Final Report

DEMONSTRATION PROJECT: MITIGATION OF NON-POINT SOURCE IMPACT TO LITTORAL ZONE OF LAKE CARL BLACKWELL, PAYNE COUNTY, OKLAHOMA

FY-01 319(h) Task #01-003
CA # C9-996100-07 Project 3

FUNDED BY THE ENVIRONMENTAL PROTECTION AGENCY

Subtask 5.1.2 Bioengineering Demonstration
And
Subtask 5.1.3 Erosion Control Monitoring

September 2006

Final Report: Lake Carl Blackwell 319(h)FY- 01

Agency: Oklahoma Water Resources Board (OWRB)

Task: FY-01 319(h) Task #01-003 CA # C9-996100-07 Project 3 Subtasks 5.1.2 & 5.1.3

Project Location: Lake Carl Blackwell, WBID 620900040280, HUC11050003030

1.0 PROBLEM STATEMENT

This project is one element of a watershed-wide parent project, "The Stillwater Creek Watershed Implementation Project", designed to reduce non-point source pollution. The Stillwater Creek basin is listed on the 303(d) list for siltation, pesticides, suspended solids, nutrients, and unknown toxicity.

Lake Carl Blackwell (LCB) is listed as impaired on the State's 303(d) list (WBID 620900040280) for turbidity. The Oklahoma 319 Non-Point Source (NPS) Assessment report shows that there are no point source discharges in the watershed; thus all pollution problems originate from non-point sources. A low cost, low maintenance means to control the suspended solids within the lake is needed. Addressing LCB's shoreline erosion is one step towards remediation of the in-lake turbidity problem.

Suspended solids, whether washed in from the drainage basin or re-suspended in the reservoir, serve to prevent or eliminate the establishment of an aquatic plant community in the littoral zone. Littoral plants are essential to a healthy functioning reservoir ecosystem. Littoral aquatic plants divert nutrients from algae production by absorbing nutrients from the water column during the growing season and providing direct food and aquatic structural habitat for fish. The loss of an aquatic plant community also accelerates the physical process of shoreline erosion. Once physical processes such as shoreline erosion have begun in Oklahoma reservoirs it often takes human intervention to stabilize the shoreline long enough to establish the littoral zone as a functioning community. Bioengineering methods have been developed that halt the erosive processes long enough to allow for the establishment of a healthy aquatic plant community. This can result in low-cost long-term erosion control.

2.0 SUMMARY:

The long-term outlook for stabilizing 250 feet of the bank at Site 1 is good. While there was mortality among the live staking the surviving willows were well distributed along the length of the site. Provided the CGRs withstand the wave action, we are confident the plants will thrive and protect the bank.

The Coir Geotextile Rolls (CGR) with "live staking" was a very simple treatment that has a high probability of success. We strongly recommend future erosion control work at Site 1 and at numerous comparable sites around the lake. This single treatment type would result in a very dense stand of willow trees heavily armoring this eroding bank. This treatment should be complimented with the bottom tier planted with herbaceous aquatic plants. This methodology is excellent to use at sites with vertical banks and water levels on the bank high enough to wick into the CGRs loaded with herbaceous plants. The willow trees formed by "live staking" will create a dense thicket that is inappropriate where broad lake access or viewing is desired. There are many other possible configurations available for planting willow cuttings such as "wattles" and "brush mattressing" that could still be attempted on LCB.

Unprotected herbaceous plantings in the water were not found to be an option at LCB. Further work may be done using large pens or mud flats above the normal water line.

Breakwaters using cedar trees or CGRs were found to be ineffective and will not be used in the future by OWRB.

Lake levels were a prominent issue in regard to plant survival in this project. Water levels stayed unusually high during the implementation phase. The normal pool elevation regimen at Carl Blackwell is two to three feet drop in August to September. This normal dropping pool was key to success at the sites; plants could establish and spread in the shoreline mud lakeward of the escarpment during this drawdown period relatively safe from herbivory. An unusually wet August left the lake full to the spillway throughout the remaining growing season. This left the plants exposed to waves and aquatic herbivory resulting in very significant losses to the plantings. Projects involving aquatic plants will always have to contend with weather conditions and water levels. It is crucial for a project to have several seasons for planting to increase the chance for suitable conditions for establishment.

This grant has been a successful outreach tool by being the originator of future erosion control work on the lake. An excellent partnership was established by this grant between the Oklahoma Water Resources Board (OWRB) and Oklahoma State University (OSU), in particular the Lake Carl Blackwell staff. The assistance and involvement of OSU was exemplary. Not only did OSU donate staff time and heavy equipment towards this project, they became interested in the concept of bioengineered shoreline management. OSU of its own accord instigated further bulrush plantings in the lake and is currently partnering with OWRB in seeking state funding to continue the erosion control efforts begun through this EPA Region VI grant.

3.0 MEASURE OF SUCCESS:

The Measure of Success as defined in the Project QAPP is as follows:

"A7.5. Decision Rule

If the breakwater and other controls are intact and functioning as intended (with a positive accumulation of sediment) and plants are showing positive growth trends, treatment will be considered successful at that time and recommended for future observation."

3.1 Breakwaters:

Tiered Fiber Rolls (CGR): While the CGRs proved to be impractical as a breakwater they undoubtedly protect the black willows and waterwillows they maintain while giving immediate fortification to the escarpment from further erosion. The CGRs also caught and maintained upland or bank erosion at the site. We consider this treatment successful and recommend future observation at the least. It would be best to finish out the site with additional CGRs and one more round of black willow planting.

Cedar tree breakwater at Site 1: did not significantly reduce erosion (0.97" avg. sediment loss) or protect the plants behind it. We would not recommend this treatment without sufficient heavy equipment such as mechanical tree shears to cut and transport very large trees.

Cedar tree breakwater at Site 2: may have reduced erosion (0.39" avg. accretion). It did not adequately protect the plants behind it. We would not recommend this treatment without sufficient heavy equipment such as mechanical tree shears to cut and transport very large trees.

3.2 Survival and growth of planted vegetation:

Tiered Fiber Rolls (CGR) with Live Staking: Plants planted in and behind the CGRs are showing a positive growth trend. The willow "live stakes" have excellent potential in the long term to heal the points of the site where they have survived. The treatment is fast and easy with a respectable survival percentage. We consider this treatment successful and recommend future observation at a minimum. It would be best to finish out the site with additional CGRs and one more round of live staking.

Softstem bulrush pen using 6" potted plants: Plant survival was good and beginning to spread showing positive growth trends. While late in the project, this treatment is considered successful. The plantings have already survived significant wave action.

Experience has proved that softstem bulrush is a prolific spreader and should quickly fill the pen and protect the shoreline behind it. Evidence from caged bulrush at the site strongly suggests that herbivory is the biggest inhibitor at this site for softstem bulrush. That problem should be negated with the wire pen.

Uncaged planting: Survival was extremely poor at all sites except where plants were above the waterline. This treatment is considered unsuccessful and is not recommended for Lake Carl Blackwell.

Caged planting: Survival was adequate where wave action was not limiting at Site 1. At Sites 2 and 3 the cages made little difference in plant survival and are not recommended as a treatment alternative at high-energy sites.

4.0 TASK 1: DEVELOP SHORELINE EROSION CONTROL PLAN

Deliverables: Shoreline Erosion Control Plan for Lake Carl Blackwell

The field reconnaissance was conducted by land and boat on August 27, 2004. The plan entitled "Shoreline Stabilization Plan for Lake Carl Blackwell [FY-01 319(h) Task #01-003 CA # C9-996100-07 Project 3]" was written by Hollis Allen of AllEnVironment Consulting, finalized by OWRB and delivered to EPA via Oklahoma Conservation Commission December 20, 2004.

The plan presented the several sites and methods available for demonstration. The methods of choice for the sites were log breakwaters to protect herbaceous plantings and use of tiered fiber rolls against the escarpment.

Site selection took into consideration several factors: representative shoreline types, sediment capable of supporting plantings and access adequate to bring in materials.

4.1 Site Descriptions:

The three project site positions are delineated in Figure 1.

