Executive Summary

Tyler Island

Levee Protection & Habitat Restoration Plan

by
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Project Description and Primary Biological/Ecological Objectives

This project involves the use of biotechnical bank and levee protection and enhancement methods to foster an increase in size of shaded riverine aquatic, instream herbaceous cover, and tidal perennial aquatic habitats. These features will improve water quality, foster and increase of macroinvertebrate populations, and improve habitat for priority species, including Delta smelt, splittail, San Joaquin and east-side tributaries fall-run chinook salmon, and other anadromous fishes that use this area for habitat and migration corridors.

Approach/Tasks/Schedule

We propose to incorporate various combinations of organic fabric, plant materials, and geotechnical substances that will serve the dual purpose of erosion control and habitat creation. Some of the methods include the use of ballast buckets, coir biologs, and coir mats. These will be installed along various reaches of the North Fork of the Mokelumne River and Georgiana Slough at Tyler Island. If funded, this project would begin in the fall of 1997.

Justification for Project and Funding by CALFED

This project will demonstrate how cost-effective biotechnical materials can reduce erosion on fragile Delta levees and simultaneously provide priority habitat for priority species.

Budget Costs and Third Party Impacts

Anticipated budget costs are presented in Tables I, II, and III. Third party impacts should be minimal.

Applicant Qualifications

The project team represents an extremely qualified group of people and organizations, with considerable experience in restoration implementation, scientific monitoring, and fisheries science. They include Jeffrey A. Hart, Ph.D., restoration ecologist; Tyson Holmes, Ph.D., research design scientist; Steve Sinnock, P.E., of Kjeldsen, Sinnock, and Neudeck; Stephen Shaner, Ph.D., invertebrate biologist; Dr. Michael McGowan, Ph.D., fisheries biologist; Gary Kirtlan, farmer and restorationst; and L & F Farm Labor.

Monitoring and Data Evaluation

Research level monitoring will form an integral part of the project, using appropriate experimental design parameters. Parameters to be measured include plant survival, plant cover, physical habitat heterogeneity, water quality, and abundance and distribution of fish and macroinvertebrates associated with the various restored vegetation treatments.

Local Support/Coordination with other Programs/ Compatibility with CALFED objectives

This project is fully supported by Reclamation District 563, which maintains the levees surrounding Tyler Island. The Reclamation District views the proposed methods and techniques to have the following long term benefits: 1) alternative, cost effective method to stabilize actively eroding earthen slopes; 2) means of providing additional slope stability in areas of existing revetment.

Tyler Island

Levee Protection & Habitat Restoration Plan

Applicant

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Applicant Type: Private Corporation
Tax ID #94-3274391

Participants/Collaborators

Reclamation District 563

RFP Project Type: Restoration / Monitoring Research

Tyler Island

Levee Protection & Habitat Restoration Plan

A. Project Description and Approach

The San Joaquin -Sacramento River Delta is considered to be the ecological hub of the Central Valley. Bank erosion and loss of riverine habitat is a major concern for the entire Central Valley river system and is an especially severe problem in the Delta region. While the natural processes of erosion and deposition are highly desirable in natural river systems, erosion in the Delta results in the irrevocable loss of riverbank, a response by flood control agencies to armor levee embankments with revetment, and the cumulative loss of riparian, shaded riverine aquatic, and high quality instream habitat.

The major goals of this project are: 1) the use of biotechnical bank and levee methods to protect and enhance natural earthen banks and reveted sites; 2) the creation of desirable shaded riverine aquatic (SRA), instream cover, and tidal perennial aquatic habitats of value to many priority fish species; and 3) a scientific based monitoring and experimental program to document (a) the relative merits of different biotechnical approaches compared to existing site conditions, (b) the contribution of instream living cover to by fish and macro-invertebrates, and (c) improvements in water quality.

This project is innovative for its use of soft, biotechnical materials. We propose to incorporate various combinations of organic fabric, plant materials, and geotechnical substances that will serve the dual purpose of erosion control and habitat creation. Some of the methods include the use of ballast buckets, coir biologs, and coir mats, planted with abundant quantities of the appropriate native species to provide erosion control and create habitat favorable for priority species.

We have selected two very different areas -- Georgiana Slough and the Mokelumne River -- for protection and restoration at Tyler Island (Figure 1). The Mokelumne River section has been extensively riprapped, and the goal here is enhancement and creation of vegetation on the revetment. All embankments and levee slopes on the Mokelumne River chosen for restoration are non-project levees and banks (Figure 2). Georgiana Slough consists mostly of natural earthen banks. The goal for this slough is to provide biotechnical, non-revetment forms of protection and enhancement (Figure 2).

Figures 2-8 detail the design concepts, methods of installation, and anticipated end product of these elements.

B. Location and Geographic Boundaries of Project

Tyler Island is a 8,583 acre tract in southern Sacramento County, immediately south of Walnut Grove. It is bounded on the northeast by Snodgrass Slough, on the west and southwest by Georgiana Slough, and on the south and east by the Mokelumne River. The management

entity is Reclamation District 563. The principal role of the Reclamation District is levee maintenance to protect farmlands, residences and commercial buildings from flooding.

