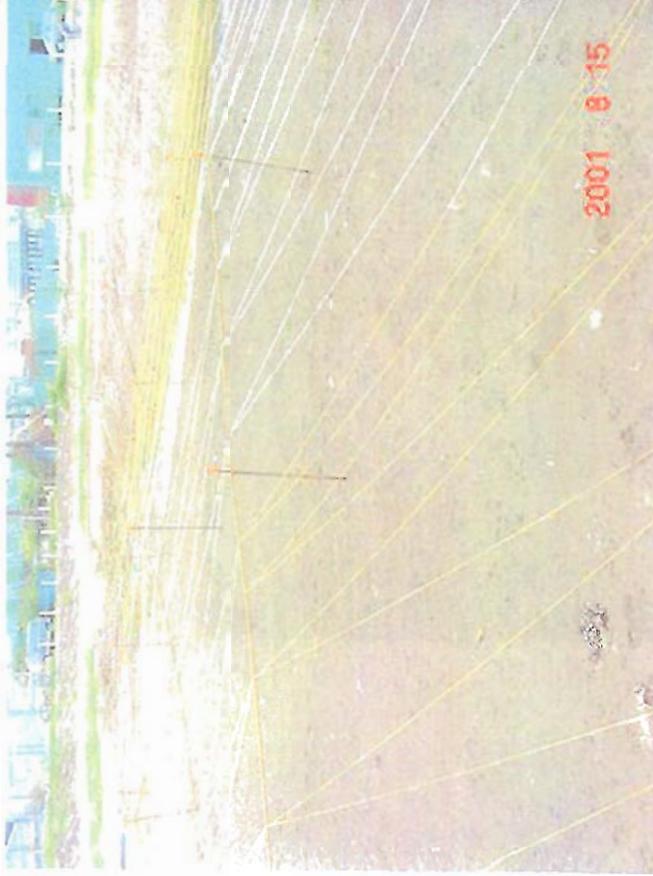


2004 8 2004

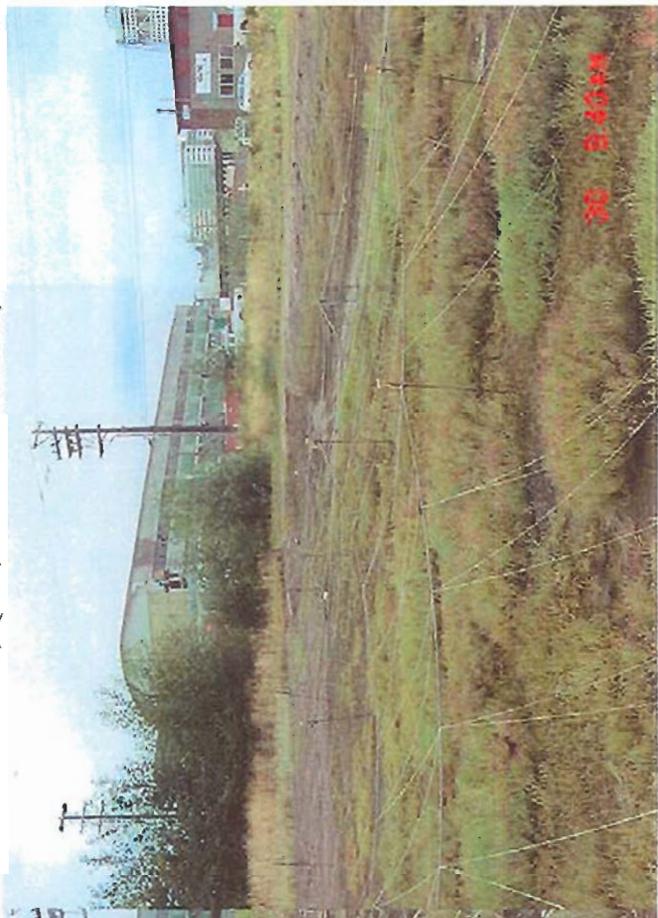
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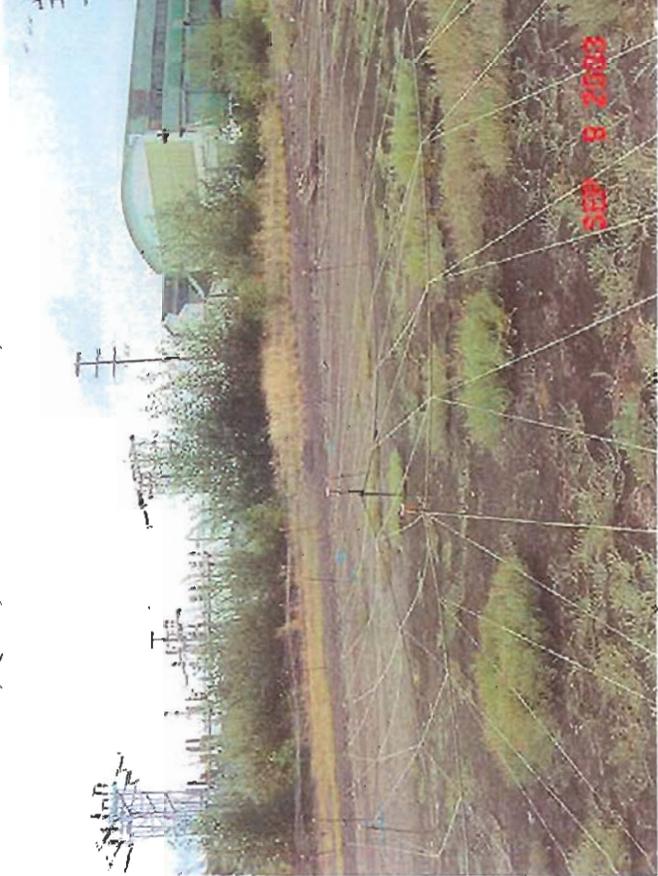
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Event: Yr 1-2, Qtr 4; Date: 08/20/2002; Photo Point: LM3B