Site 1 is a very typical shoreline found surrounding the lake. It is a hard clay vertical 4-foot escarpment over a softer clay shallow flat. The maximum fetch is 3 ½ miles from the east however the prominent fetch would be one-half mile from the north. Cattle graze the site and have made ruts in the escarpment to reach the water. The site was protected on the shore by installing a solar powered electric fence. There was never any evidence of cattle entering the site over the duration of this project. This site was protected lakeward with a cedar tree breakwater and planted with a broad band of herbaceous plants that once established would protect the shoreline. This remote site was chosen in part because of its proximity to a large source area of cut cedar trees. It later determined that these trees were too old and decayed to be used for this project. Ultimately newly cut cedar trees were used for this site.

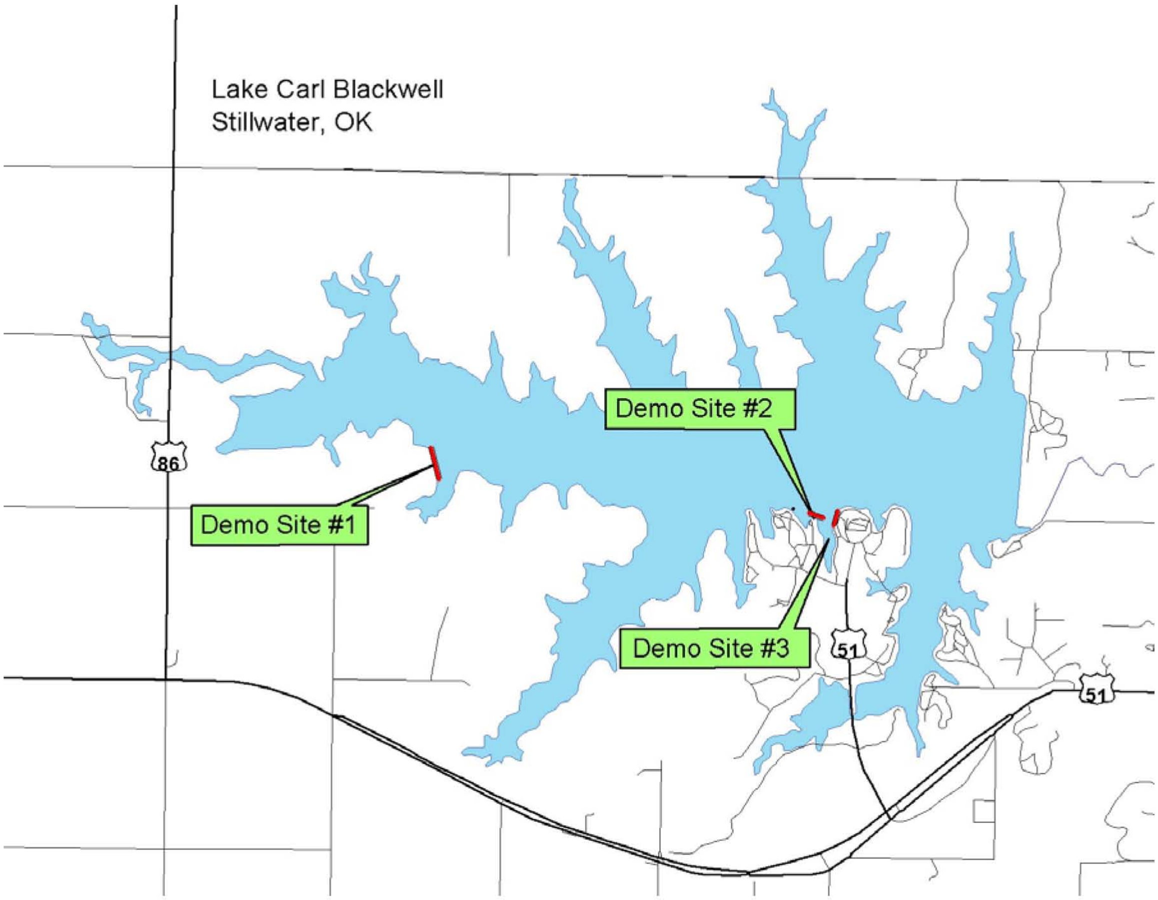


Figure 1: Map of Lake Carl Blackwell with Demonstration Sites Indicated.

Figure 2: Site 1 (specifically Transect 4) before implementation, hard clay vertical escarpment with shallow flat bench

Site 2 is a highly eroded sandstone escarpment with large rocks in the planting zone mixed with an excellent substrate for plants. It has a fetch of 1½ mile. This is a campground site that is quickly eroding away. This would be an excellent point to establish an herbaceous buffer zone to halt this erosion.

Figure 3: Site 2 (specifically Transect 2) before implementation, sandstone vertical escarpment with silt and clay bottom.

Site 3 This site (Figure 4) has hard clay substrate coupled with soft soil that had been recently washed into the area from earlier attempts by park management to clean up the face of the bank. The depth at the bank was at or below the toe of the escarpment. While the site had a newly built rock jetty on its north side, the effective 1½-mile fetch was from the northwest and continued to affect this site.

Figure 4: Site 3 (Transect 7) old concrete rip rap on bank. CGRs on shore

5.0 TASK 2: IMPLEMENTATION OF BIOENGINEERING TECHNIQUES

Deliverables: Incorporated into the Final Report

5.1 Objectives

To accomplish the project objectives, the following goals were established for the sites:

1. Installation of wave deflection barriers (breakwaters) to provide protected calm waters for growing aquatic plants.

2. Establish stands of emergent aquatic plants behind the breakwater as a permanent system to dissipate wave energy and replace the project breakwaters as they decay.

3. Experiment with multiple types of breakwaters and plants to measure and demonstrate their effectiveness, complexity and suitability to the project.

Installation occurred over multiple visits between June 27, of 2005 and May 30, 2006. Water levels were unusual for LCB with late rains for the summer so that normal evaporation did not bring the lake down as they usually do in the summer months. The project expectations were that the lake would drop about 2 feet over July and August leaving the plants protected from rough fish and waves and free to grow and spread in the exposed mud. Further, the breakwaters were not expected to be under the constant stress of high waves but rather, sitting in shallow water. This did not occur. The water levels stayed within a foot of the top of the spillway and left the planted sites in one to three feet of water depth.

5.2 Breakwater Construction

CGR Breakwaters

The *CGR breakwaters* used in this project are 20”x10’ fiber rolls made from coconut husks encapsulated in nylon netting. CGRs are roughly $10 per linear foot but are easy to install, function as a direct planting medium and naturally disintegrate over time.

On June 28, 2005 the CGRs were initially set in place using 3/16” cabling tied down to rebar and wood stakes (Figure 5). CGRs were difficult to anchor in the substrate at site 3. This site had a combination of very hard clay sandstone bottom and soft unsettled sediment. In most instances, the stake either could not be driven sufficiently into the substrate or the substrate was too soft to hold the stake. After two unsuccessful attempts to stake the down the CGRs we purchased duckbill anchors on the advice of our consultant, AllEnvironment. These deep-cabled anchors used drive rods and beveled anchors that rotate 90^0 in the sediment when pulled taught. The CGR breakwater continued to wash out from persistent high water and waves. In some cases netting was torn from the anchors and the fiber spilled out. In other cases where the sediment was very soft the anchors themselves were pulled out.

Figure 5: Site 3 CGRs initially installed with rebars, later converted to duckbill anchors.

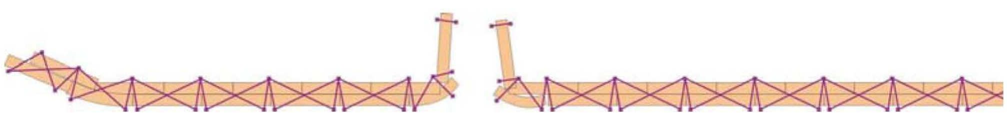


Figure 6: Anchor and cabling layout for CGRs

Cedar Tree Breakwaters

Cedar trees were cut by Lake Carl Blackwell Park staff and hauled to sites 1 & 2. On June 28 – 29, OWRB staff constructed the cedar tree breakwater at site 1. Site 2 breakwater was constructed later, on July 22, August 4 and 5. Staff used T-posts and connected trees with plastic coated cable. T-posts were set at roughly 8-foot intervals at a four-foot depth. Typical trees were 8-10 feet tall with an 8”-10” basal diameter. Two rows of cedars were set between posts in opposing directions to give maximum breakwater width throughout. The Site 1 breakwater was 525’ in length. The Site 2 breakwater was 225’ in length

5.3 Planting Implementation

After breakwaters were installed herbaceous aquatic plants could be planted. Potted plants had been purchased from 2 vendors, comprised of 6" pots and 2" plugs of various species (see Sections 5.3.2 – 5.3.7 for details). Waterwillow (*Justicia americana*) and Potamogeton spp. were harvested from Lake Thunderbird near Norman, Oklahoma. Species planted and their targeted elevations are listed in Table 1.