The project area is located along the banks of Georgiana Slough and the Mokelumne River. Reclamation District 563 maintains only for the left bank of Georgiana Slough (facing downstream), of which approximately 2000 ft. has been reveted. The District manages 10.7 miles on the right bank (facing downstream) of the Mokelumne River, all of which has been been reveted. All restoration and enhancement measures will take place on levees under the jurisdiction of the District.

C. Expected Benefits

The **priority stressors** to Tyler Island levees and riverbanks that will be addressed are: 1) channel form changes induced by erosion; 2) erosional cumulative loss of riparian, shaded riverine aquatic, and instream habitat; and, 3) loss of riverbanks and levees, which may increase the risk of catastrophic failure of Delta levees. The funding of this pilot project will bridge concerns of local farmers and reclamation districts regarding levee stability, flood control, and environmental restoration. Expected environmental benefits, in terms of habitat, include the protection and enhancement of 2000 feet of riparian and instream habitat on Georgiana Slough, and the enhancement and creation of approximately 3000 feet on the Mokelumne River. These protected sites will serve the dual role of restoring **priority habitats** -- shaded riverine aquatic, instream cover, and tidal perennial aquatic habitats -- thus benefiting target **priority species** including Delta Smelt, Splittail, San Joaquin and East-side tributaries fall-run chinook salmon, and other anadromous fishes that use this area for habitat and migratory corridors. These projects will also demonstrate the compatibility of levee protection and habitat enhancement to the agricultural community, resource agencies, and environmental interest groups. As demonstration pilot projects, they will aid in guiding the development of adaptive maintenance and restoration projects throughout the Delta. Since the kinds of efforts included in this proposal represent the most cost effective and feasible methods for immediate habitat creation and levee protection in the Delta, these measures should garner political support for larger-scale ecosystem restoration projects. To foster the general educational benefits of this project, periodic public workday/workshops will be held in which H.A.R.T., Inc. will invite the public, especially the local farming community, to follow the progress of this project.

D. Background and Biological/Technical Justification

Ongoing bank erosion, poor habitat conditions, and the dual needs of levee protection and habitat improvement make this a compelling project. While natural vegetation still remains along the Georgiana Slough, there has been considerable embankment and riparian habitat loss over the years. The Mokelumne River section consists almost entirely of barren riprap embankment.

Levees were first constructed in the Delta to drain wetlands for agricultural production. The functions of these levees expanded over time to include flood protection for agricultural lands

and towns, roadways, control salt water intrusion, and maintenance of navigational shipping channels.

A general study of levee erosion recently concluded that for 540 miles of levee investigated, 86% of the Delta banks and levees have been reveted, while only 14% were non-reveted. Levee and bank erosion is believed to be caused by: 1) wind waves; 2) boat wakes; 3) current flow; 4) rainwash; and 5) gravity. The study goes on to report that the most common kinds of levee erosion occurred at the bases of non reveted levees, within thinly reveted levees, or just above the cover on reveted levees.

The role of plants in stabilizing riverbanks and similar areas has been widely documented. This project represents an extension of H.A.R.T.'s ongoing research and development of biotechnology for river bank stabilization and habitat improvement. H.A.R.T.'s work on the Lower American River and elsewhere in the Delta show the relative merits of different vegetation and landscape materials and their relationship to the erosion/depositional process (Figures 4-7). These data demonstrate that increasing plant and fabric roughness on revetment sites can simultaneously reverse the erosional cycle and induce deposition. These same kinds of techniques, as discussed below, can be used to stabilize and enhance sites at Tyler Island.

A component of instream plant cover not explicitly included in the Fish and Wildlife Service characterization of SRA consists of herbaceous species (Figure 7). To date, nearly all of the emphasis on instream SRA cover has been with dead, woody material. A number of plant species are adapted for growth at shoreline edge environments in the Delta, such as sedge, bulrush and cattail. Instream living cover likely would provide additional, if not complementary, benefits to more woody SRA features. First, this cover type is more fine grained, thus would probably provide complementary or greater benefit to small fry and fingerling salmonids and other species compared to larger SRA elements. Second, a greater macro-invertebrate population is found on living cover compared to dead woody material. Fry and fingerlings of most species are largely dependent upon invertebrate prey for their survival. An entirely new approach to providing this type of habitat involves the use of "ballast buckets" (Figure 7).

The highly innovative methods outlined in this proposal are the most feasible approaches to easily and inexpensively developing desirable habitat in the Delta. While created berms and set-back levees are highly desirable, they are very expensive, require lengthy planning efforts, and can lead to loss of farmlands which may not always be economically or politically acceptable. This project would differ from most in that the bulk of the funding resources are directed towards actual installation of habitat. Since much of the plantings will consist of fast growing herbaceous plants, benefits to fisheries should be evident within two to three years. The use of biotechnical enhancements, by stemming erosion, will ensure durability of habitats. The biological benefits therefore will be comparatively large and long lasting.

