Wetland Technologies Corporation, on behalf of the *Mobil Mining & Minerals Company*

presents the:

MM&MC *Wetland Restoration Plan*

September 10, 1995

An approximately 35 acre site consisting of a 17 acre area of tidally influenced wetlands and uplands, and an 18 acre area of freshwater wetlands and uplands; located south of, and adjacent to the, Houston Ship Channel, within the City of Pasadena, County of Harris, Texas

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General Information

Identification of Parties

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Introduction

This **Plan** is comprised of a summary of previous reports and plans (including photos and drawings) for review by Trustees assigned at some future date to monitor **Project** compliance (who may not be familiar with the history of the Settlement Agreement).

New Federal Standards: This **Restoration Plan** has been organized according to guidelines set forth in Federal Standards promulgated in the 3 book series on the subject of restoration of aquatic systems as follows:

1.) Kusler, Jon A. and Mary E. Kentula. 1990. ***Wetland Creation and Restoration.*** Island Press. Washington, D.C.

2.) National Research Council. 1992. ***Restoration of Aquatic Ecosystems.*** National Academy Press. Washington, D.C.

3.) Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, J. C. Sifneos. 1993. ***An Approach to Improving Decision Making in Wetland Restoration and Creation.*** Edited by A.J. Hairston. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Research projects implemented by the Environmental Protection Agency's Wetlands Research Program (WRP) are designed to supply this information;(1) consequently, our firm has organized all of the aquatic systems restoration, creation, and enhancement plans according to these formats.

The latest publication (second edition) of item 3 above, announced that the information contained will be formatted (developed) into new Federal Standards to apply to all **Restoration Projects** subject to agency review within the United States; therefore care has been taken to prepare project plans in accordance to these guidelines.(1)

Project Location

The subject property, an approximately 33 acre tract of currently degraded land, is located south of the Houston Ship Channel at the **MM & MC** plant site, City of Pasadena, County of Harris, Texas.

Project Benefits

The Planned tidally influenced site will be the only significant brackish water wetland located within this portion of the Ship Channel area. Turbid water observed in the Ship Channel (at the site) during a period without rainfall exhibited characteristics of water heavily influenced by outfall from sewerage and industrial plants. Consequently, the **Project** is intended to provide the documented water cleansing effect of shallow water wetlands to a section of waterway that currently contains none.

Finfish Nursery Habitat: Rain water inflow, large project size, nutrient uptake, sediment trapping, and oxygenating effects of the new wetland may not be significant to overall Ship Channel water quality. However, it will significantly improve water quality within the immediate project area for marine nursery purposes; the success of (and the relative level of success of), which is the Primary Performance Criteria of the Project.

Habitat Creation and Species Diversity: Secondly, a somewhat diverse wildlife habitat may develop over time in the Freshwater northwestern quarter where the final system outfall is planned to be located. This final surge pond will have shallow areas 10" to 24" in depth to provide habitat for aquatic vegetation. The various floodplain tree species to be planted in this work area will promote an increase in total species diversity.

Rainwater is planned to be collected separately within two freshwater pools specified to be excavated in the tidal area, in order to provide a constant source of relatively clean drinking water for area wildlife.

Nutrient Modification: Thirdly, there may be some improvement in reduction of nutrients remaining in MM & MC effluent outfall into the Ship Channel. The Freshwater system could remove a measureable amount of nitrogen remaining in effluent after wastewater plant treatment. Also, other nutrients will be modified to lower levels.

Finally, pH of waters within both Project areas will tend to be adjusted towards neutral irrespective of whether they enter the systems as acidic or alkaline.

Project Description

General Design Criteria

Section I: Tidal Wetland Component

General Concept: This **Project** component involves the development of approximately 17 acres of created and enhanced tidal wetland, as is more fully described within the site **Wetland Restoration Plan** following on page 16. **The project concept envisions creation of good quality wetland comprised mostly of brackish water finfish nursery habitat; with a small fresh water interface and a very lengthy upland edge (compared to the upland size).**

The Plan is developed directly from field observation of the proposed site's existing conditions on October 26, 1992. As the subjective estimate of wetland "quality" is directly related to complexity of different adjacent habitats; we have included an additional biodiversity effect from development of freshwater wetlands on the 16 acre balance of the subject tract, and 60 acres of riparian habitat directly adjacent of the south boundary.