Shovels were used to wedge in plants that were then heeled in place in the sediment. Submersed species and deep planted emergents were further protected from herbivores using 2"x4" wire mesh caging. The target caging was thirty 3' diameter ring cages of uncoated welded wire 5' tall and thirty cages of vinyl coated wire 4' tall.

5.3.1 Water Levels for Planting Considerations at LCB

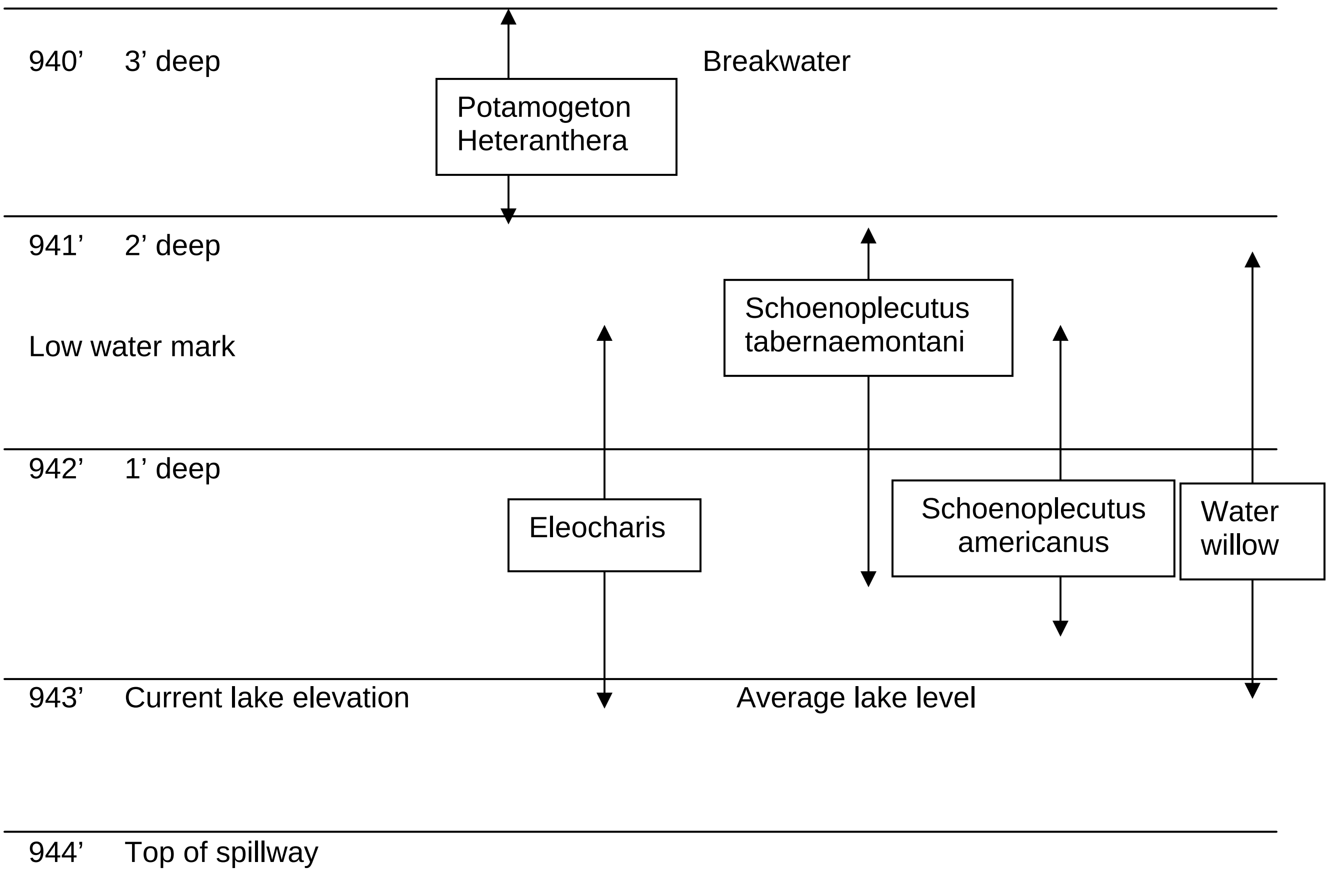
Typical water levels for Lake Carl Blackwell vary based on the rainfall, as the lake does not have a control gate. Water is released only by overflowing the spillway. The top of the spillway is at 944 ft. Aquatic plants targeted specific depth zones by species. Table 1 represents the planting plan developed for the LCB with the emergent plants at or above the normal low waterline and submersed plants below the normal low waterline.

5.3.2 Planting elevations by species

Plant species	Common Name	Min (ft)	Max (ft)
Heteranthera dubia	Water star-grass	939	941
Potamogeton illinoensis	Illinois pondweed	939	941
Potamogeton nodosus	American pondweed	939	941
Ceratophyllum	Coontail	939	941
Eleocharis palustris	Common spikerush	941.5	943
Eleocharis quadrangulata	Squarestem spikerush	942	943
Schoenoplectus tabernaemontani	Softstem bulrush	940	942.5
Schoenoplectus americanus	Common threesquare bulrush	941.5	942.5
Justicia americana	Water willow	940	943

Table 1: Plan – Depth zones targeted by species

5.3.3 Target Planting Depths



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5.3.4 Planting Plan Allocation

- 300 *Schoenoplectus tabernaemontani* plugs
- 200 *Schoenoplectus americanus* plugs
- 200 *Eleocharis quadrangulata* plugs
- 200 *Eleocharis palustris* plugs
- 20 *Heteranthera dubia* plugs
- 20 *Potamogeton nodosus* plugs
- 20 *Potamogeton illinoensis* plugs

5.3.5 Transplanted

- 200 *Justicia americana* bare root sprigs from Thunderbird
- 100 *Potamogeton/Chara* bare root sprigs harvested from Lake Thunderbird

5.3.6 Planting Detail by Site

Site 1

This site faces east with no trees and thus has full sun exposure. It is very turbid at only 2' to 3' deep with soft red clay sediment that is constantly stirred from wave action. The breakwater was meant reduce the turbidity as well; however, submersed plants should be planted as shallow as possible and allowed to grow into the deeper lake as plants establish and water clears. This is a remote site with no public access except by boat. The eastward fetch is around 3.5 mi. Cattle have occasional access to this site. It was protected with an electric fence. This site has a very long shallow bench.

Figure 7: Demonstration Site 1 - entire site

Figure 8: Site 1 - South end

Figure 9: Site 2 - North end

Cedar Tree Breakwater Construction – June 28, 2005

Cedar trees cut by Carl Blackwell staff were pulled into the water by hand to a line roughly 60 ft. from the shore and attached to t-posts set on 8-10 foot spacing. The trees were tied to the t-posts using coated 16-gauge cable. Trees were configured into two rows in opposing direction (top to bottom) with t-post between. This breakwater was 525 feet long. Water depth at the time of construction was 3.5 - 4 feet.