E. Proposed Scope of Work

This is a new project, the implementation of which can begin at the time of funding. The sequence of activities and tasks include: 1) obtaining Reclamation Board Permission; 2)

development of specific experimental and monitoring designs; 3) purchase of biotechnical fabric material; 4) survey and assessment of pre-project (baseline) conditions, including existing vegetation, water quality, fish, and invertebrates; 5) installation of fabric; 6) collection and growth of native materials; 7) planting; and 8) monitoring. The application for a Reclamation Board permit will be initiated at funding (if not before). The installation of the biologs and fabric will be initiated in the fall of 1997 (along with an additional installation in 1998). It is anticipated that these materials will capture sediment the first winter, thereby facilitating plant installation the following spring, summer, and fall. Plants will be collected in the winter of 1997-1998, used as cuttings, potted in ballast buckets, or potted in standard containers for later planting. Mapping of restoration sites (by Kjeldsen, Sinnock,& Neudeck, Inc.) will be done in the fall of 1997, as will placement of recession pins (see below). Installation of plants will begin in the early spring of 1998. Fortunately, many of the species to be used in the planting are locally available and will be used as a source in transplanting. Follow-up planting and completion of installation will occur in year two (1998). Monitoring will begin in year two and will be complete in year three. Progress reports, detailing work completed to date and the financial status, will be submitted quarterly.

F. Monitoring and Data Evaluation

Generally speaking, biotechnical methods can be cost effective compared to hard construction techniques. However, they can become expensive if considerable labor is required. A goal of the Tyler Island restoration project is to use those techniques that are cost effective. We will test various approaches, keeping track of and reporting the hours required for particular kinds of installation. This information will become part of the financial monitoring program.

Research level monitoring will form an integral part of the project. Restoration projects will be laid out as formal experimental designs (with replication) to permit quantitative comparisons of the effectiveness of the different restoration strategies (treatments) on erosion control, plant survival and growth, and habitat quality (as measured by fish and macro-invertebrate populations). Non-treated (i.e. control) sites will be included within the experimental designs to permit comparison to a "do-nothing" strategy. Use of proper replication and experimental design will allow treatment effects to be examined across a variety of sites and conditions, possibly including: reach position (e.g., upper, lower end of Georgiana Slough); subreach (outside bend, inside bend, straight); orientation to wind (for wave relationship, e.g., long fetch, short fetch); level of ambient wave action with respect to boating (correlated with boating speed); initial vegetation characteristics (density and architecture of vegetation); texture of embankment materials (sandy/clayey); bank slope; and presence of recreational access.

For the coir biolog treatments, volumetric samples will be removed before and after flooding events throughout the implementation and study period to monitor sediment entrapment by the biologs. Before and after photos on revetment site research plots will be taken to compare flood impacts on the amount of soil cover across treatments. Erosion/deposition will be monitored on soft-bank sites through the use of recession pins at restoration and control (non-treated) sites. Recession pins are long nails or spikes (pins) that are inserted at equal distances

from each other in a straight line parallel to the bank face and sufficiently deep into the bank so that they are not lost during bank failure. Midway between each pin and the bank face, alignment pins are secured to assure that the measurements stay along the same line over time. To document deposition, washers are placed below the head at the level of the existing bank surface. The pins will be surveyed at various times of the year (monthly) as well as after major hydrological events (e.g., winter storms).

Indicators to be measured to assess the success of habitat improvement will include 1) plant survival; 2) plant cover; 3) physical habitat heterogeneity as determined by spatial heterogeneity in cover types (e.g., rock, soil, vegetation) and the complexity of hydraulic flow patterns; 4) abundance and distribution of macro-invertebrates ; 5) water quality monitoring of temperature, dissolved oxygen, total dissolved solids, and transparency; and 6) direct countings of fish (using non-lethal seining techniques). These measurements will be made periodically in treatments and controls in all habitat types.

G. Implementability

This low-tech but innovative project has received the approval and support of the local Reclamation District (RD No. 563). It will require very little regulatory approval. The proposed project would take place on levees under the jurisdiction of Reclamation District 563. For the Mokelumne River site, all work would occur on a non project levee. Since this project involves only the placement of fabric on the embankment and the installation of plants, it is anticipated that a permit would be only necessary from the Reclamation Board as a prerequisite for work to begin. On Georgiana Slough, the work would be done adjacent to a project levee, but entirely on the embankment area. A Nationwide Permit, required by the U.S. Army Corps of Engineers, would be required. Approval by the Reclamation Board for notice and approval of levee maintenance would also be required.

IV. Costs and Schedule to Implement Project

A. Budget Costs.- Table I, II and III show the estimated costs of the tasks described in the Scope of Work section. Funding for this project and subsequent monitoring are requested from CALFED Category for 100 percent of the total cost. However, it is estimated that funding may also be obtained from Department of Water Resources Delta Levee Subventions Program, in which case the amount request from CALFED would be less.

B. Schedule Milestones. H.A.R.T., Inc. anticipates beginning restoration in late fall, 1997. The following schedule is proposed: 1) obtaining Reclamation Board Permission; 2) development of specific experimental and monitoring designs; 3) purchase of biotechnical fabric material; 4) survey and assessment of pre-project (baseline) conditions, including existing vegetation, water quality, fish, and invertebrates;

5) installation of fabric; 6) collection and growth of native materials; 7) planting; and 8) monitoring.

