Fifth, the manufacturers of fence materials will be a valuable source of experience and advice.

(b) Fence Design - Engineering

The principal engineering parameters which define a fence are

1. Height of Fence, H
2. Length between posts, S
3. Embedment depth of posts E
4. Permeability of curtain P
5. Material to be used in curtain, in posts, in anchors and in guys.
6. Orientation of Fence relative to wind (if fence is straight)
7. Shape of fence if not straight.

Parameters through 7 must await the results of research to be conducted in the first phase of the Owens project, although experience and preliminary investigations have already been conducted into item 5 and indicate that an all plastic fence system is probably the best.

Parameters 1 through 3, while also based partly on the results of previous research, will be determined by calculations based upon well established principles of mechanics. This will require information on the materials properties of both the fence materials and the soil at the selected fence locations. This information will be determined by laboratory testing at UCD of samples of fence making materials and of soil from Owens Lake. These tests will be augmented by tests on full scale fences installed at UCD followed, if necessary, by tests on full scale fences on the Owens lake bed. Professor White is investigating the possibility of using a transportable wind machine to expedite such tests.

In view of the extensive amount of fence which are envisaged it is anticipated that the design process will involve an iterative process in which calculations based upon wind tunnel tests will be used to produce prototype designs which will then be evaluated and, if necessary, modified prior to installation.

(c) Installation Methods for Fences

The first phase of the fence investigations will involve relatively small lengths of fences designed primarily to verify the results of the wind tunnel tests and previous experience on the lake bed. Such lengths of fence may be installed by hand and with a relatively inexperienced crew with little need for exceptional efficiency or speed. However when full scale fence placement is undertaken, this will clearly change. It will then be possible to save much money and time by designing a highly coordinated procedure for transport and installation of the fences. While the detailed investigation of this aspect of fence installation will not be undertaken until the next phase of the project, preliminary ideas and prototype equipment will be developed and filed for future reference and use.

(d) Economics of Fence Installation

The full scale remediation effort which is planned will require many miles of fences which will represent one of the major costs of the remediation program. Even small savings per unit length in the cost of the fence or of its installation will return enormous savings over the long range effort required at Owens.

It is anticipated that the most economical method of installation of fencing will involve an automated process utilizing a specially designed piece of moveable equipment which works in conjunction with a trained team of human workers. The design of this equipment will be initiated during later stages of the project.

(e) Logistics

The installation of what may be hundreds of miles of fencing in a remote desert site creates many special problems, among which may be mentioned:

1. access to the construction sites,
2. storage and protection of equipment and supplies,
3. production of special equipment to facilitate fence installation,
4. surveying to establish fence locations and to locate personnel and equipment on the lake bed, and
5. provision of human needs for personnel installing fence.

Each of these items will present a problem to be solved. Some individual problems are discussed below. Undoubtedly others will arise as the project continues.

Access to Lake Bed

The conditions on the lake bed can vary from "a crust which is rock hard," through "sticky mud" to "standing water." Obviously it will be a difficult task to move equipment around under such a variety of conditions. Three approaches may be adopted. In one method, a series of roads could be created which will remain accessible (for chosen equipment) through most weather conditions. In the second, a variety of transportation devices could be designed and constructed, each device being designed to be usable under one set of surface conditions. In the third approach, a combination of the previous two is used. The optimum solution may be arrived at my discussions with those who have the most experience of traveling on the lake bed and with the designers of equipment for such conditions. Some possible devices range from simple balloon tires to ground-effect machines, helicopters and airships.

4) TASK 92-A: Alternate

Project 92-A: Alternate replaced 92-E (Addendum) with all parameters identical, including cost. (See above, 92-E Addendum)

Description:

A series of four fence/dune arrays, roughly in a linear direction down the playa slope, each up to 3/4 mile long, but curving to match terrain and possessing some randomization in length and placement, be used between the GBUAPCD wetlands plots on the north sand sheet (see plan). Estimated total fence available (after returning the UCD/SLC fence fund to $50,000) - about three miles.

Work Plan:

Project 92-A (Alternate) replaces 92-E (Addendum) with all parameters identical, including cost (see above, 92-E Addendum).

Purposed Work Plan:

1. A series of fences/dune arrays, up to 3/4 mile in length, could provide significant modification of saltation and dusts. This would allow us to make sand migration measurements, PM-10 measurements, and photographic observations of dust both before and after the wetlands are emplaced. This would greatly aid our design of future arrays, as well as assisting the GBUAPCD's evaluation of the effectiveness of their program.

2. Any mechanical disturbance of the surface by berming, etc., of the GBUAPCD wetlands tests is a potential source of salting coarse particles that could generate PM-10 dusts, increasing downwind PM-10 and confusing the results of the tests, especially the later dust suppression component. The fences would replace much of the need for berming and suppress dusts from any berming necessary.

3. Upwind saltating particles brought into the array from the northwest will make the first fence, on the northwest edge, different from downwind fences.

4. The resulting dunes, even if very low, could be used for road access to the test plots even when water is present in the plots themselves.

5. Any accidental generation of fluffy crust in the wetting/drying cycle would be protected from abrasion even when water is not present.

6. The resulting dunes would provide some topography in direct contact with water, with potential for the vegetation tests in future years.

7. The fence/dune arrays would be "proof in place" that a serious pilot scale pre-mitigation tests is in progress during 1992, while the pumps and piping are being designed and built.

8. A series of 4 fence/dune arrays, approximately 3/4 miles in length, could provide significant modification of saltation and PM-10 dust. This would allow us to make sand migration measurements, PM-10 measurements, and photographic observations of dust both before and after the wetlands are emplaced. This would greatly aid our design of future arrays, as well as assisting the GBUAPCD's evaluation of the effectiveness of their program.

9. The emplacement of the arrays in the north area was presented on January 10, 1992. Task 92-A: Alternate meets some of the stated goals of the original proposal, Tasks 92-A and 92-B (Figure 6).