Figure 10: Site 1: Installation of Cedar Tree Breakwater

Initial planting – 8-12-05

Plants were planted within the 525' breakwater, which was built roughly 60 feet out from the escarpment and at an elevation of 940'. Twenty four cages were installed at this site

Planting Totals – See Planting layout in Figure 11:

8 *Heteranthera dubia*	cages
18 *Potamogeton nodosus*	cages
10 *Potamogeton illinoensis*	cages
80 Harvested *Potamogeton*/Chara	cages & unprotected plantings
100 Harvested *Justicia americana*	Individual plantings unprotected
200 *Schoenoplectus tabernaemontani*	cages & unprotected plantings
150 *Schoenoplectus americanus*	Individual plantings unprotected
50 *Water willow plugs*	Individual plantings unprotected
50 *Carex annectans*	Individual plantings unprotected

Initial Planting of Site 1

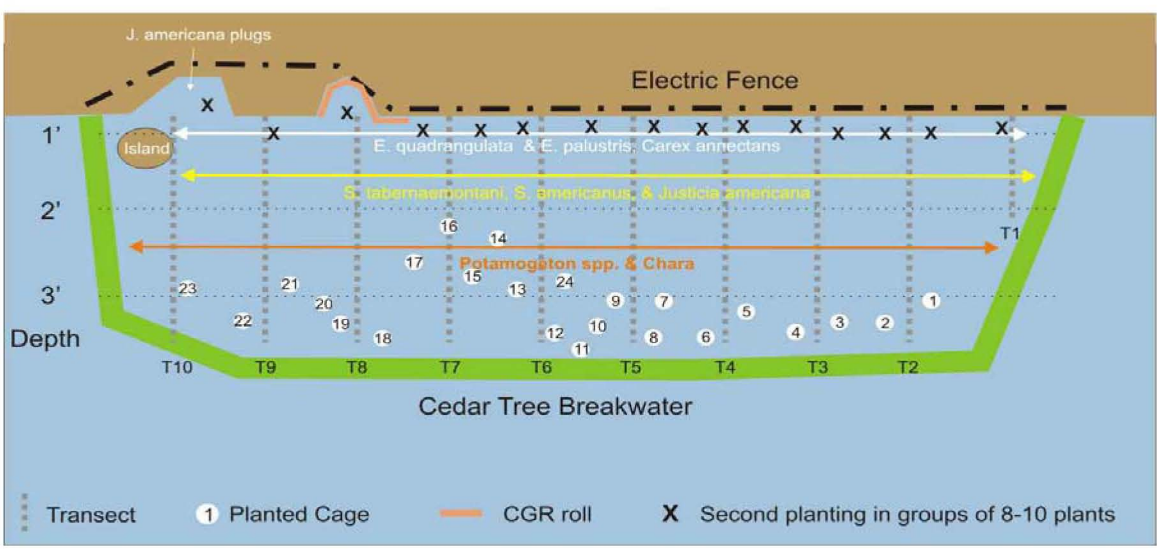


Figure 11: Site 1 Initial Planting Layout as of Summer 2005

An initial assessment of the plantings was made on September 7, 2005. At that time it was discovered that most of the Site 1 plants were gone except for the 6" potted plants in the ring cages which appeared to be fine. We suspect this was due to either herbivory or more likely that the small 2" plugs and bare root transplants were washed out by wave action before they had a chance to root in. Several floating plugs found at the site evidenced this.

Second Planting – 9-16-06
In response to this problem we replanted with 150 plants of bulrush and juncus plugs and 100 water willow transplants from a nearby cove. Extra care was taken to create a *slit* in the sediment with the shovel instead of digging a hole that will easily wash out. That slit, once planted, was then well heeled in to ensure that the plugs were securely in the sediment. Also, the plants were planted in patches or groups of 8 to 10 plants instead of spreading them out on a meter grid. There were significant losses to this planting as well. The caged plants at the site continued to do well. Mortality of the uncaged plants must be to either aquatic herbivory or the small size of the uncaged plugs or both. The caged plants were large 6" potted nursery plants whereas the uncaged species had been smaller 2" plugs that were more susceptible to washing out. Also, the cedar tree breakwater acted as habitat or a fish attractor which would likely increase herbivory.

Third Planting – 3-6-06
Upon failure of the breakwater at Site 3 (see Section 5.2) the CGRs were moved to Site 1 and installed in two tiers for 250 linear feet against the escarpment. Each roll had five 5' rebar pins driven into them 3 feet into the sediment. Three pins were driven on the low side of each roll. The remaining 6" of rebar was bent over the roll with a rebar bender. The combination of the long rebar with firmly crimped ends and the second tier of rolls on top tied the CGRs into the bank very well. There were large waves up to 2 feet high on the day of the installation that showed no apparent affect.

CGRs were planted with dormant black willow (Salix nigra) cuttings, a/k/a "live stakes" above and between rolls (Figure 12). The live stakes were cut on the same morning from a drainage ditch in Edmond, OK and transported to the site for planting. Using a steel drive rod and sledge, 1 foot deep holes were driven into the bank (Figure 13). Cuttings soaked in a bucket of root promoting solution before planting. Minimum stem diameter was ½ inch. Planting density was roughly one foot. Holes were tamped closed with a drive rod.

Fourth Planting - 3-22-06
Planted 100 cut stems of cottonwood (Populus deltoides) and flowering dogwood (Cornus florida). The cottonwood was dormant however the dogwood had already flowered. These were planted between the willow cuttings. None of these cuttings sprouted. It was perhaps too late in the season to do this.

Fifth planting – 5-19-06
Planted fifty 6-inch pots of softstem bulrush in and constructed a 50' x 20' wire pen (Figure 14) to protect them from herbivory. The bulrush was planted in three rows and situated in front of an especially eroded portion of the bank. The expectation is that over time this pen will fill in completely and protect this area from further erosion. Observing the vigor of last year's caged bulrush from last year made it seem reasonable that 6-inch

potted bulrush might be able to establish here. Lastly, another 100 water willow were directly transplanted into the first tier of coir rolls at the site.

Figure 12: Newly installed CGRs at Site 1 with dormant willow cuttings at 16 inch intervals

Figure 13: Driving one-foot deep holes for willow cuttings

Figure 14: Bulrush pen installed at Site 1

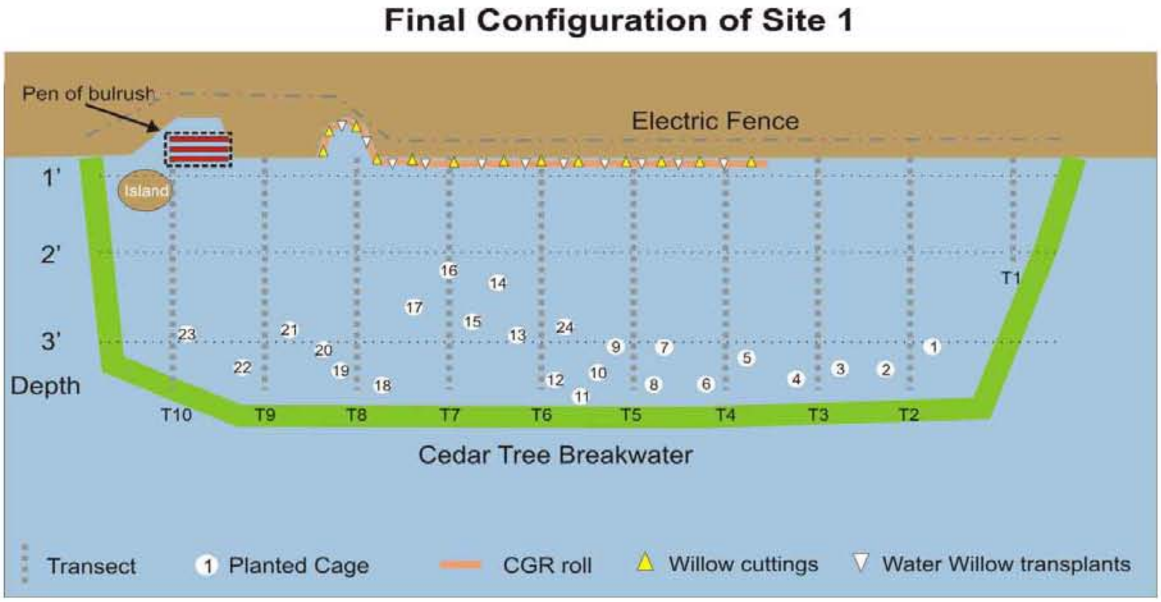


Figure 15: Site 1 Final planting layout as of Spring 2006

Site 2:

This site faces north into the main body of the lake in a small cove. A road passes right by the site, with a campground directly shoreward. Though it is in a heavily used area, public access to the site is more limited due to the 6-8 foot height of the escarpment. Just west of the site, public access permits use as a swimming area. The maximum N-NE fetch at this site is up to 1.3 mi. This site has very large rocks from ½ ‘ to 4’ in diameter. Soft sediment lies between the rocks providing easy planting and expansion for plants. Once plants fill the spaces between rocks the shoreline should have substantial protection from waves.