D. Third Party Impacts.

There are not anticipated third party impacts.

V. Application Qualifications

This project will be delivered by Habitat Assessment & Restoration Team, Inc., (H.A.R.T., Inc.). , a company that has been established to bring a strong scientific basis to restoration. Jeffrey A. Hart, Ph.D., will serve as project manager. Jeff has had 30 years experience in environmental biology, having worked on several continents in the area of forestry, botany, wildlife biology, genetics, scientific research, arboriculture, and restoration. He graduated in environmental biology from the University of Montana (1971), and holds graduate degrees from University of Montana (1974) and Harvard University (1983). He has published in leading refereed journals, and has taught courses, including restoration ecology, at several universities. In the Sacramento region, he has had considerable success in designing and implementing restoration projects (e.g., Stone Lakes National Wildlife Refuge), biotechnical projects (e.g., Dry Creek, Lower American River), and resource studies (e.g., Cosumnes River, Lower American River). His clients include mostly government agencies and non-profit organizations such as the Sacramento Area Flood Control Agency, Sacramento County Water Resources Division, Ducks Unlimited, and The Nature Conservancy. Hart has successfully completed restoration contracts with Ducks Unlimited (contact Jim Well at 852-2000), and has made considerable progress with the CalTrans Beach Lake Mitigation site (call Dave Wyatt at 324-6634).

To assist in the implementation, planning, technical, and monitoring components, several key people and business entities will work in cooperation with H.A.R.T., Inc. These include:

Gary and Greg Kirtlan (Kirtlan Bros.) will serve as lead job supervisors in directing the planting and installation crews. Gary Kirtlan (contractors license #603638) has successfully worked for Hart as foreman over the last 2 years. L and F Labor Contractors (California Labor Contractors License #4619) will provide the bulk of the human labor to install the plants. These crews have been responsible for past work at Stone Lakes and will work under the direction of Kirtlan Bros. and H.A.R.T. employees.

Tyson Holmes, Ph.D., will assist and/or direct many of the aspects of the experimental design, plant monitoring, sediment-deposition monitoring, and statistical analyses. Tyson Holmes has served as research-design consultant to various terrestrial and aquatic ecosystem management and restoration projects. His clientele includes public agencies, private non-profits, consulting interests, and universities.

Stephen Shaner, received his Ph.D. in Biological Ecology in 1981 from the University of California at Davis, where he studied Crangonid and palaemonid shrimps in the San Francisco Bay and delta. He has taught invertebrate zoology and marine biology at several universities, and

is currently on the University of California extension faculty. Dr. Shaner has worked at the Regional Water Quality Control Board (Region 5) and the State Water Resources Control Board, and for the last 11 years has been an environmental consultant for projects in freshwater, estuarine, and marine systems. Dr. Shaner will be responsible for invertebrate monitoring for this project.

Michael McGowan, Ph.D. is a fisheries ecologist with academic and consulting experience in juvenile salmon migration in the Mokelumne / Georgiana Slough area of the Delta. Mike has researched and published on fishes, taught limnology at the university level, and established water quality monitoring programs in the S.F. Bay area. He is a participant in the Interagency Ecological Program's Estuarine Ecology Team and a member of the San Francisco Bay Estuarine Habitat Goals Fish Focus team.

Steve Sinnock, of Kjeldsen, Sinnock, and Neudeck, will provide surveying and mapping services.

Reclamation District 563 has given approval for this project, including all design concepts. They will be kept abreast of all developments, including quarterly reports.

VI. Compliance with standard terms and conditions

The applicant will comply with standard terms and conditions, including Items 8, and 12 that are provided in the RFP.