Event: Yr 2-3, Qtr 4; Date: 09/09/2003; Photo Point: LM3B



Event: Yr 3-4, Qtr 4; Date: 08/30/2004; Photo Point: LM3B

Appendix B:
Additional Photos 1-2

Photo 2
Small woody debris accumulation near Photo point LMI



Photo 1
Pipeline, Pipeline stockpile, and new curb near Photo point R2



Appendix C:

**A Study of Intertidal-Wetland Restoration in Puget Sound
Summary**

A STUDY OF INTERTIDAL-WETLAND RESTORATION IN PUGET SOUND

Principle Investigator: Dr. Kern Ewing
Center for Urban Horticulture, University of Washington
kern@u.washington.edu, 206-543-4426

Research Study Coordinator: Ms. Jeanne Hughes
3825 Interlake Avenue North, Seattle
jeanne.hughes@speakeasy.net, 206-547-2087

With funding from the National Oceanic and Atmospheric Administration provided by the Washington State Sea Grant Program, we are undertaking a study of intertidal wetland restoration in Puget Sound. This project includes the following facets:

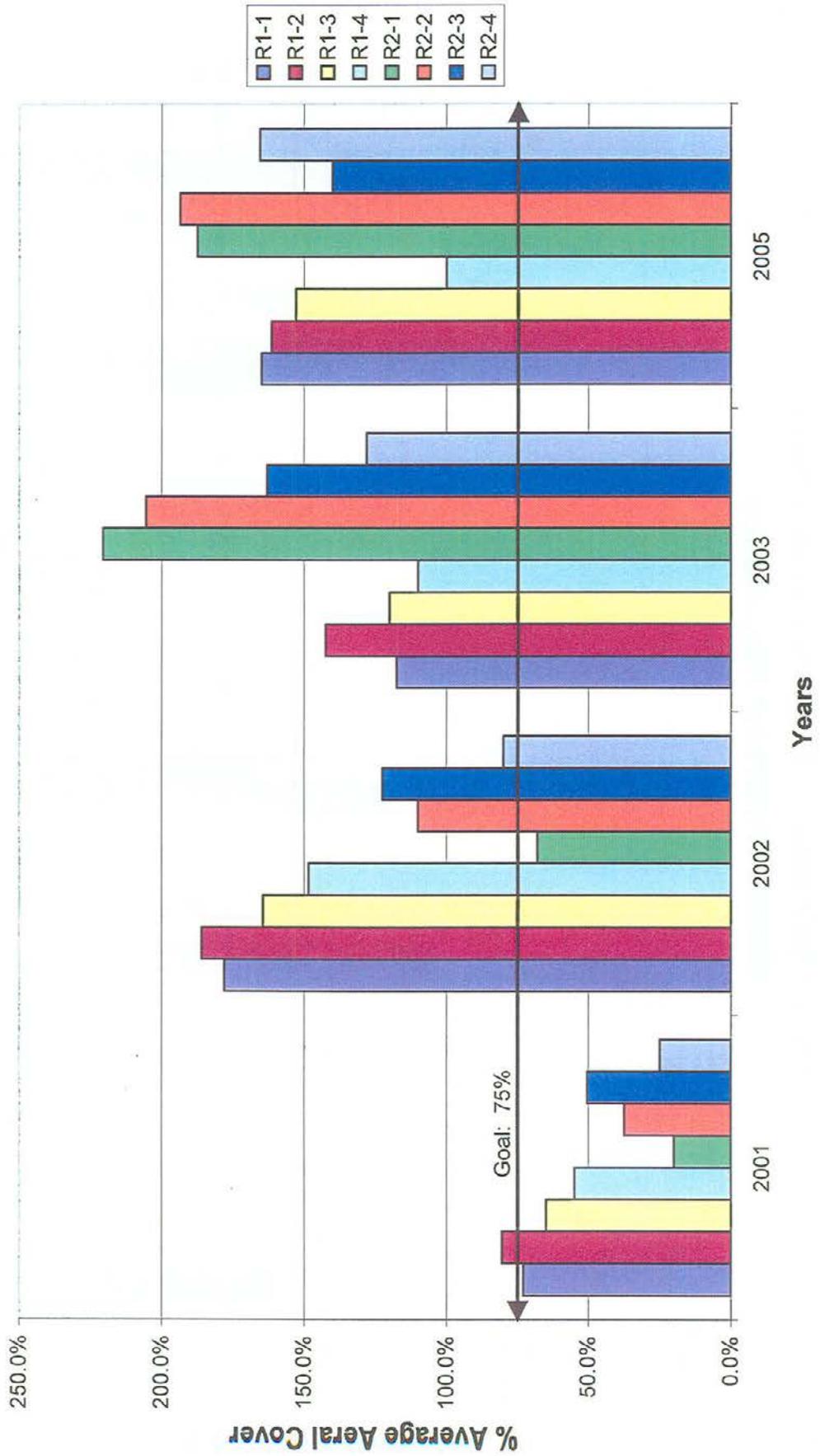
- 1) A literature review of publications relevant to the autecology and synecology of intertidal plant species, cultivation and propagation of these species, and restoration. A complete reference list will be compiled in an electronic database and the most relevant publications will be annotated in a separate bibliography. Objectives of this technical review are to identify gaps in our knowledge of plant species distribution across environmental gradients, to identify possible propagation methods and planting procedures for species and plant communities, and evidence of factors affecting successful establishment of species.
- 2) An inventory of intertidal-marsh restoration sites in the Puget Sound where development of intertidal vegetation was a defined objective. Information collected includes the location, habitat type (i.e., salt, brackish, or freshwater intertidal marsh), date restoration efforts commenced, responsible party, restoration techniques used, monitoring protocols, and evidence of successes and failures.
- 3) A sampling design and methods plan. At chosen restoration sites, transects will be placed perpendicular to environmental gradients. Along these transects, plots will be used to assess vegetation cover and five environmental factors: salinity, surface elevation relative to tidal datum, sediment particle size, redox potential, and proportion of organic matter in sediments.
- 4) Statistical evaluation of environmental gradients relative to species success.
- 5) Recommendations for marsh restoration and monitoring.