10. I could honestly say that, in my opinion, there is nothing that one could do as quickly or cheaply to reduce Keeler violations of PM-10 than place these fences.

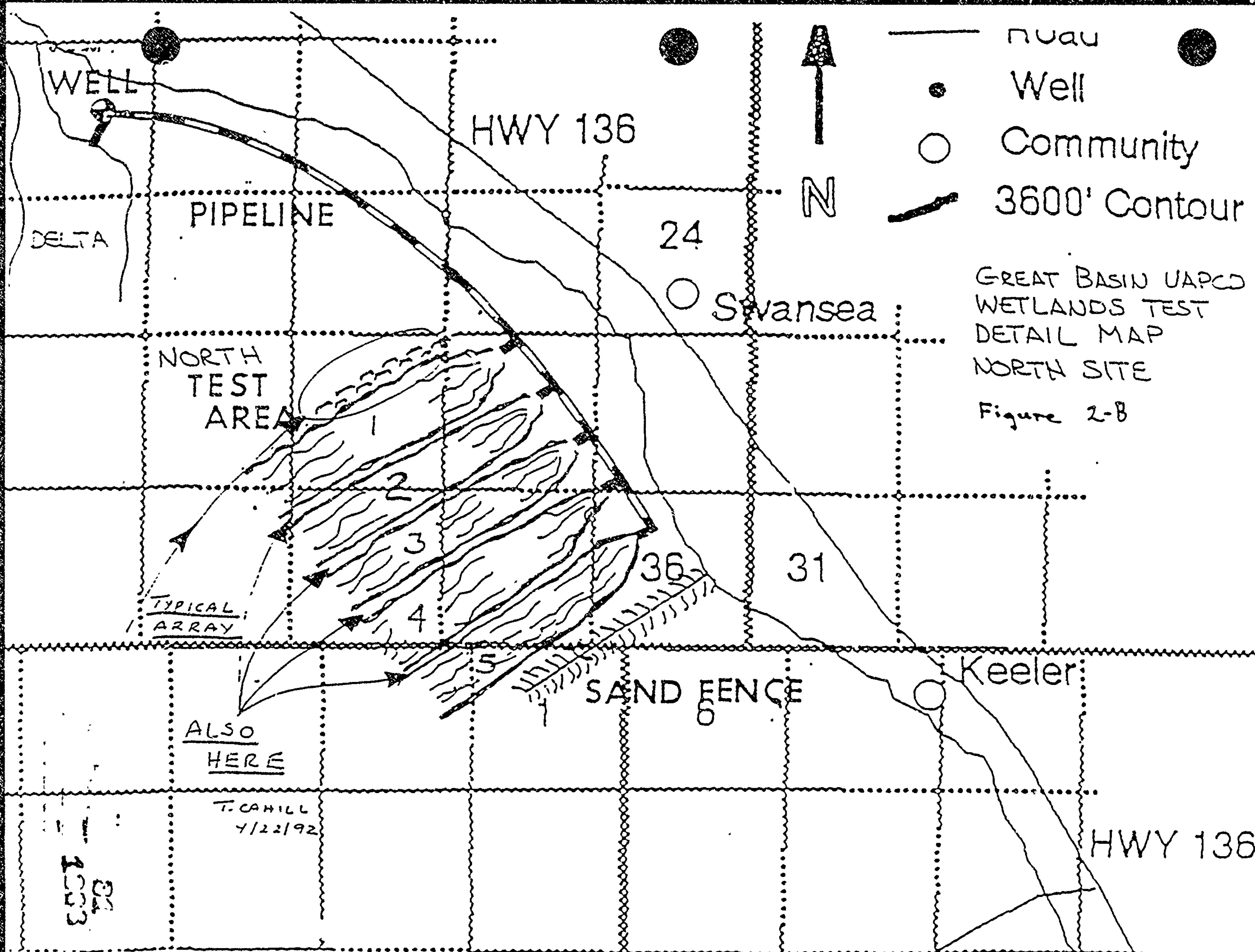
However:

1. The diversion of so much fence north will make the south arrays less extensive and thus decrease the value of the array tests.