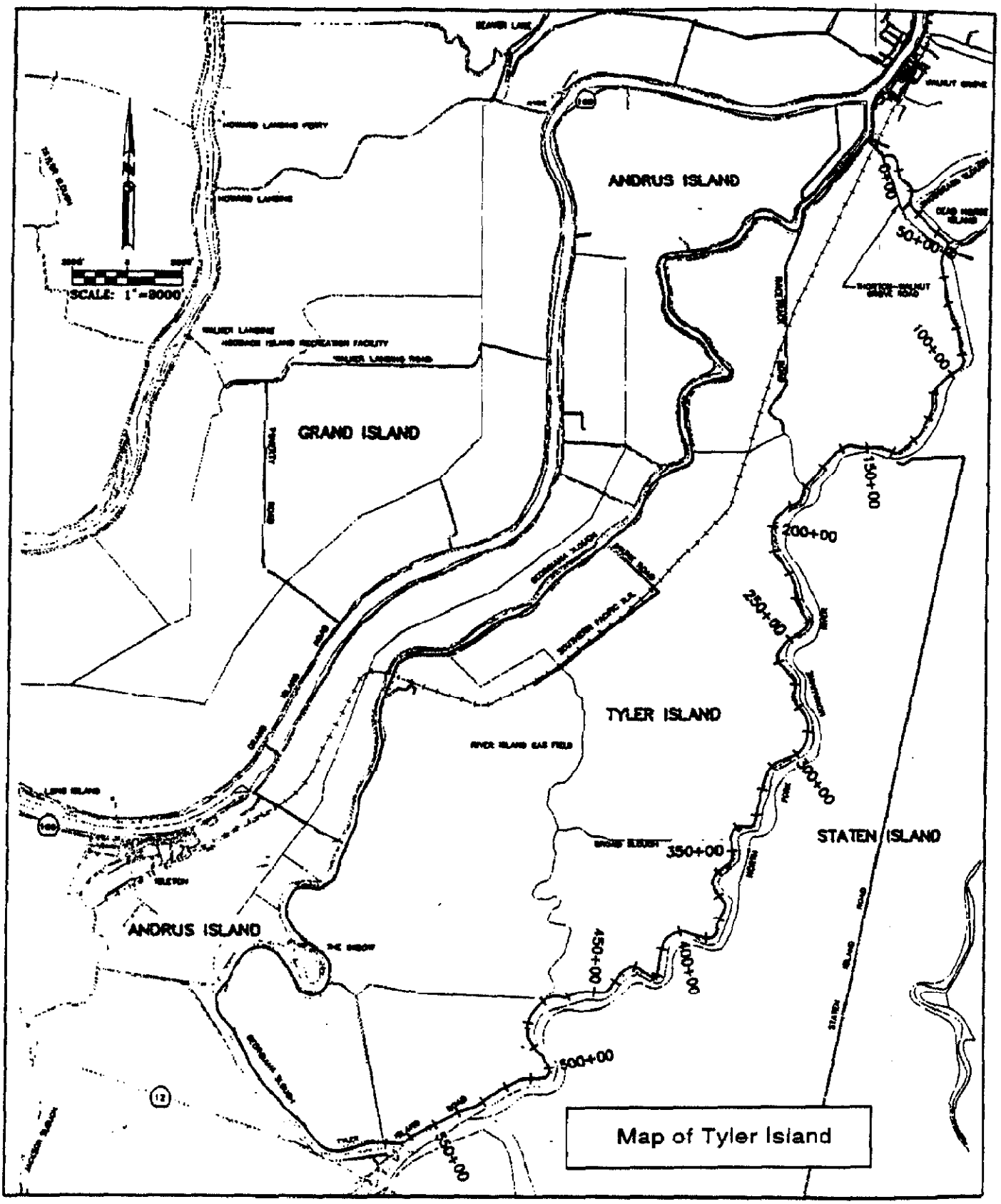

Figure 1

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Tyler Island Restoration

Erosion Control Coupled with Habitat Improvement

Above: The embankment portion of the Mokelumne River consists of 10.7 miles of reveted upper slope, much of which has a low berm that is exposed at low tide. The plans for the upper, reveted slope include the direct installation of plants into the rock interstices and the use of coir fabric with straw mulch to aid sediment entrapment. The upper slope of the revetment will be planted with low growing graminoids (e.g., sedge and wildrye), wild rose and other plants that will provide (limited) habitat but importantly will serve to stem erosion and facilitate sedimentation, thereby enhancing levee stability. A limited portion of the base of the revetment slope is available for SRA plantings, and isolated stands of alder, ash, and tule are suggestive of habitat potential. To guarantee success of tule plantings in the tidally inundated, low berm mudflat environment, a new technique utilizing **ballast buckets** will be used for plant establishment (see following description).

Above: Georgiana Slough is rather unique in the Delta in the extent of its non-reveted, soft bank. The restoration goal will be to utilize biotechnical bank protection measures to conserve the existing soft bank and enhance them by encouraging deposition (and simultaneously discouraging erosion) through the use of plants and organic fabric materials. The principal technique for erosion control will involve various combinations of coir fascine, or "biologs", ballast buckets, brush boxes, and brush layering techniques. These approaches will both protect levees and improve habitat values.

Figure 2

Habitat Assessment & Restoration Team, Inc.

Tyler Island Restoration

Establishing Plants On Revetment:
An experiment conducted on the Lower American River by Hart & Holmes.

Above: The first step was to direct soil, using a pressurized water hose, into the riprap.

Some of the sites were covered with coir (coconut) fabric, placed in shallow trenches, and anchored with rocks.

In the plots lacking coir, plants were installed in the soil between the rock.

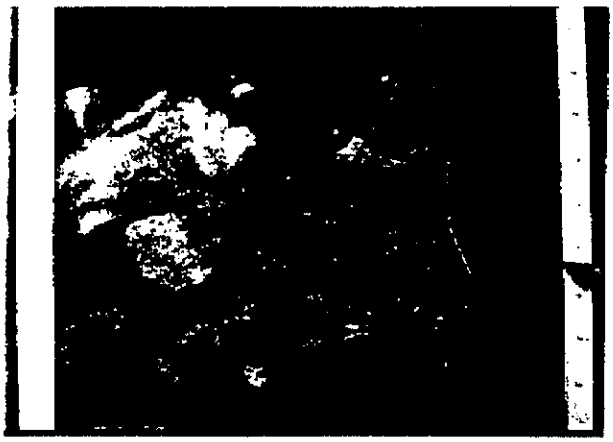
In plots having coir, the plants were installed through the fabric.

Figure 3

Habitat Assessment & Restoration Team, Inc.