Figure 16: Site 2

Cedar Tree Breakwater Construction – August 4, 2005
Cedar trees cut by Carl Blackwell staff were installed at Site 1. This breakwater is 225 feet long, and was placed at around 940' msl.

Planting – 8-12-05
Planting Scheme and site layout is shown in Figure 17. Planting numbers and species of plants are listed below.
Plants:

3 *Heteranthera dubia*	cages
7 *Potamogeton nodosus*	cages
20 Harvested *Potamogeton/Chara*	cages & unprotected plantings
100 Harvested *Justicia americana*	Individual plantings unprotected
50 *Schoenoplectus tabernaemontani*	Individual plantings unprotected
50 *Schoenoplectus americanus*	Individual plantings unprotected
50 *Eleocharis quadrangulata*	cages & unprotected plantings

12 cages were installed at this site

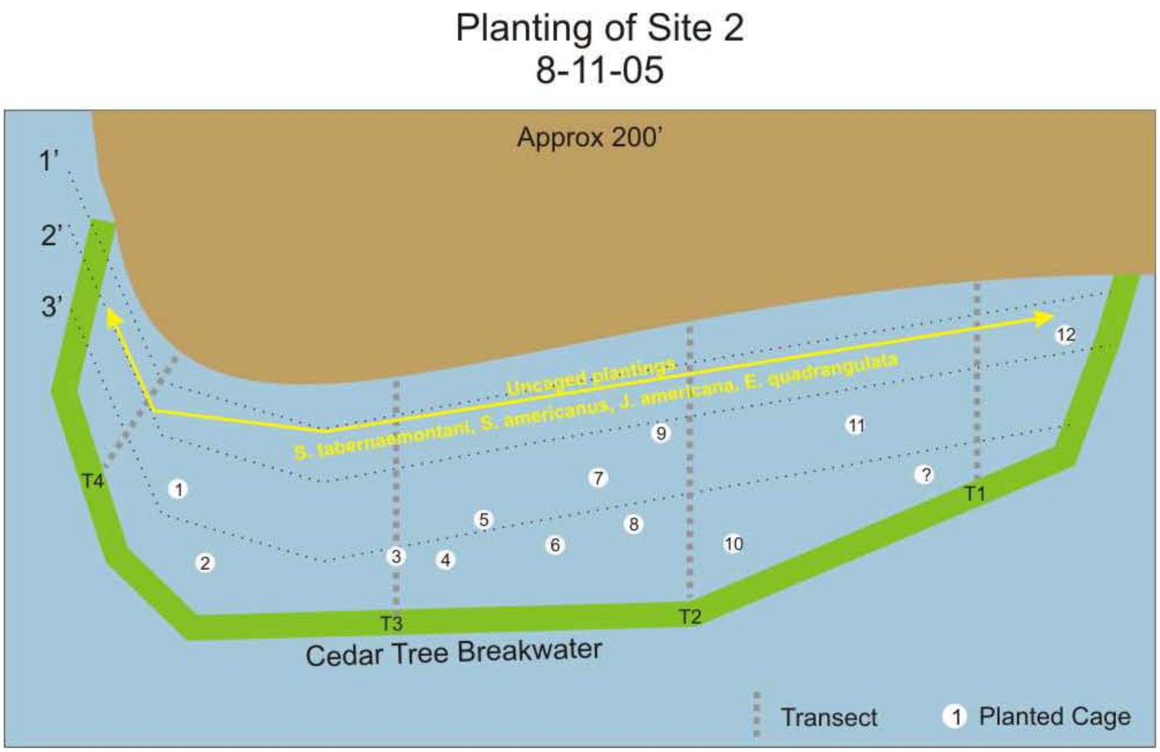


Figure 17: Site 2 planted layout as of Summer of 2005

Site 3

The site faces west with a 1.5-mile fetch from the northwest. It has a new rock jetty protecting it from the north. This site has a combination of very hard clay substrate and loose soil deposited during construction of the jetty and earlier attempts to reshape the shoreline. This highly eroded area with sparse riprap of broken concrete is quite visible to the public being near a boat ramp. The lake manager wanted to see the site protected and given a more aesthetic and natural appeal.

A CGR breakwater was put in at the site and anchored in two rows at and just below the water line (Figure 18).

Figure 18: Site 3 looking north - Plantings in and behind CGRs. Green cages of submersed species in background.

Plants were planted in the shallows behind the CGRs, in the CGR material itself and in cages in the three to four foot depths. Plants were installed at the site as defined below. Site layout and planning is shown in Figure 19. Nine cages were installed at this site.

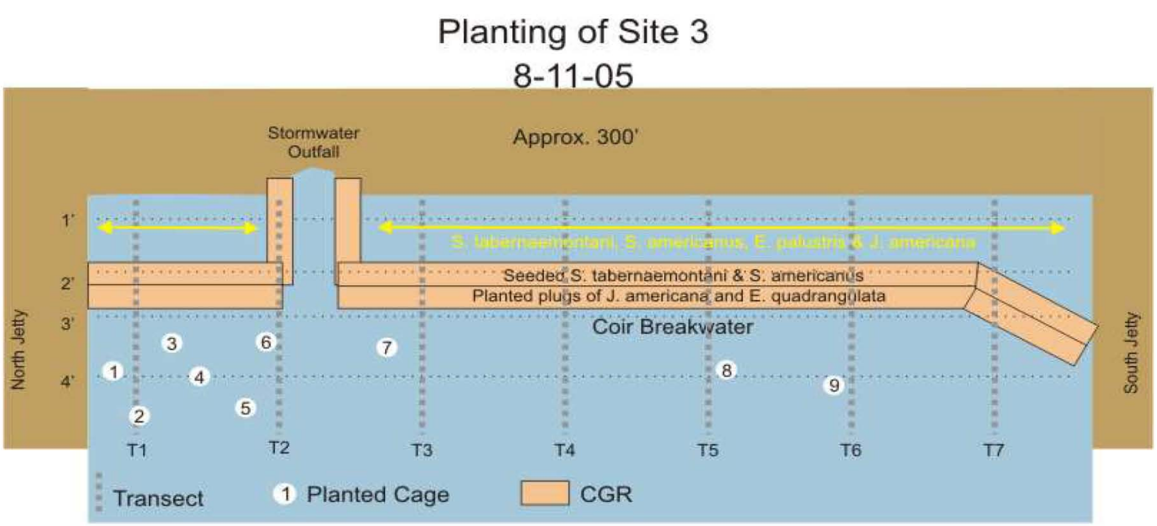


Figure 19: Site 3 planting layout

Plants:
50 Justicia americana
50 Schoenoplectus tabernaemontani 8 in cages
50 Schoenoplectus americanus
70 Eleocharis quadrangulata 4 in cages
70 Eleocharis palustris
4 Heteranthera dubia 4 in cages
4 Potamogeton nodosus 4 in cages

High energy wave action continuously loosened the CGRs at the site. It was eventually decided to pull the CGRs and move them to Site 1. (See Sections 5.2 and 5.3.6 "Third Planting").

5.4 Plantings and Plant Survival

(as of May 30, 2006)

Detailed numbers of plantings by site and species are delineated in **Table 2** below. Site 1 plantings were from several planting events between August 2005 and May 2006. This is more fully explained in section 5.3.7. A majority of the survival was from plants that were cage protected or out of the water where they were protected from wave action or fish herbivory. Numbers of plants were counted as individual stems or plant clumps. Caged plants were initially labeled 25% filled for a species. Cages deemed 50% filled by a plant counted as 2 plants, 100% filled were 4 full plants. Additional plants outside the cage were counted as individual stems found around the cage.