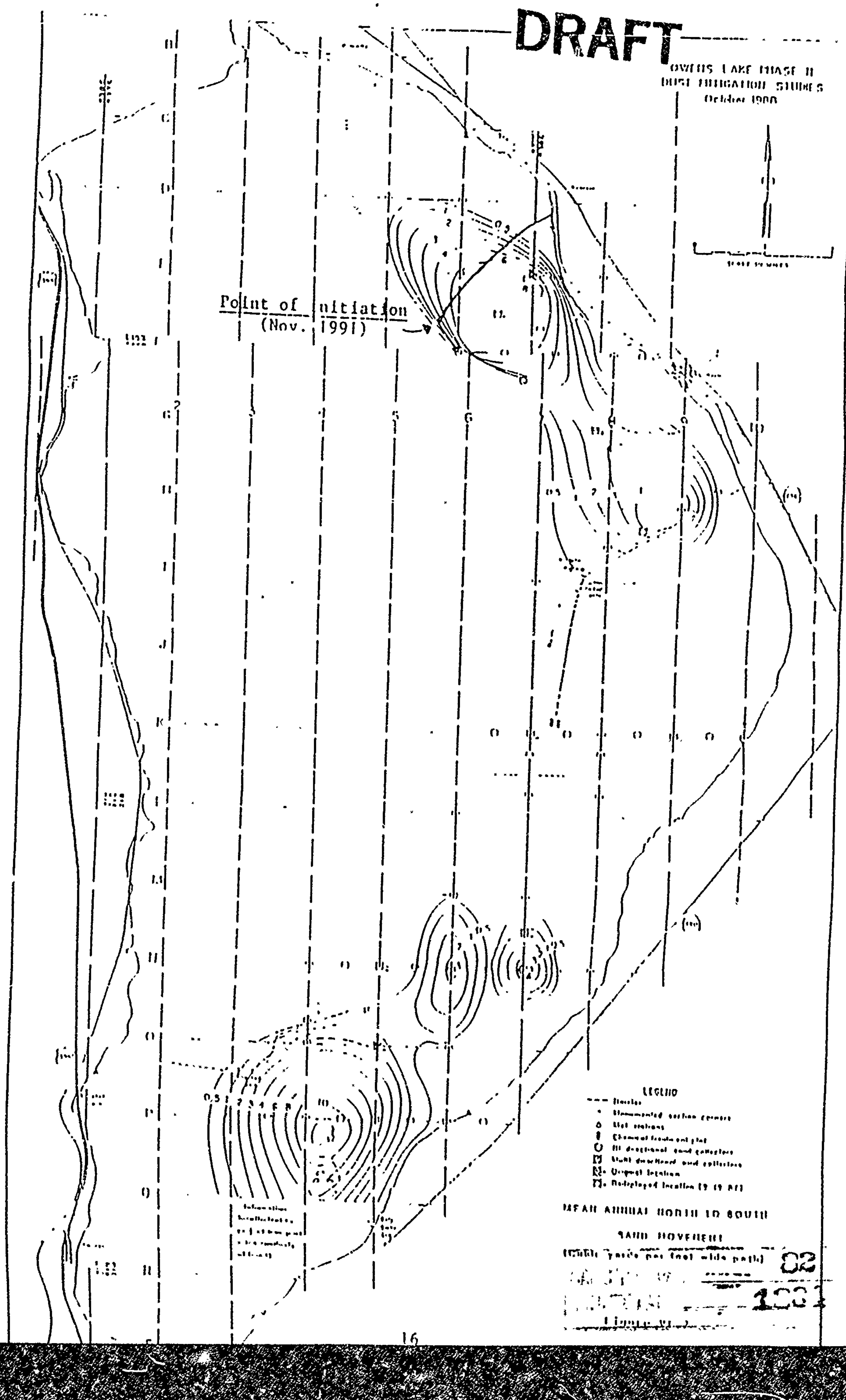
2. We are not sure that we can get that much construction done in Fall 1992. Some of the benefits of the fence/dune barriers would be reduced if they could only be built in Spring 1993.

3. We could not provide as detailed evaluation of these fence barriers as we had planned for the arrays (now in the south) without diverting efforts from that area.

4. The wetlands plots would be fixed in location by the dunes, and some future plans could be thwarted by the artificial relief.



Road
Well
Community
3600' Contour
N
GREAT BASIN UAPCD
WETLANDS TEST
DETAIL MAP
NORTH SITE
Figure 2-B
WELL
DELTA
PIPELINE
HWY 136
24
Swansea
31
36
1
6
NORTH
TEST
AREA
1
2
3
4
5
TYPICAL
ARRAY
ALSO
HERE
SAND FENCE
Keeler
HWY 136
T. CAHILL
7/22/92


DRAFT
OWENS LAKE PHASE II
DUST MITIGATION STUDIES
Point of Initiation
(Nov. 1991)
LEGEND
MEAN ANNUAL NORTH TO SOUTH
SAND MOVEMENT

7) TASK 92-D

Description:

Enhancing the sulfate well riparian corridor by emplacement of sand fences, redirection of water, and test planting of locally derived vegetation.

Purpose:

1. Extensive survey of existing vegetation on or near the Owens Lake playa in its full ecological setting, including:

    a. Vegetation
    b. Physical environment
    c. Chemical environment

        i. Soil
        ii. Water
        iii. Wind Protection

2. Collection of test samples for cultivation at UCD and in the playa.

3. Evaluation of the sulfate well area, which has been mitigating dusts for decades, generating a riparian corridor, and serving as a home to wildlife. It is our model for the future of the Owens Lake bed. We wish to evaluate how much additional effort is needed to enhance its effectiveness.

4. The sulfate well corridor lies upwind of Keeler on the southern dust storms more common in spring. Any mitigation in this area will reduce PM-10 dusts in such events, but the scale is too small for any serious effect 1992-1993.

5. We need data on revegetation efforts on the lake bed and the waters of the sulfate well may be a good model for future well-supported riparian corridors.

6. A good production well is available to provide the additional water for a future enhances riparian corridor.

7. Should be far enough from Task 92-A:Alternate and the GBUAPCD wetlands tests to not affect those tasks.

Oversight: Tom Cahill, Don Nielsen, Jim Richards, Cathy Toft, Susan Ustin; Mei Ling Yau

Work Schedule:

1. Survey of vegetation 7/1/92 - 7/1/93.

2. Detailed mapping of existing water flow patterns, barriers, etc. 7/1/92-7/30/92.

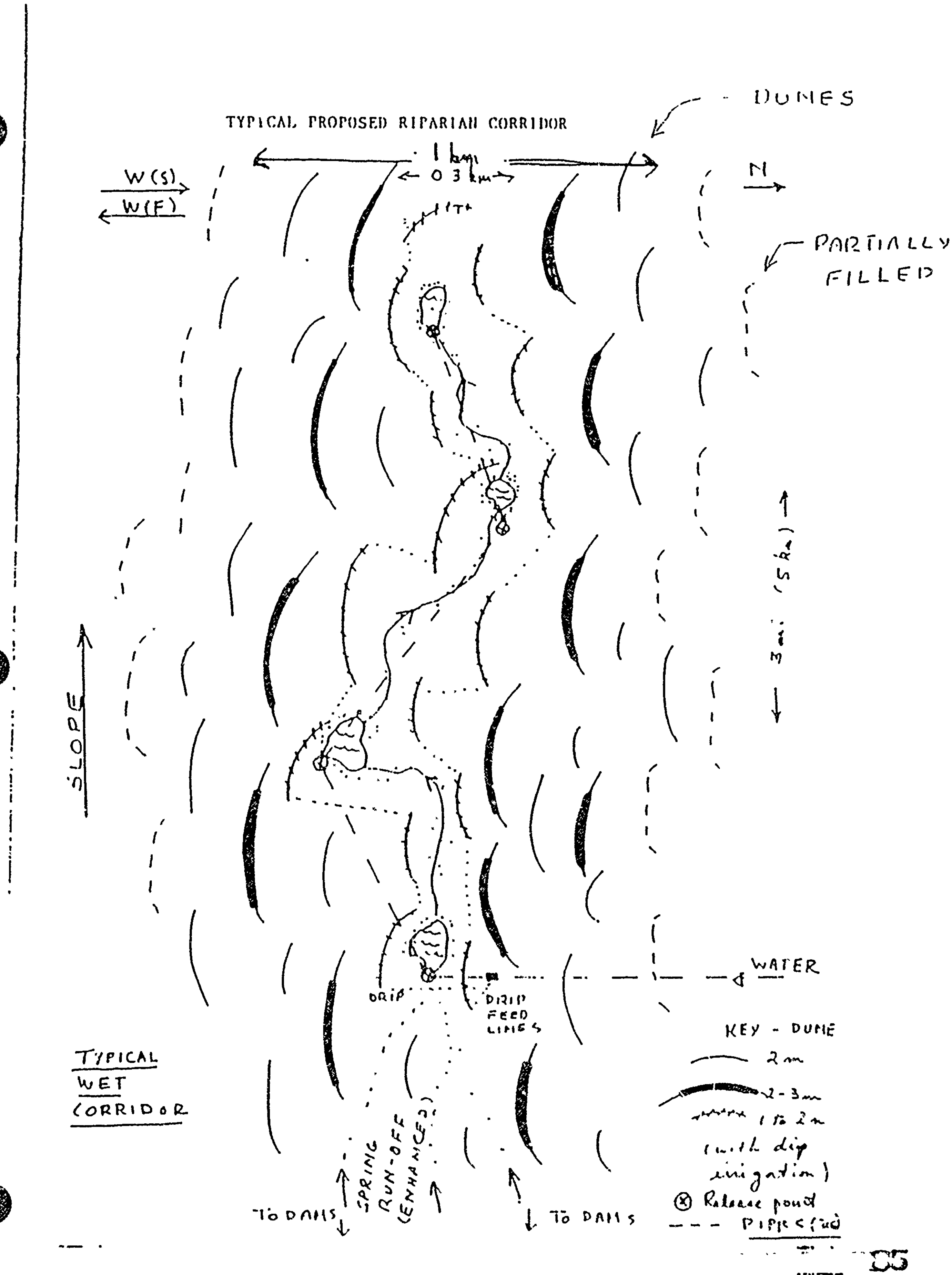
3. Placement of sand fences west to the sulfate well to form a protective barrier for plantings 8/1/92-10/1/92 (note: may draw resources from the western team, based at Olancha, for this task).

3. Engineering evaluation of water course changes along historical channels (8/1/92-10/1/92).

4. Establishment of vegetated test plots along the corridor using locally-derived vegetation (9/1/92-9/1/93).

5. Evaluation of Dirty Socks Well wetlands as the basis for a dune-stabilized riparian corridor (9/1/92-7/1/93) (Figure 7).

TYPICAL PROPOSED RIPARIAN CORRIDOR



GENERAL PROTOCOLS FOR TASKS

PROTOCOL 1: All requirements and deliverables of the California State Standard agreement ARB A-132-105 Owens Lake, California Air Resource Board, 2/10/92 - 8/9/93 are hereby incorporated by reference.

PROTOCOL 2: All of the requirements in the SLC Mitigation Plan are hereby adopted in full, and will be part of any sub-contracts.

PROTOCOL 3: Before deployment of any sampling or test procedures, a complete literature review will be performed in order to ensure that the optimal techniques will be utilized. It may be necessary to modify previously-suggested techniques if review indicates that a different technique may be more effective.

PROTOCOL 4: On-Site Sand Fence Construction: Stewardship.

We are keenly aware that any operations on the lake bed have the potential to increase dust generation through destruction of the existing surface crusts, enhanced erosion/ degradation of the lake bed, etc. Therefore, all access and construction activities at the north site must be strictly controlled, as any disturbance of the crust of the lake bed can influence subsequent measurements. For this reason:

4.1 All construction activities shall do minimal damage to existing crusts. In particular, access trails to sites shall be clearly mapped out and followed.

4.2 Fence emplacement shall always commence at the edge closest to the salt pan and work up-slope. The fences shall be built directly upon the access road itself, which will then be blocked by the fence and its guy ropes.

4.3 Whenever possible, only a single trip shall be required for each fence emplacement, after which no visits shall be made by heavy equipment to the fence unless required by fence failure.

4.4 Only a severely limited number of access points shall be allowed giving access to the test array area of the playa, and each shall be barred by a locked gate and explanatory signs. Only a single access road will be used for all activities if possible. Every trip along this road by any vehicle will be logged, and signs will be posted at the control point. A log will be kept at this location and in the central control office (see Figure 1).

4.5 Within the test site, an attempt will be made to make all roads lie along future fence lines, so that wherever there is broken crust, there will also be a future dune (see Figure 1).

4.6 An absolute minimum of vehicular activity will be allowed beyond the test section further southwest of the fence array. We will cooperate with the GBUAPCD and all other activities to ensure that the area roughly 1 mile on each side of the fence has no other activity during this period. This conforms to the written protocols.

4.7 Any fence material that is not beige in color will be removed once the tests are concluded, if this is mechanically possible. If not, a second beige portion will be used to hide the offending portion, so that the future dunes will eventually cover it.

PROTOCOL 5: Day-To-Day Task Operations, Sequential Plan.

5.1 UCD will establish a central operations/laboratory site and supply center in Inyo County, to enhance communications with all active groups on the lake, especially the GBUAPCD.