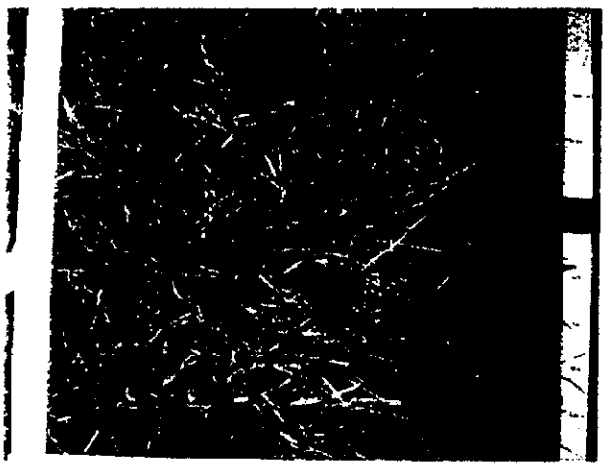
Tyler Island Restoration

Experimental Procedure Different combinations of sedge, annual grasses, coir fabric, and an inner blanket were employed to test the relative effectiveness of the different treatments After more than 3 months of flooding, the following results were observed.



The control plots, using soil alone: →

Average percent rock cover went from 20% to 84% that is, a 64% loss of soil cover.



In plots with annual grasses →

Average percent rock cover stayed about the same, approximaely 20%; thus neither erosion nor deposition occured.

In plots in which only sedge was planted. →

Average percent rock cover was 55%, a loss of about 25% soil cover

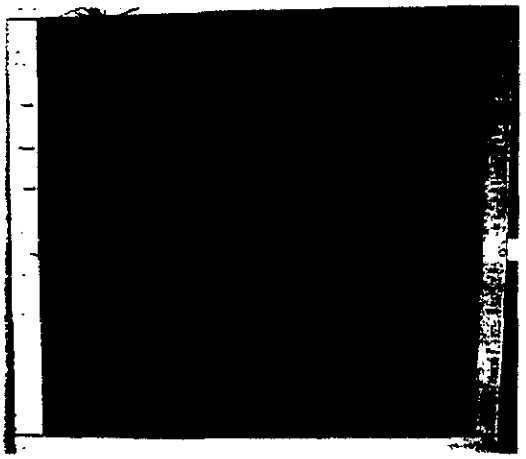
Figure 4

Habitat Assessment & Restoration Team, Inc.

Tyler Island Restoration

The addition of coir fabric to the experimental design resulted in significant gains in deposition

The application of coir + annual grasses → Resulted in considerable deposition, with percent rock exposed after flooding averaging 9%., an 11% decrease of rock exposed.



The application of coir + an inner blanket + annual grasses + sedge → Resulted in increased deposition, with percent rock exposed after flooding being only 1%, a 19% decrease of rock exposed.

Conclusion: The greatly diminished habitat values on riprap and similar materials have been of great concern to the environmental community; understandably. successful methods in vegetating revetment sites would offer considerable opportunity for creating riverine habitat values in the Delta. To date, successful establishment efforts have been marginal. The results of these experiments highlight the importance of herbaceous plants and landscape fabric in providing the amount and quality of roughness necessary to protect revetment sites from scour and to encourage sediment deposition, conditions necessary for successful riverine habitat restoration.

Figure 5

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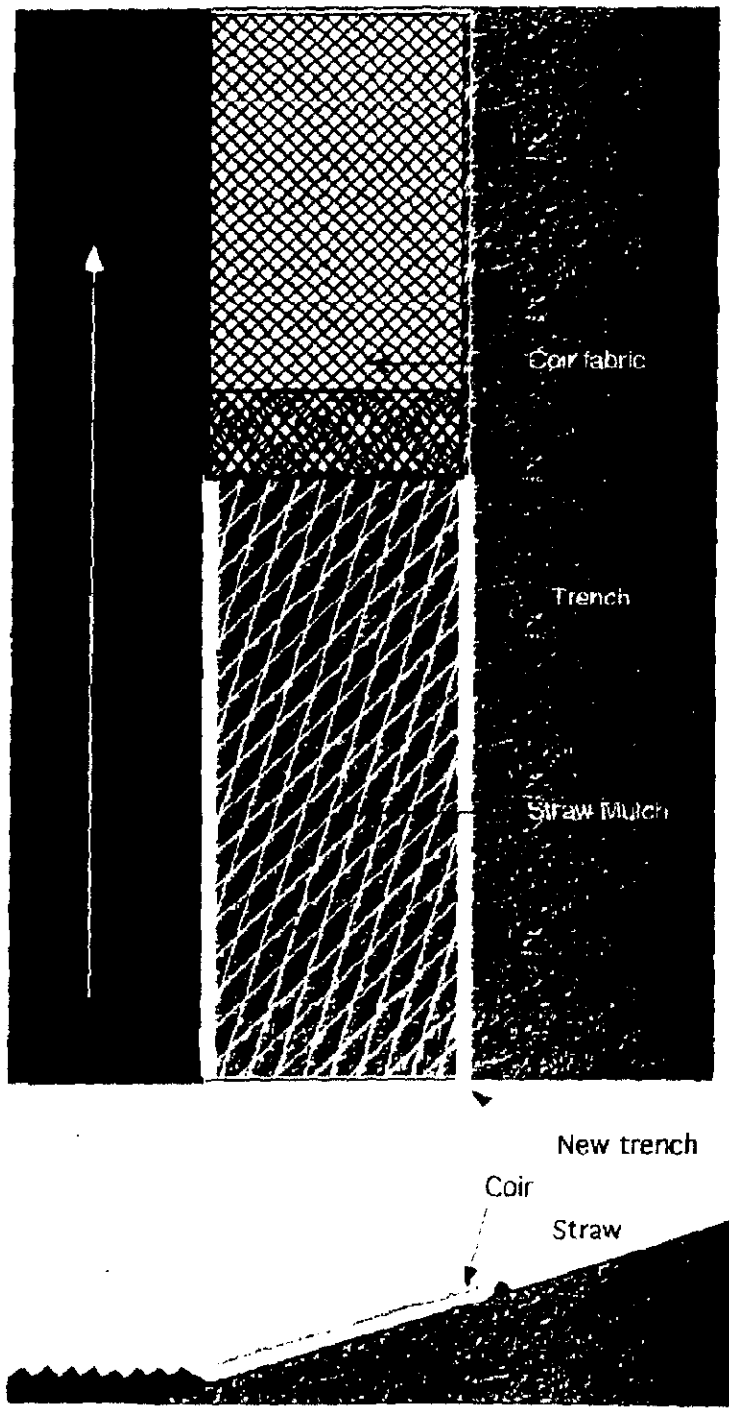
Tyler Island Restoration