Planting Results:

	Site 1			Site 2			Site 3		
	# Planted	# Survived	% Survived	# Planted	# Survived	% Survived	# Planted	# Survived	% Survived
Totals	**1555**	**327**	**21.0%**	**294**	**4**	**1.4%**	**298**	**16**	**5.4%**
Unprotected:									
waterwillow	250	19^	7.6%	100	2	2.0%	50	0	0.0%
softstem bulrush	350	0	0.0%	50	0	0.0%	42	1	2.4%
common bulrush	150	0	0.0%	50	0	0.0%	50^	6	12.0%
squarestem spike				50	0	0.0%	66	5	7.6%
flatstem spike							70	0	0.0%
Black willow	476*^	102	21.4%						
Yellow Fox Sedge	50	0	0.0%						
CGR waterwillow	100*^	91	91.0%						
Caged:									
water stargrass	8	2	25.0%	3	0	0.0%	4	0	0.0%
am. Pondweed	18	4	22.2%	7	2	28.6%	4	4	100.0%
ill. pondweed	10	66	660.0%						
softstem bulrush	13	2	15.4%				8	0	0.0%
squarestem spike				14	0	0.0%	4	0	0.0%
potamogeton/chara	80	2	2.5%	20	0	0.0%			
Penned:									
softstem bulrush	50*	40	80.0%						

* Planted in Spring of 2006
^ Plants at or slightly above the water line

Table 2: Planting Results

Two assessments were taken in the project. The first assessment was taken three weeks after the initial plantings on September 7, 2005. The second and final assessment was taken the following spring on May 30, 2006.

The original monitoring design of counting plants along a transect had to be abandoned. While we did make a point to travel along each transect looking/feeling for plants, the site density was simply too low for a transect system to give meaningful information. Surviving plants were few enough to make counts of individuals possible. Consequently, numbers of plants in Table 1 are not extrapolated from a sampling system but are one to one plant counts.

The overall percent survival for each site is 21% at Site 1, 1.4% at Site 2 and 5.4% at Site 3.

6.0 TASK 3: EROSION CONTROL MONITORING

Deliverables: Incorporated into the Final Report

Monitoring of site elevations and plants began immediately after the installation of breakwaters. Sediment accretion or erosion was measured at the sites by setting a T-post at the end of each plant monitoring transect. At sites 1 & 2 transects were 50 feet apart and ran from the escarpment to the breakwater. Because the CGR breakwater at Site 3 was only a few feet from the bank the posts were set just inside the CGR and ran 50 feet outside the breakwater. The distance between transects was still 50 feet. These surveys occurred concurrently with plant monitoring on September 7, 2005 and a second final measurement on May 30, 2006. Diagrams of the transect placement at the three sites are shown in the site diagrams (Figure 15, Figure 17 and Figure 19). Measurements were taken from the top of the post to the sediment and recorded. The results are shown in Table 3 below.

Table 3 shows the measurements on each transect post for beginning and ending measurements. It also shows the change in sediment elevation over the period as well as the average change for the entire site. Site 1 shows an average *net loss* of 0.97 inches for the 9-month period. Site 2 shows an average *net accumulation* of sediment of 0.39 inches site wide. Post 4N was turned over by a large cedar tree that came loose from the breakwater. Hence, no second measurement was taken for that point. Site 3 was dismantled months before the spring assessment. In January 2006 a backhoe was used in the lake to remove the CGRs for use at Site 1. This greatly disturbed the sediment at the site and resulted in knocking down two t-posts. Given the great disturbance and complete absence of a breakwater at the site any measurements would be highly misleading and were therefore not measured.

Elevation Survey Results:

SEDIMENT ACCRETION MEASUREMENT - Lake Carl Blackwell					
Site 1:	09/07/2005	05/30/2006	**Δ**		**Avg. Δ**
Stake #	**Distance (in.)** to bottom of White Mark on post *North side of T-Post*				
1-1E	38.5	40.25	1.75		**0.97**
1-1W	43.25	47	3.75		
1-2E	45.38	46.5	1.12		
1-2W	46.25	49.5	3.25		
1-3E	45.5	45.5	0		
1-3W	47.63	50.5	2.87		
1-4E	44.75	43.5	-1.25	Accretion	
1-4W	52.75	53.5	0.75		
1-5E	46.75	46.5	-0.25	Accretion	
1-5W	52	52.5	0.5		
1-6E	50	50	0		
1-6W	53	54	1		
1-7E	45.5	46	0.5		
1-7W	53.5	53	-0.5	Accretion	
1-8E	41	41	0		
1-8W	44	45.5	1.5		
1-9E	45	45	0		
1-9W	48.5	53	4.5		
1-10E	46	46	0		
1-10W	57	57	0		
Site 2	09/07/2005	05/30/2006	**Δ**		**Avg. Δ**
Stake #	**Distance (in.)** to bottom of White Mark on post *West side of T-Post to* Sediment *Not Rock)*				
2-1N	50	51.5	1.5		**-0.39**
2-1S	54	49	-5		
2-2N	48.25	47.5	-0.75	Accretion	
2-2S	53	53	0		
2-3N	54.5	53.25	-1.25	Accretion	
2-3S	57.25	54.5	-2.75	Accretion	
2-4N	58.5	NA	NA		
2-4S	52.75	58.25	5.5		
Site 3	09/07/2005	05/30/2006	**Δ**		
Stake #	**Distance (in.)** to bottom of White Mark *North sid of T-Post*				
3-1E	33	N/A	N/A		
3-2E	50.5	N/A	N/A		
3-3E	42	N/A	N/A		
3-4E	46	N/A	N/A		
3-5E	48	N/A	N/A		
3-6E	51.75	N/A	N/A		
3-7E	49.25	N/A	N/A		
3-0E	34.25	N/A	N/A		

Table 3: Sediment Elevation Measurements

* Note: “E”, “W”, “N”, ”S” denotes stake placement on transect, either east, west, north, or south.

7.0 DISCUSSION

7.1 Planting Survival:

The survival for each site is 21% at Site 1, 1.4% at Site 2 and 5.4% at Site 3. Survival overall was poor due to aquatic herbivory and wave action. Wave action was sufficient in some cases to wash out some plantings. Plugs were noted floating about at the sites one week after installation. Subsequent re-plantings occurred soon thereafter. Moving sediment from wave action can also make survival or spread difficult. Site 1 had better results than the other two sites because of the different methodologies being used and the continued efforts to rework that site.

7.1.1 Site 1

Aquatic herbivory is the most likely source of mortality at Site 1 evidenced by the broad survival of caged plants (See Table 2). The low 2.5% survival of the "Potamogeton/chara" group is the exception and most likely due to being bare root transplants as opposed to established potted plants. Wave action may have been more of a factor in this case perhaps by washing out the bare root propagules.

Survival of uncaged plants *in the water* at Site 1 was 0%. The only surviving uncaged plants were those up on the shore or planted into the escarpment. Plants on the upper shore *above the water line* or on the escarpment suffered neither wave action nor herbivory from rough fish and consequently had superior survival percentages. These plants are waterwillow, *Justicia americana*, and black willow, *Salix nigra*, plants in Table 2. In the table there are two waterwillow categories. The "waterwillow" category was planted throughout the site with the surviving 19 plants found on the shoreline of the site and not exposed to the waves or rough fish. "CGR waterwillow" as its name suggests were planted directly into the two CGR tiers and hence out of the water.

The most promising results of this project are to be found in the CGR plantings at Site 1. The black willow trees are fully expected to establish as they are well protected by the CGRs. It will likely take three or more growing seasons before the willows are rooted in well enough to provide substantial protection to the bank. The CGRs are rated to last seven seasons and for that reason should adequately sustain the trees. The waterwillows there are also expected to spread well within the CGR medium since they were kept wet through most of the summer. Once established they can handle drought conditions should it come about.

Of the submersed species, Illinois pondweed (Figure 21) had the highest survival rating at 660% due to the exceptional growth both inside and out of the cages. All of its cages filled to capacity and extended to plants two feet beyond their cages. At one point there was a thick ring of pondweed for 5'-10' beyond the cages. Much of this was found washed against the embankment two weeks later when we returned with a camera. Most likely broken up by a storm and some herbivory. American pondweed and water stargrass maintained and survived without significant expansion. We can conclude for this time period that wave action and herbivory was within tolerable limits for Illinois pondweed.