5.2 Weekly meetings will be held beginning in summer 1992, with attendance (in person or by telephone) of:

a. State Lands Commission personnel.

b. Great Basin personnel.

c. LA Department of Water and Power personnel, or their contractors.

d. UCD sub-contractors.

e. Cooperating agencies such as the Air Resources Board, US Navy, Department of Fish and Game, Lake Minerals Corporation, etc.

We also invite specific attendance by members assigned to monitor the project by the Owens lake Task Force.

5.3 Layout of the dune array, with regard to environmental considerations, plans for future studies, obstacles, etc. Mark locations, establish access point and trails, following protocols described in Task 92-E.

5.4 Construct dune array, following the protocols described in Task 92-E, using the results of 92-F (See Figure 2).

5.5 Deploy instrumentation and equipment for monitoring saltating particles, san migration, sand depth, wind field, PM-10 generation, and related parameters upwind of, downwind of, and around the dune array, as described in Task 92-A, Category 5.

5.6 At completion of the construction phase, the monitoring and evaluation phase will begin and continue through the 1992-1993 dust "seasons" to 1/1/94.

5.7 Quarterly reports will be prepared (10/1/92; 1/1/93; 4/1/93; 7/1/93), and a final report be 10/1/93.

PROTOCOL 6: Data Gathering for Evaluation of Mitigation Effectiveness via Instrumentation.

6.1. Observation of Test Fence Area. A detailed written and photographic log will be maintained and updated for each sand fence on a regular basis (suggested term: bi-weekly upon completion of sand fence array, lake bed and weather conditions permitting. During winter months [Dec.-Feb.] of difficult conditions on the lake bed, suggest monthly visits). Information on the fence's physical condition, captured sand depth, and weather history will be recorded. Additionally, as part of the ARB study, the test area will be targeted by an automatic camera site during dust events.

6.2. Sand Level/ Dune Growth Measurement. A series of land level measuring posts to determine minor variations of sand levels will be placed throughout the entire sand fence array test plot at 100-meter intervals, soon after the test plot is established. The grid point spacing will be decreased to 50 meters forming a total database of approximately 592 points. Posts inside the experimental dune area as well as the sand fences themselves will be measured for dune growth after each moderate to large dust episode. Readings from posts in other areas will be measured monthly. Data will be analyzed, mapped and correlated to the mean wind velocity and time lapse photography (see ARB proposal) of the associated dust storms.

6.3 Windflow/Turbulence Measurement and Assessment of Test Fence Area. Three portable and two semi-portable meteorological (met) towers will be available to determine the mean and turbulent flows in and around the fence arrays. The air flow over each of the three individual study areas will be determined and compared under similar meteorological conditions. Because the flow in fence regions is extremely turbulent, severe nonlinearities exist. These nonlinearities increase dramatically at closer distances to the fences and thus surface variables such as u. and shear stress near the array cannot be determined directly. However, the mean and turbulent flows can be correlated to data derived from the Davis wind tunnel (Task 92-B), allowing a better approximation of these variables.

The met towers will be deployed in various configurations in each individual study area. Data from the different configurations will be evaluated and used as appropriate for optimization of future fence designs. Deployment of equipment and field measurements for this project will begin upon the completion of the test fence array and continue through December 1992. Data analysis will continue at least through February.

6.4. Soil and Sediment Sampling.

Surface samples of free and crusted sediments from the lake bed will be taken from sites upwind, downwind, and around the test array, and from additional sites on the Owens Lake playa. Sand collection with BSNE sand collectors and isokinetic dust collectors will be done on playa as part of the existing contract with the Air Resources Board.

Additional saltating sands will be collected with additional collectors located at the and near test fence array. Thirty-five multidirectional surface sand collectors will be installed throughout the study area, with the majority located close to the fence array: 27 throughout the experimental array, 4 located in series normal to the GBUAPCD 1-mile fence, 3 in the control area, and the remaining one in further reaches downwind of the study plot. Six additional vertical sand collectors will also be deployed along the outer boundary of the experimental dune area, two for each section of the study plot. These will have North and South oriented collectors at seven heights: 0.2, 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 meters above the ground surface. Total volume will be measured and physical samples obtained.

In addition, core samples of the dunes building up under each sand fence will be taken.

Collection of sand from the devices described above will be measured on the same schedule as the sand level measuring posts described in Protocol 5.2.

Soil and sediment sampling procedures will be followed pursuant to generally-recognized procedures described in detail in several documents including the guidebooks "Methods of Soil Analysis" by the Soil Science Society of America: "Soil Survey Manual" of the U.S. Department of Agriculture, Soil Conservation Service: the U.S. EPA document "Control of Open Fugitive Dust Sources": and soil sampling procedures taken from the document "Quality Assurance/ Project Plan for Determination of Particle Size Distribution and Chemical Composition of Particulate Matter from Selected Sources in California," prepared for the California ARB by Desert Research Institute.

Sample collection will be performed in conjunction with the other fieldwork described in this project, continuing through the Fall 1992 and Spring 1993 dust seasons. Samples will be archived at OLTG field headquarters in Lone Pine and at UCD.

6.5. Soil and Sediment Analysis. A selection of the sand and sediment samples will be analyzed for bulk chemistry by standard chemical techniques. Some samples may be analyzed by PIXE (Proton-Induced X-ray Emission) for trace element content, which can be related to other physico-chemical parameters of the sample. The particle size distribution will be determined by sieving with ASTM-approved test sieves, aqueous extraction and/or resuspension (as appropriate), and their mineralogy will be determined by optical (petrographic) microscopic examination, scanning electron microscope (SEM), transmission electron microscope (TEM) and/or X-ray diffraction, as appropriate. Other physical characteristics, including angularity, will also be measured for selected samples as appropriate

The core samples from the dune, including individual depositional layers from each dust event when discernible, will also be analyzed by a selection of the above techniques.