More specifically, this particular design increases the effective habitat potential of the marine nursery (both area and quality); with a small amount of year-round fresh drinking water provided to the existing wildlife population. Combined with the 16 acre balance of the subject property, and with the adjacent Cottonpatch Bayou 60 acre watershed; **the entire discrete ecosystem will contain a large amount of "edge effect", which indicates a substantial increase in biodiversity to be available in the immediate area.**

Wetland Creation: Specifically, the **Project** will involve lowering the elevation of approximately 16 acres of sloping upland area to diverse shelf levels of 0" to 18" height at mean low tide. Up to 70% of these shelves would be exposed at mean low tide. Additionally, two new inlets/outlets would be excavated to the Ship Channel; in order to provide additional dissolved oxygen through the resulting flushing action, and to provide access to mature individual fish.

Wetland Enhancement: It appears that the site's existing 1 acre brackish water wetland is very low quality habitat due to the loss of oxygen when the falling tide "isolates" the remaining pool during hot weather. **Therefore, improvement of the tidal pool inflow is added to the project credit as "enhancement", for a total restoration credit of 17 acres.**

Freshwater Collection: Freshwater pool #1--A small part of the upland area to be lowered below the existing elevation would act as a **rainwater collection system** when cut off from the **MM & MC** plant drainage. This will be accomplished by cutting the slopes back on the eastern side of the outfall ditch, shaping a collector ditch around the planned soil storage area, and falling to a small excavated pool.

The resulting small freshwater pool will be located above the brackish water interface (constructed above historical high tide), in order to provide a year-round source of good quality drinking water for area wildlife.

Freshwater pool #2--An existing 0.15 acre freshwater wetland (containing mostly *Typha sp.*) will be avoided entirely, and enlarged by excavating a pool about 4' deep into the surrounding uplands to allow for **possible additional rainwater collection**. The storm water will runoff from the upland area located directly adjacent to the far east boundary of the tidal project. This upland area will be lowered to a gentle slope downwards to the north; with a storm water swale extending to the enlarged wetland such that rainwater will eventually collect within the pool. If so, it may serve as an additional source of drinking water for various species of mammal and bird populations.

Existing Upland Area: The approximately 1 acre of very high upland located along the northwest border of the tract would be avoided (existing elevation left as-is); and act as a buffer between the Ship Channel and the brackish water project as it contains relatively good upland habitat value. This area includes mature tree specimens of cottonwood, hackberry, and cedar elm. It also contains a variety of established berry producing species currently being utilized by the existing wildlife population.

An additional 16 acres of upland (balance of the subject tract) would become part of the **Project** by relocating the existing storm water channel to flow directly north from the **MM & MC** plant, and excavation of the uplands into freshwater wetlands for a total **Project** area of approximately 33 acres.

Existing Conditions

General Area Photograph: Aerial photo of Restoration Project area, with adjacent lands & waters.

Section II: Freshwater Component

General Concept: The **MM & MC (001) outfall** will be relocated from the tidal region of the **Project** site; and will be enhanced by construction of serpentine meander ditches and several associated large shallow freshwater wetlands.

Wetland Creation: Conceptual design of the (secondary) **Freshwater Project** specifies construction of two surge ponds in order to prevent flooding the site, whether from daily outfall surges, and/or excessive rainfall events, as is more fully described in the following Wetland Restoration Plan and attached drawings. **The watercourse between ponds and large shallow wetlands is specified to "meander" in order to increase total time that plant outfall water remains in the system.**

In several places where the meanders reverse course, shallow wetland shelves will be leveled (not excavated) and planted with site-adapted plant species. This wetland area assists in retaining the plant outfall water for a longer period of time in the system.

Detention Capacity: One of the surge ponds will be located directly beneath the treatment plant outfall, and the other specified holding pond is to be located at the bottom of the slope, directly before outfall into the Ship Channel. The two surge ponds will contain a long term detention capacity (retention time is to be 24 to 48 hours, not including stormwater) of standing water from 4' to 8' deep below normal pool level; and will additionally provide a floodpool capacity above normal pool level of 2' to 4' for short term retention in order to slow streamflow velocity. Large shallow wetlands to be associated with (at the edge of) these surge ponds are specified to be predominantly from 0" to 10" in depth.

Grading of specific hydrologic elevations are to be conducted such that the deeper surge pond outfalls into shallow wetlands and meanders within the water's flow path; thereby providing extended contact time with the naturally occuring microbial community in an alternating aerobic/anaerobic cycle.