Figure 20: Survivors - black willow and waterwillow. Uncaged but out of water

Figure 21: Illinois pondweed filling cage at Site 1.

Noting the very healthy caged softstem bulrush already in place can survive well at this site an attempt was made to plant a large penned area (50'x20', Figure 22) directly in front of the worst eroded zone using vigorous 6" potted plants (see Section 5.3.7). This fast growing colonizer should grow into dense tall stands and fill the pen to perform an excellent shoreline buffer. This area was planted only 11 days before the final assessment, so it is too early to say with any certainty what these plants will achieve.

The initial results however were excellent showing 80% survival, new shoots and rhizomal spread.

Figure 22: Softstem bulrush pen

7.1.2 Site 2

This site's poor plant survival, 1.4% overall, can be attributed to wave action since even the caged plants did not survive well. One cage of American pondweed did survive with expanded growth within the cage. The 50% coverage is credited as 2 plants out of the 7 planted for a survival of 28.6%. Six cages had been turned over during the spring with no surviving plants to be found. The remaining 6 cages were empty as well. Two individual waterwillow plants survived but did not send out rhizomes to make new plants. The breakwaters were not visibly effective at reducing the high-energy waves coming into the site. No further efforts were made to replant.

Figure 23: Potamogeton nodosus at Site 2

7.1.3 Site 3

This site also had problems with herbivory and wave action. The only surviving plants were those out of the water or in a single cage protected further by its proximity to the north jetty. The surviving caged plants were American pondweed at 100% coverage. Surviving emergent plants were small clumps of squarestem spikerush, softstem bulrush and common bulrush found above the waterline and thus protected from wave action and aquatic herbivory. While this site was planted initially into and behind the CGR, the breakwater was unstable killing most of the site plants. The breakwater was eventually abandoned and CGRs moved to Site 1 to abut the bank there.

Figure 24: Spikerush and common bulrush above the waterline at Site 3

7.2 Erosion Control / Breakwaters:

To truly determine what affect, if any, a breakwater had on a site it would be necessary to have some preliminary measurements of sediment movement at the site over some period of years. This was not an option for this project.

Site 1: shows an average *net loss* of 0.97 inches for the 9-month period. While there is certainly room for variation in yearly accumulation at the site, a 0.97 inch loss would strongly indicate that the cedar tree breakwater did not stop erosion or net any accumulation.

The CGRs against the escarpment however, are catching the eroded upland soils and demonstrate rapid backfilling. The CGRs in Figure 25 had been in place four months at the time of the photo. No initial measurements were taken nor was a system put in place to measure the backfilling rate or potential.

Figure 25: Erosion on escarpment backfilling CGRs

Site 2: shows an average *net accumulation* of sediment of 0.39 inches site wide. This breakwater may have helped to reduce or even accumulate sediment at the site. The opposing results between Sites 1 & 2 using the same breakwater type begs an explanation. It is possible that 0.39 is within the limits of sampling precision and the number is just *noise* in the data. It is also possible that there are annual fluctuations at the sites and this finding was during a positive fluctuation. It is feasible that the different results between sites 1 & 2 may be explained by the shorter fetch at Site 2, a shorter distance to the shore, different sediment types, the large rocks in the sediment, and the larger cedar trees placed there. Historical measurements at both sites would be necessary to know the extent of natural sediment fluctuations and to help the extent the breakwater affected sediment accretion there.

Site 3: Breakwater was dismantled and moved to Site 1 (See Sections 5.2 & 5.3.6 "Third Planting").

Coir logs (CGR), while excellent abutments to a bank, were impractical as a breakwater at this high energy site and should not be used without a substantial amount of support such as rock on its lake-ward side. Anchoring alone at this site was not enough to hold CGRs in place. It may be necessary to add rock on the lakeward side of the CGRs to adequately hold them in place. This could make CGRs too costly to remediate long expanses of shoreline.

APPENDIX A

Plant Monitoring Photos

Site 1 Transect 1

Location: S1 – 1

Description: Short Transect, No Zoom shot.

Date: August 11, 2005

Time: 10:05 am

Location: S1-T1

Description: Short Transect, No Zoom shot.