Analyses will be performed at UCD in laboratories of the Department of Land, Air and Water Resources, Civil Engineering, Facility for Advanced Instrumentation, and Crocker Nuclear Laboratory. Analyses will be performed as facilities are available, and can be done during the winter season when access to the lake bed is limited.

6.6. Aerosol Monitoring. Although the Mono-Owens Davis Dust Model suggests that the individual study areas on the test plot will have little effect on the total PM-10 generation on the Owens Lake bed, under microscale conditions it is theoretically possible that at moderate distances downwind there could be a slight decrease in PM-10 concentrations. If the sand fence array prevents saltation of large particles, PM-10 generation downwind will be suppressed. However, the relatively large amount of fine (PM-10) aerosols generated upwind of the individual study areas on the test plot will have time to be diluted by turbulent diffusion and their areal density will be reduced. Thus, there may be a slight dip in PM-10 concentrations just downwind of the fences. To test this theory, four UCD-designed Solar Monitoring for Aerosols in Remote Terrain (SMART) samplers (see ARB proposal) will be deployed in various configurations throughout the experimental dune area. The SMART units will be operated, and their resultant data analyzed, using standard methods described in the Air Resources Board proposal. The SMART units will allow for the optimization of aerosol collecting on the lake bed before the evaluation of the larger array to be built in Summer 1993 begins.

The exception to this premise occurs for 92-A Alternate and MODDM predicts significant PM-10 reductions should this option be chosen.

PROTOCOL 7: Analysis of environmental impacts.

The areas and activities of the proposed work represent such a modest change in prior and present activities as to justify a "Negative Declaration" under CEQA. In fact, all activities are designed to mitigate a serious environmental problem, and any minor impacts caused by construction will be more than offset by reduction of PM-10 dusts.

Please refer to the attached State Lands Commission document (included as an Appendix), "Proposed Negative Declaration... Proposed Dust Remediation Pilot Program-- Owens Lake," which addresses these concerns comprehensively.

PLEASE NOTE: Other protocols may be generated during the tests at Davis and Owens Lake, and these will be ready prior to the commencement of large scale lake bed operations, in summer 1992.

REQUEST FOR BID

Sand fence materials.

Not to exceed $50,000.

The University of California, Davis, Crocker Nuclear Laboratory Owens Lake Task Group wishes to solicit bids for sand (snow) fence for a major sand mitigation project at Owens Lake (near Lone Pine, California). The fence will be used to form dune arrays, each dune 6 ft high, 150 TO 300 ft in length, on the saline dry lake bed of Owens Lake.

The material proposed must have the following characteristics:

a. Height - initially 4 ft, but 5 ft, and 6 ft high fences can be considered. However, they pose problems in installation. Please make suggestions. All other things being equal, we prefer 4 ft fencing, which will be placed 2 ft above the playa.

b. Length - up to 240 foot on a spool (80 yard or 72 meter lengths, pre-cut). Can be in smaller lengths and joined on-site.

   We also wish to obtain 100 pieces of your fencing, 60 feet in length, promptly.

   You may propose that we cut to length on-site, if there is a significant savings in cost. Nevertheless, on-site equipment is not designed for over 2,000 lb per roll.

c. Porosity - initially 50%, but please feel free to propose other values based upon your experience

d. Material - we propose a lifetime on the lake bed of at least 30 years, in conditions of high salt content, high winds (to 65 mph), abrading sand, high temperature, and high sun and ultraviolet levels. Please document experience with your proposed materials in similar conditions.

e. Color - beige to light gray; sample of lake surface color provided with bid package; please submit sample of your color.

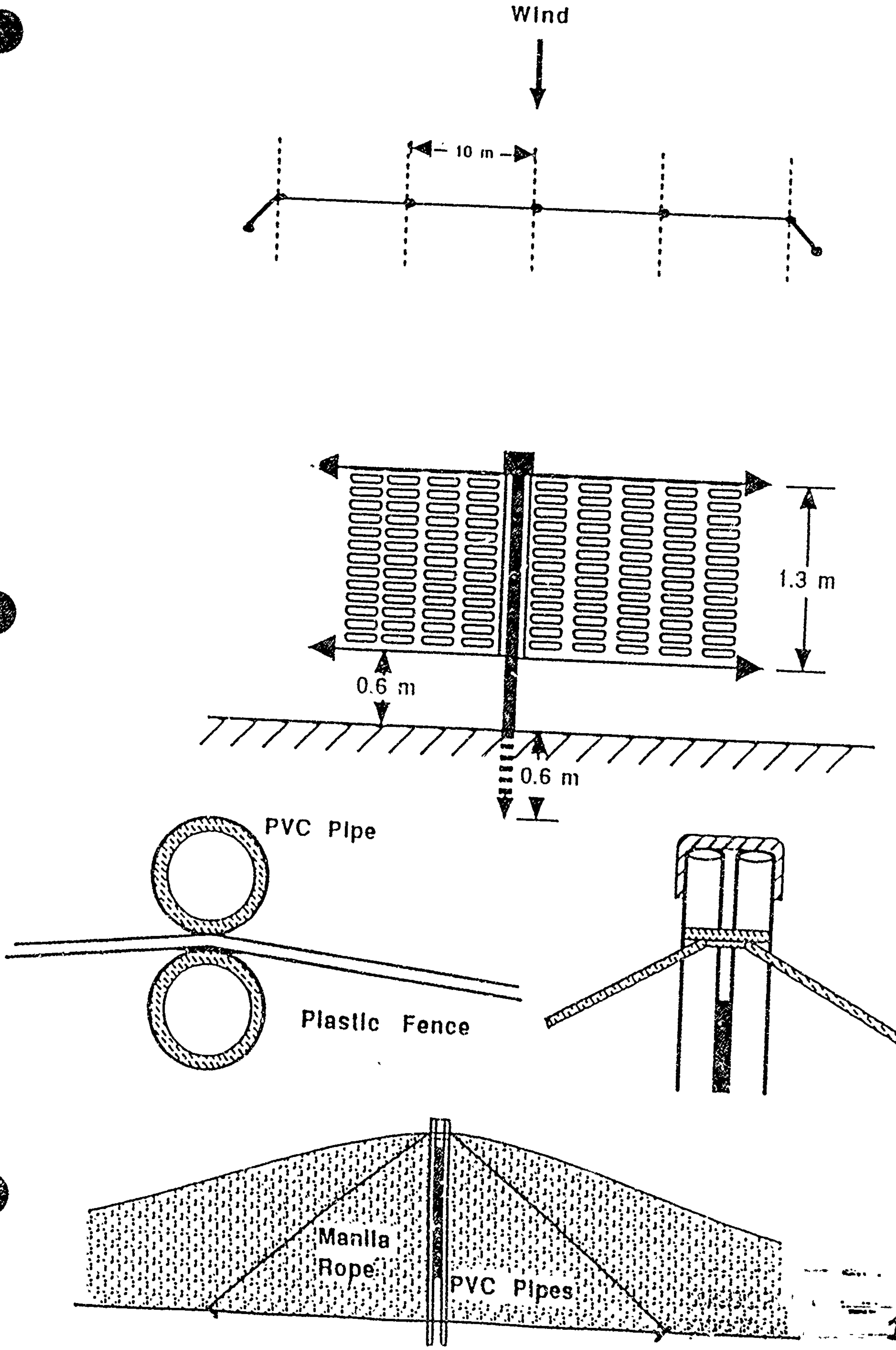
f. If the fence comes in smaller lengths and needs to be joined, detail the types of joint and their survival in such conditions.