Sequence of Techniques for Revetment Restoration.



Step 1

Add soil to rock interstices, if necessary.

Step 2.

Trench the perimeters for later placement of coir.

Step 3.

Seed with annual grasses

Step 4.

Apply straw mulch.

Step 5.

Place coir into trenches, beginning at downstream end, and roll onto slope to secure onto site.

Step 6.

Place rock / soil matrix back onto top of coir material for anchoring

Step 7.

Trench new section on upper slope for securing fabric.

Step 8.

Install the appropriate plant species.

Figure 6

Habitat Assessment & Restoration Team, Inc.

Tyler Island Restoration

Ballast Buckets:
A New Technology For Establishing Plants in Riprap

Some plants (A), having their roots entwining a rock and soil matrix, are able to grow in hydraulically challenging riverine environments. To mimic these successfully established plants, a new technique called "ballast buckets" has been invented by H.A.R.T. This involves the use of a mixture of scoria lava rock, soil, and plant material in biodegradable, organic buckets.

Ballast buckets can be planted in various mixtures of rock, either in the water or at the water's edge. Their initial weight anchors the plants, thus facilitating survival under extreme current flow. The roots will gradually grow out from the decaying bucket, thus further anchoring the plant to the substrate. These techniques will be used on both the Mokelumne River and Georgiana Slough portions of Tyler Island.

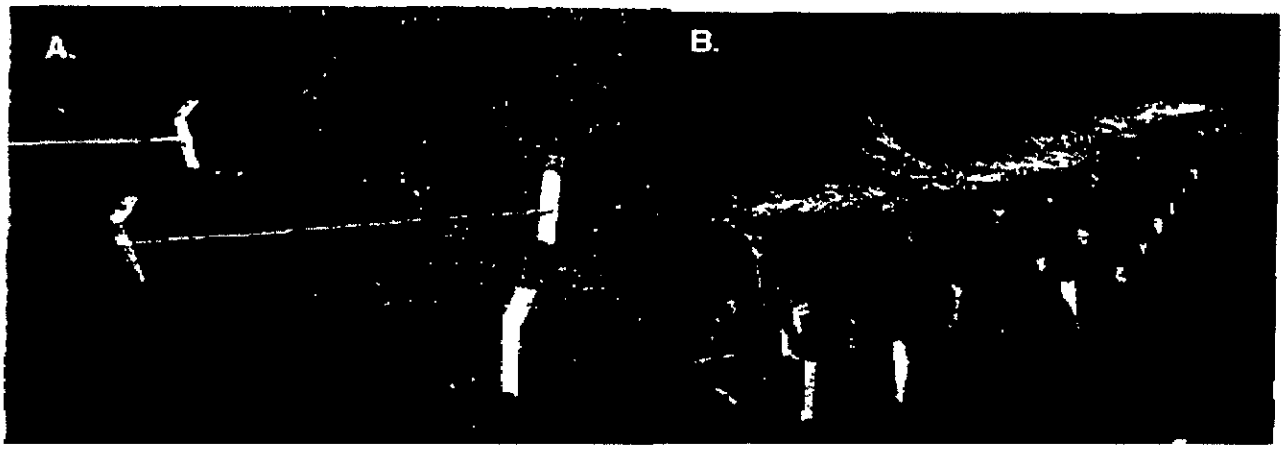
Figure 7

Habitat Assessment & Restoration Team, Inc.