The ultimate goal of the project is to create a central database for those who are interested in undertaking intertidal marsh restoration projects. We hope that the database will evolve as more of these projects are completed in Puget Sound.

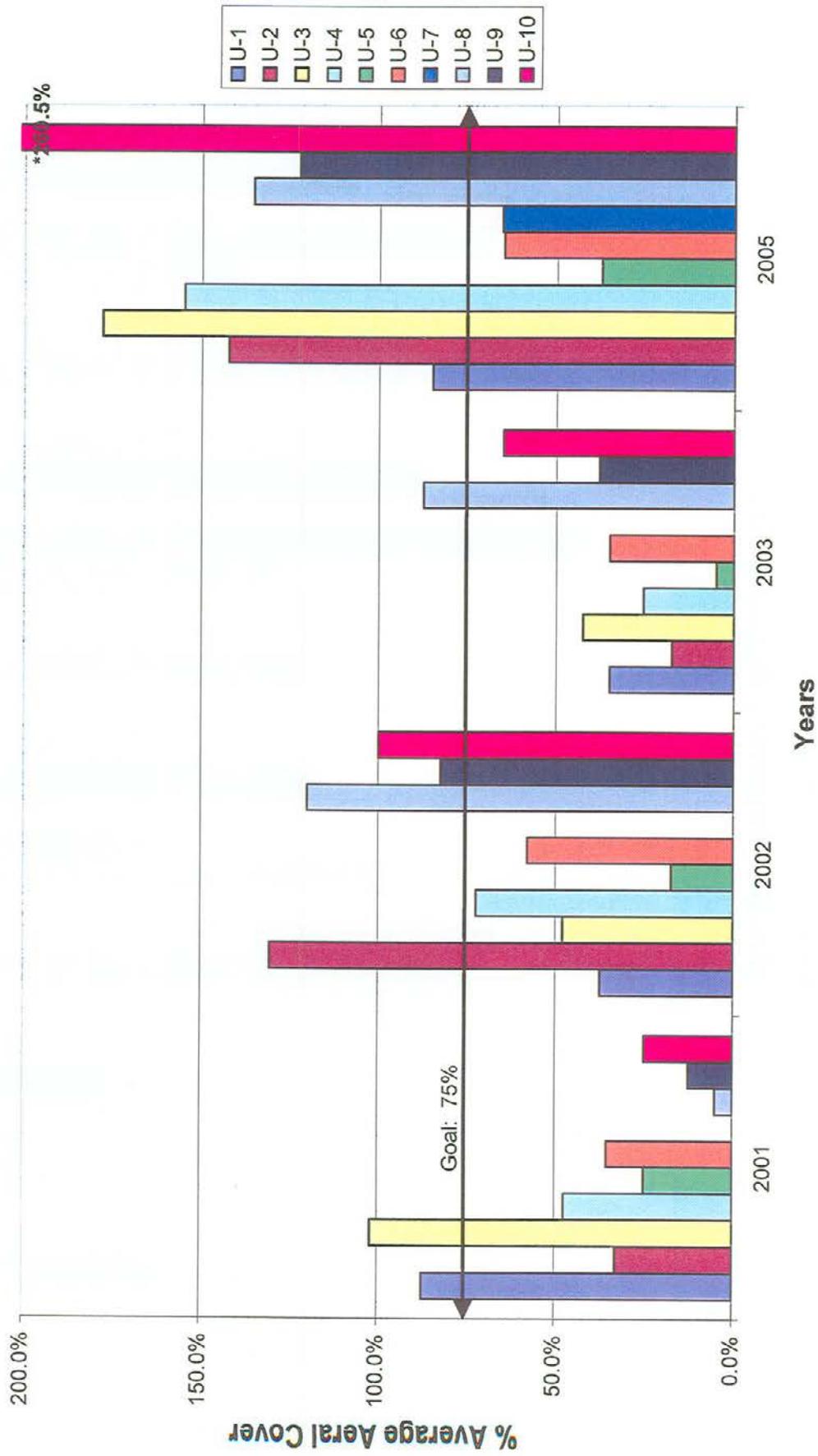
Appendix D:

**5 year look at Total Vegetative Cover and Total Native
Vegetative Cover by Habitat Area**

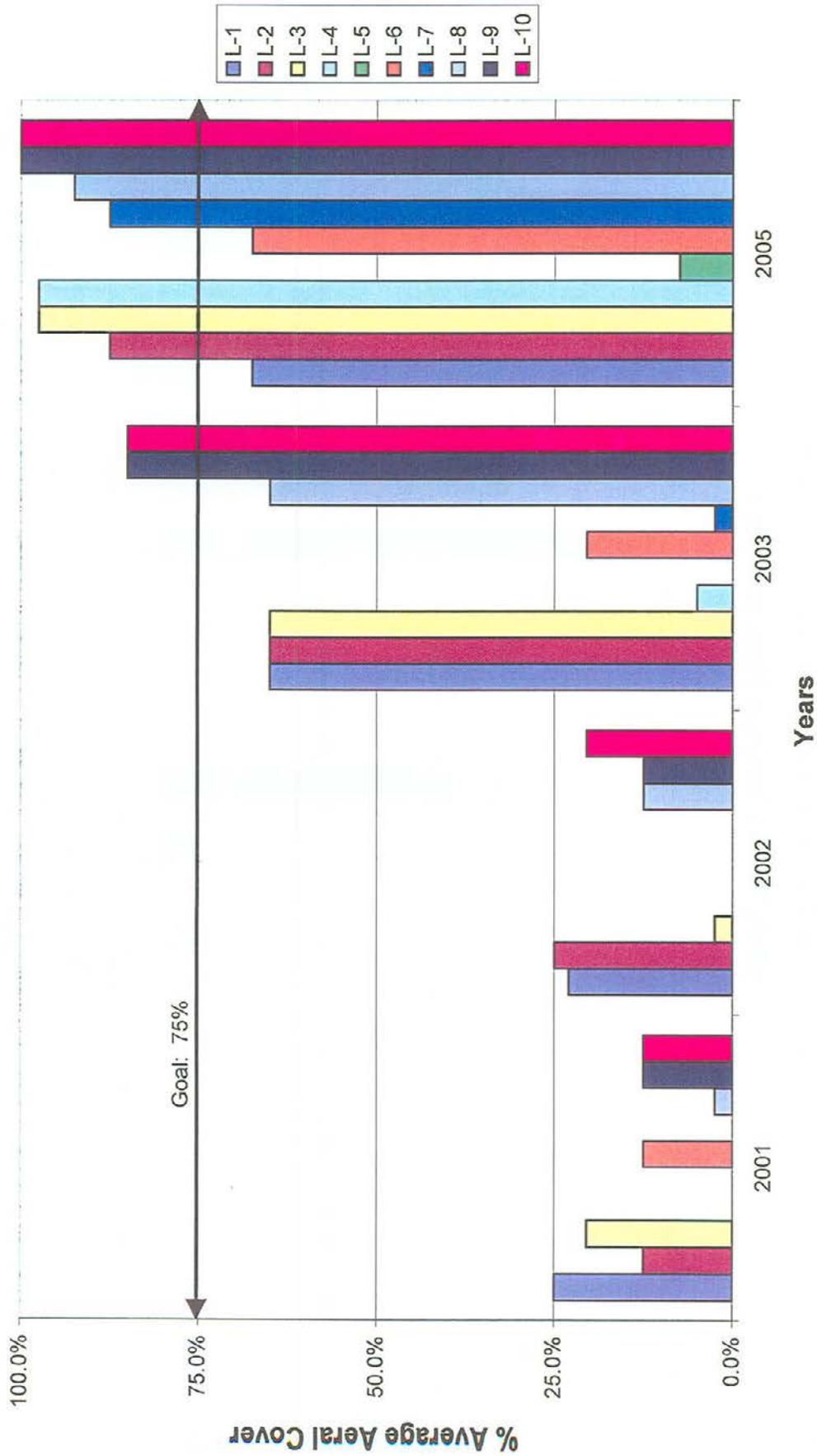
Riparian Area: Total Vegetative Cover Middle Waterway Restoration