g. If you have suggestions for fence designs, and/or additional hardware, please propose a package with these items.

Delivery: Small scale samples, to UC Davis by 8/1/92. Later materials, to a location near Ca, on or before 9/1/92. Note: we are willing to consider phased deliveries, as long as at least 30% of the order on hand by 9/1/92, and all the rest of the order by 4/1/93.

Payment terms: TBA

FIGURE 2


Wind
10 m
1.3 m
0.6 m
0.6 m
PVC Pipe
Plastic Fence
Manila Rope
PVC Pipes

REQUEST FOR QUOTE

Support of sand fence construction, 7/15/92 - 10/15/92.

Support from West Side Owens Lake, not to exceed $15,000
Support from East Side Owens Lake, not to exceed $15,000

You may bid on either or both contracts.

The Owens Lake Task Group, Crocker Nuclear Laboratory, University of California, Davis, requests quotes on support of construction efforts of sand fence-sand dune arrays and minor excavation on the Owens lake Bed.

This support will include providing:

1. Equipment for unloading from delivery trucks all materials used in the project. The weight could be as high as 2,000 lbs for a spool of fencing.

2. Mechanical equipment capable of travelling over the lake bed carrying up to 1,000 pounds of (nominal) 6 ft. fencing material, spooling the material off the vehicle onto the lake bed in a control fashion so as to lay out a series of 240 foot fence arrays. The equipment should do minimal damage to the lake bed surface crust.

3. Provision of trained operators (one/team, up to 2 teams) to operate the equipment and assist untrained laborers, (4/crew, under the direction of a UCD supervisor), emplace the fence, guy it, and do whatever is necessary to secure it and the associated diagnostic equipment. Also support safety of the work party(s). Nominally, this will involve 40 hrs/week, estimate 180 days duration.

4. Repair and maintenance of all equipment.

5. Provision of a base areas on the east side (Keeler-Swansea) and west side (Cartago-Olancha) of the lake to receive fencing equipment, supplies, etc., and keep them available in a secured work area.

6. Provision of contractor's supervisor, 20% time, 180 days, with oversight and consultations on design and implementation.

7. The duration of the contract is 15 months.

8. Bidders may bid on either or both teams, one on the west side, one on the east side of Owens Lake.

9. All bidders must have a California Contractor's License.

10. Payment Provisions TBA.

Budget Submittal Form 102

This form is supplied for presenting budget detail to the Air Resources Board. In addition to this form, alternate forms or computer printouts may be submitted.

Name of Institution: The Regents of the University of California

Address: Crocker Nuclear Laboratory
Air Quality Group
University of California
Davis, CA 95616

Title of Proposal: A Proposal For Partial Mitigation of Owens Lake PM-10 Episodes Through Control Of Saltating Particles and Reduction of Wind Sheer, 1992-1993.

Total Budget Requested: $200,000.

Period Covered(months): 15 months

(1) Statement of Binding

This proposal is firm for 120 days after the submittal date of ______________.

The following official binds to this technical and cost proposal ______________

Name ______________ Title ______________ Telephone No. ______________

Signature ______________ Date ______________

(2) CONTACT PERSON

Please provide the name, title, and telephone number of the contact person authorized to modify/clarify technical or financial aspects of this proposal.

Name	Title	Telephone No.
Thomas A. Cahill	Professor of Physics	(916) 752-1120

Budget Summary*

Direct Costs

1.	Labor	$ 56,544.	
2.	Subcontractor(s)/Consultant(s)	$ 30,000. 6,500. *	
3.	Equipment	$ 5,200. *	
4.	Travel & Subsistence	$ 13,920.	
5.	Electronic Data Processing	$	
6.	Reproduction & Publication	$ 1,500.	
7.	Mail & Telephone	$ 1,000.	
8.	Materials & Supplies	$ 54,595.	
9.	Analyses	$ 2,300.	
10.	Miscellaneous	$ 4,500. *	
	Total Direct Cost	176,059.	$ 176,059.

Indirect Costs

11.	Employee Fringe Benefits	$ 7,228.	
12.	Other Indirect Costs	$ 15,986.	
	Total Indirect Cost	23,937.	$ 23,937.

Total Project Cost	$ 199,996.

*Please provide budget details on pages 3-5. Definitions of terms used are provided on pages 6-8.