Planting: Floodpool areas above normal pool level, and those areas to be 0" to 10" in depth will be planted with vegetation ("mature" plants and "seedbank") adapted to the site. Some mature aquatic plants from off-site may be introduced. The final shallow wetland will have it's edges planted with seedlings of site-adapted floodplain tree species (ie. hackberry, cottonwood, and willow); along with some cypress, water oak, willow oak (which may or may not survive) being introduced into the restoration project.

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WETLANDS EXISTING CONTOUR MAP SALTWATER SECTION

Wildlife and Vegetation Survey

This survey was conducted on October 26, 1992 by Elizabeth Oakes, Wildlife Biologist. Atmospheric conditions were characterstic of the season, with little cloud cover and the temperature rising to 90 degrees (F). No precipitation occurred during the field inspection, and the area had received little or no rainfall since mid-September, 1992.

Topography and Drainage

This 33 acre tract is located on the banks of the Houston Ship Channel immediately adjacent to the **MM & MC** facility. The tract is completely undeveloped.

Topography ranges from 18 feet to sea level, with tidal influence of approximately 1 (one) acre surface area (the tidal pool) on the western side of the tract, and a man-made outfall ditch into the Houston Ship Channel.

Evidence of drainage into and water collection in several low points on the tract was noted, including water-stained vegetation, hydrophytic vegetation and moist soil.

Vegetation

Vegetation on the tract is characteristic of disturbed, but undeveloped acreage in the area of the study site and consists of a mixture of native and invader species. Species observed included *Ambrosia trifida* (ragweed) which was dominant on the tract; *Sorghum halepense* (Johnson grass), *Cynodon dactylon* (bermuda grass), *Digitaria sanguinalis* (crab grass), *Setaria lutescens* (yellow foxtail), *Cyperus esculentus* (chufa), *Amaranthus retroflexus* (red-root amaranth), *Phytolacca decandra* (pokeweed), *Portulaca oleracea* (purslane), *Asclepias syriaca* (milkweed), *Ipomoea purpurea* (morning glory), *Datura stramomium* (jimson weed), *Eupatorium serotinum* (thoroughwort), *Vitis spp.* (wild grape), *Ampelopsis arborea* (peppervine), *Cissus incisa* (ivy treebine), and *Solidago canadensis* (goldenrod).

Tree cover on the tract is minimal and consists of isolated specimens of *Populus spp.*(cottonwood), *Celtis occidentalis* (common hackberry), *Salix nigra* (black willow), and *Ulmus crassifolia* (cedar elm). The dead trunk of what appeared to have been a *Taxodium distichum* (bald cypress) was noted near the tidal pool.

Vegetation around the tidal pool and in low points on the tract included common hydrophytic species such as *Spartina patens* (saltmeadow cordgrass), *Pluchea purpurasens* (saltmarsh fleabane), *Lycium carolinianum* (Carolina wolfberry), *Sesbania drummondi* (rattlebush), *Heliotropium curassavicum* (seaside heliotrope), *Iva frutescens* (marsh-elder), *Baccharis halmifolia* (baccharis), *Juncus roemerianus* (needlerush), *Scirpus maritimus* (saltmarsh bulrush), *Cyperus spp.* (umbrella-sedge), *Rhynchospora spp.* (beak-rush), *Typha angustifolia* (narrow-leaved cattail), *Cardiospermum halicacabum* (balloon-vine), *Andropogon glomeratus* (bushy bluestem), and *Ptilimnium capillaceum* (mock bishop's weed). Other hydrophytic species may be present on the site but dormant due to recent drought conditions.

Wildlife

Wildlife species on the tract were determined either by direct ocular observation of individuals or by examination of tracks, burrows, bones, feathers and scat.

The largest animals on the tract are *Odocoileus virginianus* (whitetailed deer). Tracks, browse marks and day beds were observed in the field. The tract may provide forage and cover for a doe and fawn, with the animals swimming the narrow Ship Channel area or crossing the fence to adjacent undeveloped areas for additional forage.

Canis latrans (Coyote) tracks and scat (containing rabbit hair and bones) were observed on the tract. This animal may also be swimming onto the tract and/or crossing through the fence.

Evidence of *Dasypus novemcinctus* (armadillo) and *Procyon lotor* (raccoon) were observed in the form of tracks. *Rattus norvegius* (Norway rat) would be presumed to be on the tract due to its immediate proximity to the Houston Ship Channel. A *Sylvilagus aquaticus* (swamp rabbit) was observed on the tract.