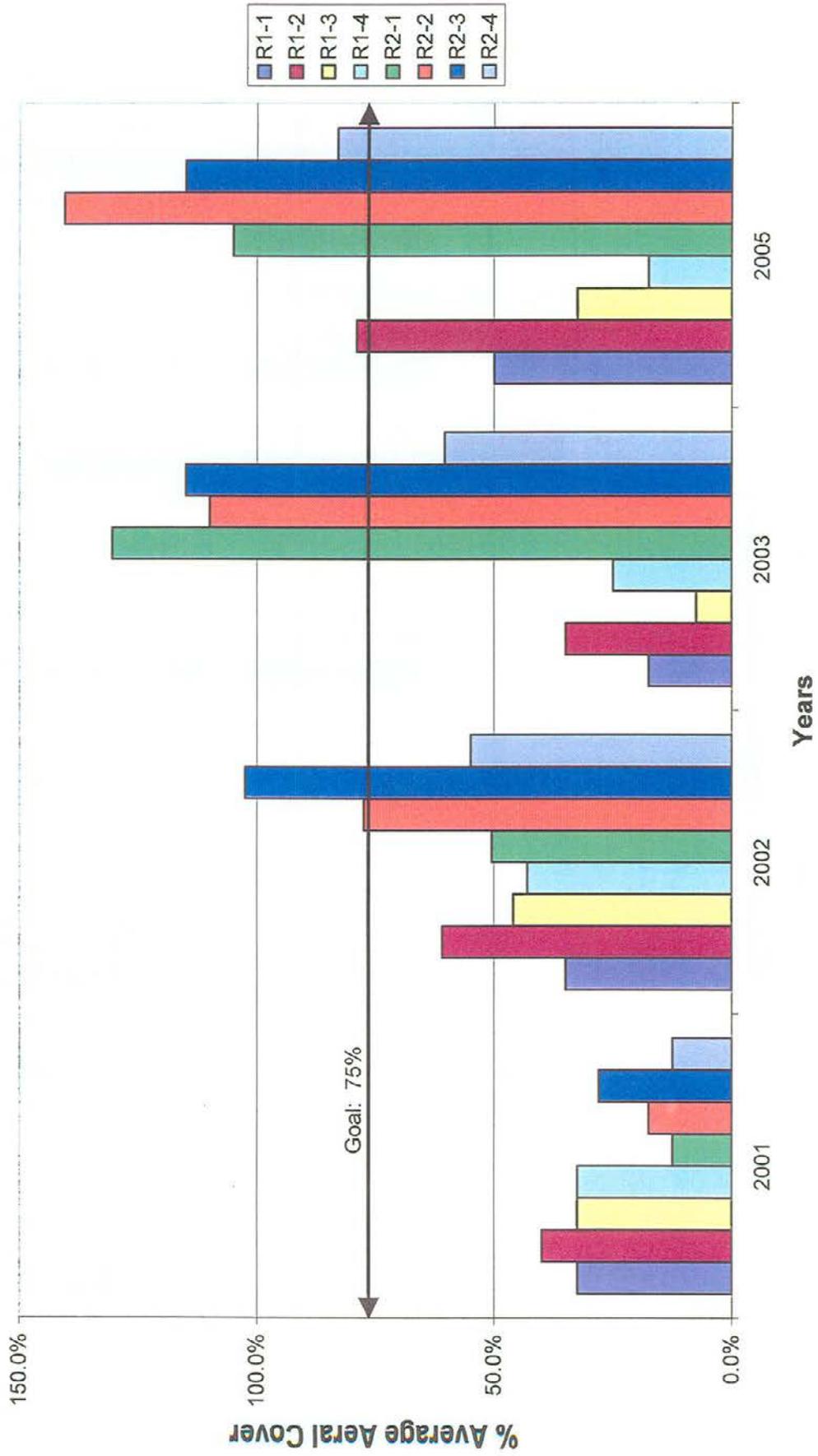
Upper Salt Marsh: Total Vegetative Cover Middle Waterway Restoration