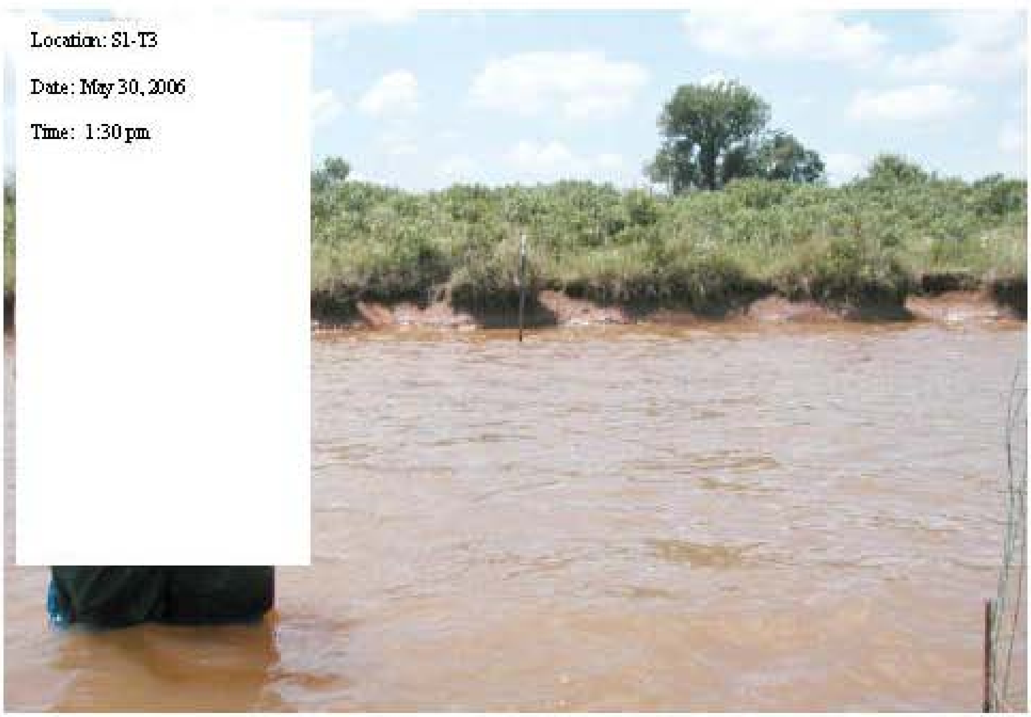
Date: May 30, 2006

Time: 1:30 pm

Site 1 Transect 2

Site 1 Transect 2 Zoom

Site 1 Transect 3



Site 1 Transect 3 Zoom

Site 1 Transect 4

Site 1 Transect 4 Zoom

Site 1 Transect 5

Site 1 Transect 5 Zoom

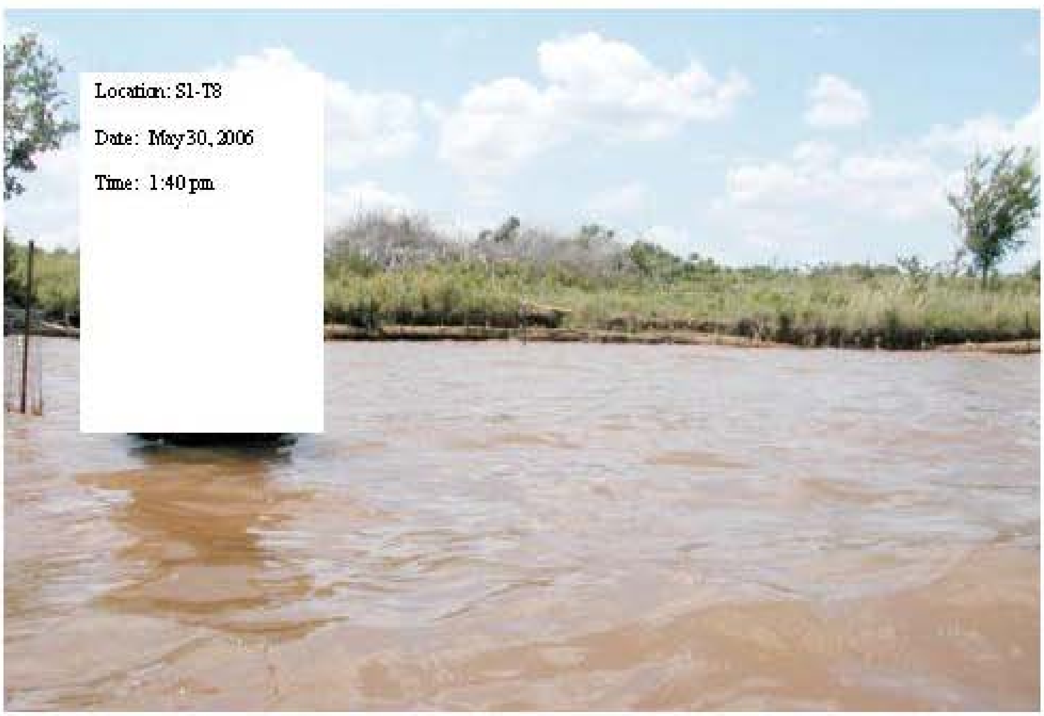
Site 1 Transect 6

Site 1 Transect 6 Zoom

Site 1 Transect 7

Site 1 Transect 7 Zoom

Site 1 Transect 8



Site 1 Transect 8 Zoom

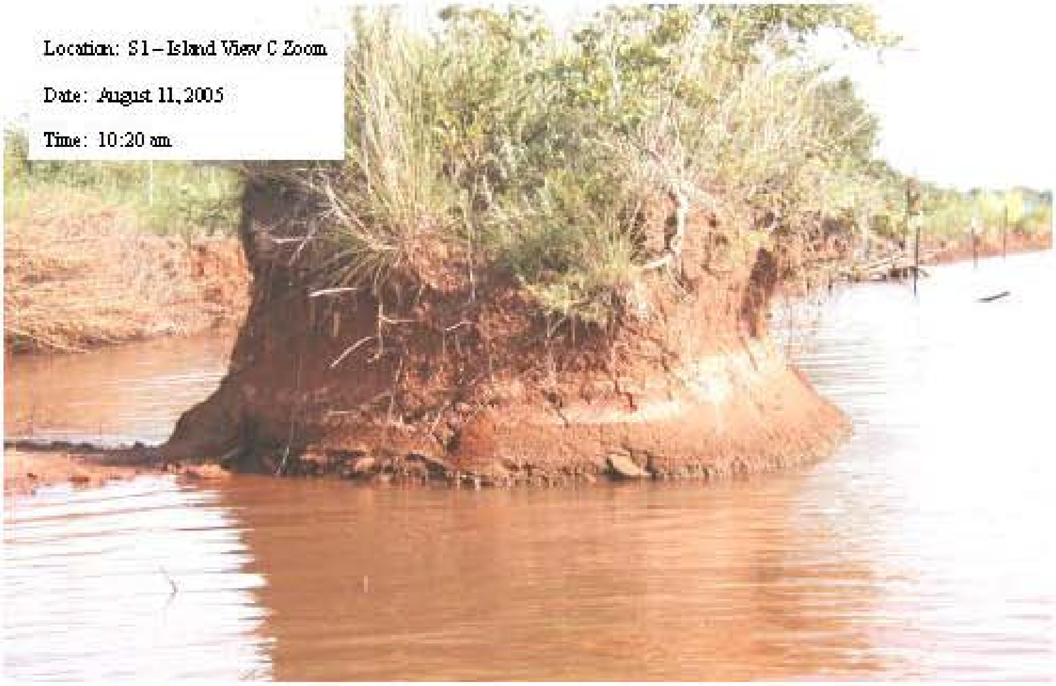
Site 1 Transect 9

Site 1 Transect 9 Zoom

Site 1 Island View A Zoom

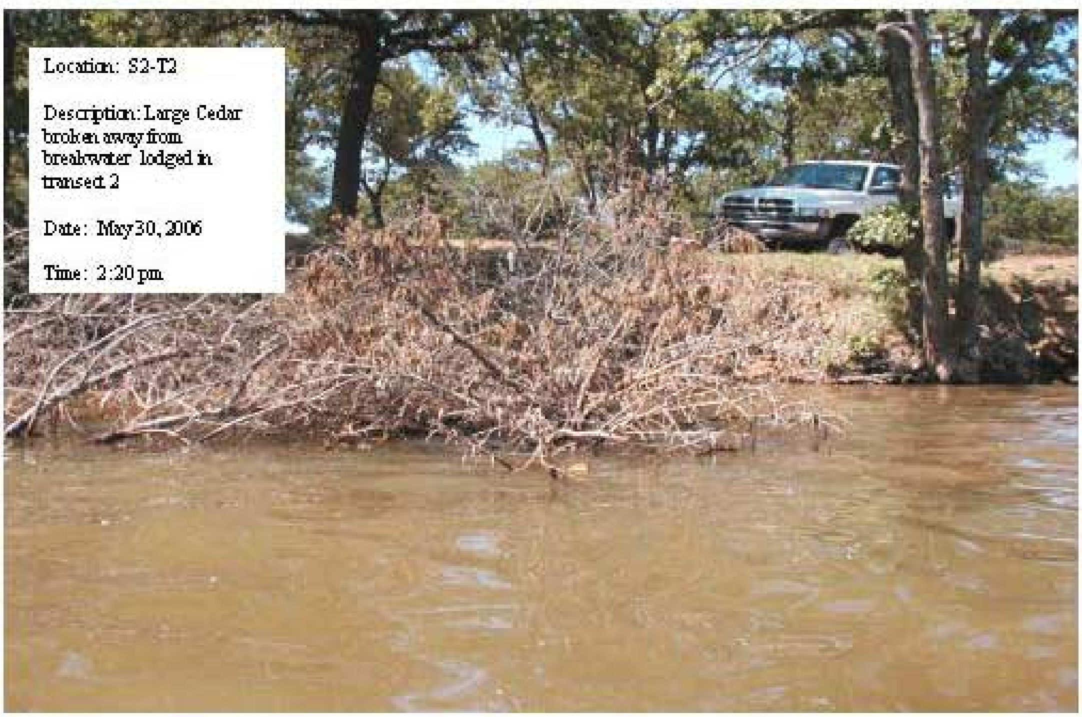
Site I Island View B Zoom

Site 1 Island View C Zoom



Site 2 Transect 1

Site 2 Transect 2



Site 2 Transect 2 Zoom

Location: S2 – T2 Zoom

Date: August 10, 2005

Time: 10:15 am

Location: S2-T2 Zoom

Description: Large Cedar broken away from breakwater lodged in transect 2

Date: May 30, 2006

Time: 2:20 pm

Site 2 Transect 3

Site 2 Transect 3 Zoom

Location: S2-T3 Zoom Not Available

Date: May 30, 2006

Time: 2:20 pm

Site 2 Transect 4

Site 3 Photos

Site 3 was dismantled months before the spring assessment. In January 2006 a backhoe was used in the lake to remove the CGRs for use at Site 1. This greatly disturbed the sediment at the site and resulted in knocking down two t-posts. Given two stakes were down and no plants were evident at or near the photo points, photos were not taken of the transects but were taken of the few plants at the site. These were mostly from a replanting effort initiated by LCB staff in May of 2006. These replanted bulrushes were *not* included in the planting results table but photos of them have been included here. Bulrushes were trimmed to < 1 ft. to help stimulate growth and reduce wave impact on the transplants.

Site 3 Transect 0

Site 3 Transect 1

Site 3 Transect 2

Site 3 Transect 3

Site 3 Transect 4

Site 3 Transect 5

Site 3 Transect 6

Site 3 Transect 7

Site 3 - Bulrush Replanted May 16, 2006

Site 3 Bulrush in Coir

Location: Site 3

Description: Softstem bulrush and terrestrial plant from seed growing in remaining CGR

Date: May 30, 2006

Time: 12:34 pm

Location: Site 3

Description: Softstem bulrush from replanting efforts May 16, 2006

Date: May 30, 2006

Time: 12:34 pm

Site 3 Spikerush and Common Bulrush