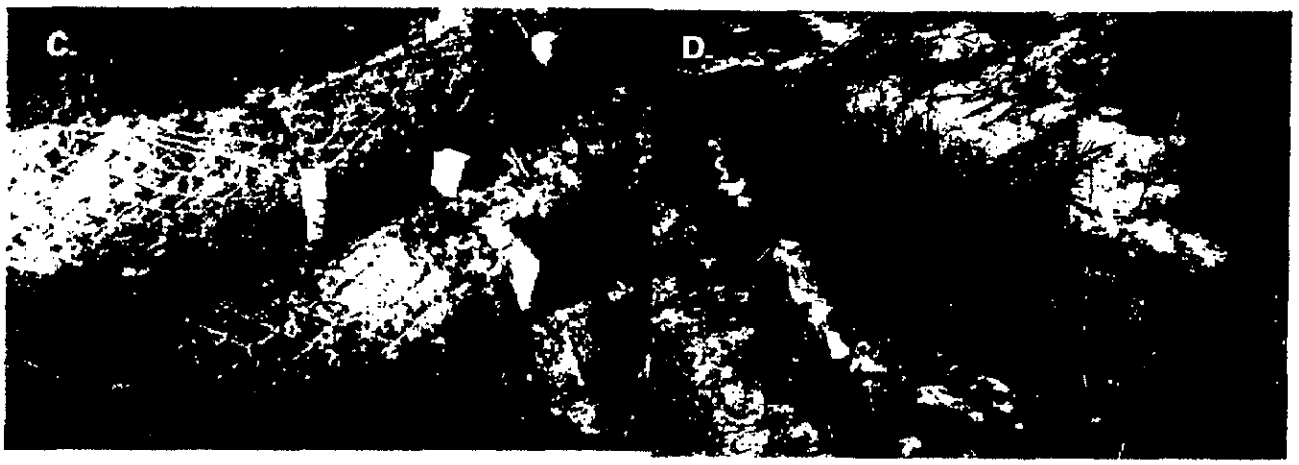
Tyler Island Restoration

Biologs

The installation of biologs on Georgiana Slough will aid bank protection and foster habitat creation.



Biologs are rolls or "logs" of coconut fibre material, fastened to embankments for protection against erosion. A. The rolls are placed in soil trenches Tapered stakes are placed on opposite sides of the rolls and partially driven into the soil at approxmately 3-4 foot centers. Twine is attached to the ends of the stakes, and then the entire stake and twine system is driven into the soil, thereby securing the roll into the soil. B. Note that several rolls can be used together.



C Plants can be planted directly into the rolls. D Biologs attract considerable deposition. After one flooding season they can become entirely filled with sediment, thereby creating ideal conditions for plant growth.

Figure 8

Habitat Assessment & Restoration Team, Inc.

Materials & Installation			
Item	Number	Unit Price	Cost
Ballast Buckets	3000	$25.00	$75,000
Installing ballast buckets	3000	$10.00	30,000
Coir blanket, materials and installation (6.5 ft. X 3,000 ft. long)	2000 ft.	$2.00 sy + shipping	12,000
Purchase of plant material	15,000 plants	1.35	20,250
Local transplanting of plants (labor)	5,000 plants	$5.00	25,000
Transportation of materials			7,500
Straw: 200 bales		2.75 per bale	550.00
Tools			2,000
Foreman supervision			30,000
Maintenance, Years 2 and 3 years			
Weeding, watering, replanting, including Foreman Supervision and work crews			30,000
		Subtotal	$232,300

Materials & Installation			
Item	Number	Unit Price	Cost
Coir rolls (biologs), average of 3 rolls	6,000 ft.	$6.00/linear foot	36,000
Stakes two 30" half stakes (tapered) every 4 ft.	4,000	2.37 per 8'	3,168.69
Stakes - labor	4,000	Cutting & installed	12,000
String and other materials			1,500.00
Installing biologs	6,000 ft.	3.00 linear ft.	18,000
Planting biologs (1 ft. Centers, transplanting)	$18,000	$5.00	90,000
Other plantings (purchased)	2000	1.35	2,700
Willow cuttings/brush matting	10,000	$1.00 / cutting	10,000
Ballast buckets	500	$35/bucket	17,500
Transportation of materials			7,500
Workboat for transportion +gas & maintenance			10,000
Kirtland Supervision			30,000
Maintenance, Years 2 and 3 years			
Weeding, watering, replanting, including Foreman Supervision and work crews			20,000
		SubTotal	$258,368.69

[redacted]		
Materials & Installation		
Personel	Tasks	Cost
Jeffrey A. Hart & Staff	Management/Field Supervision	$30,000
	Coordinate Scientific Monitoring	30,000
	Field Assistance	15,000
	Quaterly Report writing	20,000
	Office Management/Accounting	20,000
[redacted]		
Tyson Holmes	Research/Design Scientist	20,000
Steve Shaner	Invertebrate Monitoring	30,000
Michael McGowan	Fish Monitoring	30,000
Kjeldsen, Ssinnock & Neudeck, Inc.	Aerial photogammetry; topographic mapping, surveying	52,000
	Subtotal	247,000
	Subtotal from Tables I	$232,300
	Subtotal from Tables II	258,368.69
	Direct Cost Subtotal	737,668.69
	Overhead and Profit 20% (H.A.R.T., Inc.)	147,533.60
	TOTAL	$885,202.29