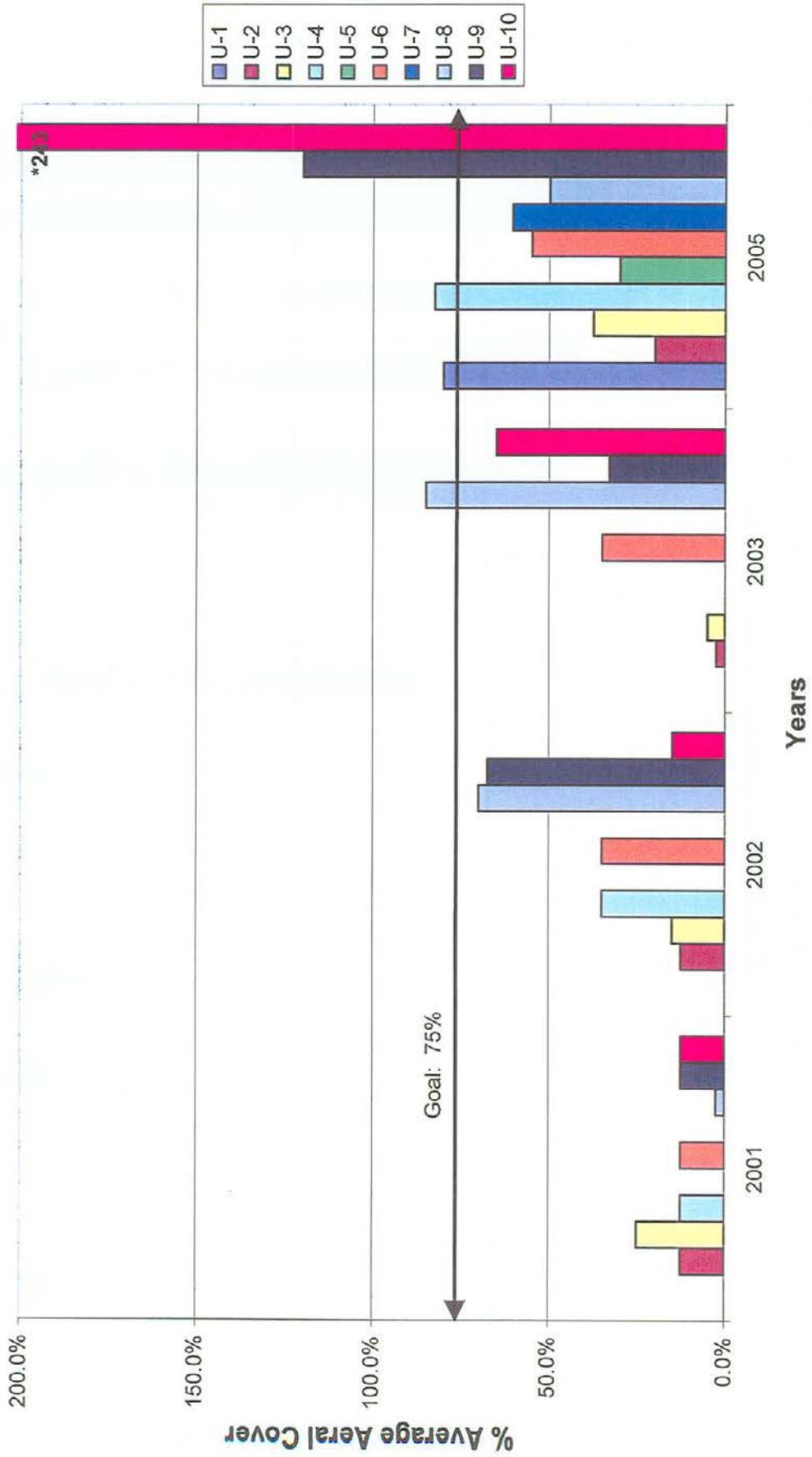
Lower Salt Marsh: Total Vegetative Cover Middle Waterway Restoration



Riparian Area: Total Native Vegetative Cover Middle Waterway Restoration



Upper Salt Marsh: Total Native Vegetative Cover Middle Waterway Restoration



*2/03