*Overhead does not apply

4. TRAVEL & SUBSISTENCE

1.	Round trips to Owens Lake 600 miles @ 0.24/mi = $144. x 15 trips	$ 2,160.
2.	Transportation at Owens Lake UC Car Rental for 6 months	2,600.
3.	Per Diem 160 days @ $26./day	4,160.
4.	Rental of housing (replaces housing)	5,000.
	TOTAL TRAVEL & SUBSISTENCE	$13,920.

PROTOCOL: TASK 92-D

BACKGROUND

A study by Kusko and Cahill of aerosols found that there are 5 major requirements for PM-10 violations at Owens Lake and, corresponding to each requirement, there are certain control mechanisms (Appendix, Table 1). First studies of experimental test plots based on these control mechanisms was done by WESTEC (1984) on the lake bed, including sand fence construction, vegetation studies on dune and unaltered lake bed, application of surface stabilizing agent, and leaching. Results of some tests performed will be discussed later. Similar studies plus flooding and sprinkling tests were performed by the Great Basin Unified Air Pollution Control District. However, most of the tests show disappointing results.

The idea of establishing vegetated dunes has been reconsidered by the UCD Owens Lake Task Group and proposed again despite the failure of prior studies. This is because of the following reasons.

First, although the fundamental goal of mitigation is to reduce the dust burden within minimum amount of water and money, a "stable, attractive, and ecologically diverse Owens Lake playa", if possible, is the ultimate goal of dust mitigation and management plan. Although restoration usually means to bring back an ecosystem to its original condition, it is redefined to be "activities which seek to upgrade damaged land or to recreate land that has been destroyed and bring it back to beneficial use, in a form in which biological potential is restored". This has similar meaning as an "alternative ecosystem", which is a management option of a disturbed ecosystem. Sand dunes with vegetation is a mitigation alternative much more ecologically sound and resembling the natural ecosystem around the playa than the other proposed methods, which are basically pure engineering work.

Second, although previous vegetation studies were not successful, vegetation does thrive naturally on some parts of the playa, for example, the Owens delta with plant species of various communities from riparian to desert scrub, the Sulfate Well region with an artesian well supporting abut 0.01 square mile of *Juncus balticus* and *Distichilis spicata*, vegetated natural and artificial dunes on and around the playa and so forth. This convincing evidence supports the possibility of vegetation establishing under the harsh conditions on the lake bed, provided that the plant communities, as well as ecology and physiology of the species within the communities, are well studied. Besides that, vegetation is still the primary means of improving air quality and an essential element in control mechanisms of dust problems (Table 1). In addition, vegetation can interfere with wind and lessen saltation. Vegetation of certain height can increase the frictional velocity and therefore increase the resistance of laminar flow. Vegetation of certain canopy structure can have significant protection against wind erosion.

On the other hand, dunes provide mesic habitats for vegetation in the desert environment. Despite the lower water holding capacity than silt and clay, the moisture in sand is more available to plants because of the less negative matrix potential. Dune vegetation, in return, can stabilize the dunes, accumulate organic matter, and finer silt and clay and can facilitate the growth of other plant species, leading to succession. Such a process from bare dune to stabilized vegetated dunes can be as fast as 10 years.

Before any implementation of the mitigation plan, however, the vegetation and dune system naturally occurred on the playa has to be studied. Plant-water-substrate relationship as well as the successional pattern, if any, of the dunes on the playa must be known so as to select the right species, plant them at the right place and right time. Proper plant selection is the key to successful dune afforestation program. Therefore, successional species (e.g. pioneer, mid-stage and climax species), their microhabitats (e.g. dune top, margin, windward, or leeward side of slope), and their niche must be identified. Besides that, physical factors such as wind direction and magnitude determine erosion rate, dune shape and ultimately the microhabitats of vegetation. Dune shape, together with other dune characteristics like dune size, particle size distribution, organic matter, carbonate content and pH, might have correlation with vegetation type and abundance if succession does exist. A study of chronosequence can shed light on succession over time.

Besides harsh physical environment, failure of natural shrub establishment on the playa might also be due to such biological factors as lack of seed bank and seed dispersal. Shrubs and other perennials have life history strategies of being long-lived, producing few but large seeds and often having a transient seed bank. That might be the reason why there are non-vegetated dunes along with the vegetated ones on the Owens Lake playa. In addition, clumped distribution of seeds indicate that seeds tend to accumulate in microhabitats such as under canopys and depressions. Lack of vegetation or such topographic features on the barren playa could also aggravate the effect. The observation that experimental plots growing barley, oats, and other crops on the playa were never invaded by seedlings of native species of the surrounding communities might also support this hypothesis, which needed to be tested with seed bank studies.

There are few studies on inland dunes or playa succession, perhaps because of the perception of lack of succession in the desert environment. Flowers' long-term study at the Great Salt Lake, Utah and the study of Vasek and Lund at Rabbit Dry Lake in Mojave Desert are among those few both supporting the idea of succession in due or mound ecosystems. Bowers also agreed that there is succession on dunes, which is the "process by which dune plants communities become increasingly similar to those of adjacent non-dune habitats" under favorable climatic conditions and limited supplies of sand. However, Pavlik believed that, under this strict definition of dunes, which are wind deposited sand, and unless the dune systems have been destroyed, succession of dune vegetation would not inclu[illegible] those from surrounding habitats.

REVIEW OF PREVIOUS VEGETATION ANALYSIS AT OWENS LAKE

Basically, there is no vegetation analysis performed on the playa itself because it is the property of the Lands Commission and no funding has been allocated on vegetation survey so far. WESTEC conducted an examination of vegetation growing along the margin of the lake bed for species selection in its revegetation study. Four native species were selected based on the observation of their distribution (*Atriplex parryi*, which grew farthest out to the lake bed) and the literature review on their limit tolerance to salt, such as *Distichilis spicata*, tolerance to