Bird species observed on or near the tract included *Phalacrocorax spp.* (cormorant), *Ardea herodias* (great blue heron), *Leucophoyx thula* (snowy-egret), *Larus delawarensis* (ring-billed gull), *Mimus polyglottos* (northern mockingbird), *Passer domesticus* (house sparrow), and *Zenaida macroura* (mourning dove). Evidence of the presence of a species of owl was observed in the form of droppings beneath a cottonwood tree, and evidence of a hawk feeding was found in the form of mockingbird feathers from a recent kill.

No bird nests were observed on the tract during our field reconnaissance. Trees on the site are isolated. Lower branches appear to have been heavily browsed.

The only evidence of reptile life found on the tract was near the mouth of the man-made drainageway at the eastern side of the tract. A species of small water snake was briefly observed but was too far away for identification.

Common minnows were observed in the water, and a large kill of *Ictiobus cyprinellus* (buffalo fish) was observed in the Ship Channel tidal area adjacent to the tract, the result of evaporation, deoxygenation, and water levels below the minimum required to sustain this fish population.

A turtle shell (probably a *Pseudemys scripta* [pond slider]) was found on the tract. No amphibians were observed during our field reconnaissance due to drought conditions.

Incorporated Recommendations for Bioremediation and Habitat Enhancement: The following items have been incorporated into the **Plan** from recommendations by Ms. Elizabeth Oakes, Wildlife Biologist.

1.) Dredge two new outlets into the existing pool to create a tidal flushing action, which will promote oxygenation and allow spawn to utilize the extensively vegetated shallow flats along the edge of the tidal pool. This tidal pool appeared to be anaerobic at the time of our field reconnaissance.

2.) Dredge a shallow pond along a man-made drainageway to permit freshwater to collect, which will supply a constant source of drinking water to mammals and birds on the tract. Create rills along the watercourse with concrete or other stone-type breakwaters to promote aeration.

3.) Enlarge the existing "low point" intermittent wetlands on the tract uplands such that additional hydrophytic vegetation species will grow in these areas, and aquatic species (other than plants) will have breeding habitat.

4.) Plant additional trees and bushes for food source, nesting sites and cover along the upper slopes of the tract.

Wetland Restoration Plan

This Plan is comprised of two separate components: **1.) Tidal Wetland Component**-the construction of approximately 16 acres of tidal wetland, enhancement of approximately 1 acre of marginal wetland into good quality wetland, including a portion of the site's lower tidal pool, and incorporation of a constant supply of fresh drinking water for area wildlife populations; and **2.) Freshwater Component**-the enhancement of the **MM & MC "001"** outfall by design of constructed surge ponds, serpentine meander ditches and associated shallow freshwater wetlands.

Section I: Tidal Wetland Design Criteria

Approximately 16 acres of the higher ground is suitable for conversion from upland to good quality wetland, along with enhancement from marginal wetland to good quality wetland of a 1 acre portion of the site's lower tidal pool.

Planned Construction Methodology

This **Plan** presents details of 1.) elevation levels to be excavated, and 2.) the particular construction methodology to be utilized in "creating" these elevations, as shown on the attached project grading contour drawings in 11" x 17" format (to-be-excavated elevations).

Marine Hydrology: will be provided by cutting in two new inlets to the Ship Channel. One inlet will be located to the north where **MM & MC's** effluent currently outfalls to the Ship Channel. This area will be deepened to approximately 2' below mean low tide (as shown on the accompanying Tidal Wetland Creation Map and attached Grading Drawings) creating a flushing action currently not present at the proposed site. The other new inlet will be located at the western boundary and will be dredged to the minimum 2' depth level. **The flushing activity is necessary to achieve the primary goal of creating good quality marine nursery habitat.**

Currently, mean low tide on a one tide day, or a very low tide below mean low tide, will cause the existing pool to experience a sudden lowering of dissolved oxygen in warm weather. This low oxygen level will prevent mature finfish from entering the area approximately 50% of the spawning season. Additionally, any successfully fertilized eggs deposited in the tidal pool may be damaged by a sudden increase in temperature coupled with a loss of oxygen.

Therefore, excavating two new inlets will allow flushing activity to be introduced into the area; raising the dissolved oxygen level, and providing a more constant temperature environment. Also, because the new inlets will be well below historical low tide, an escape will be provided for individual finfish.

Tidal Project's Freshwater Hydrology: The newly constructed watershed's first wetland will be a small shallow freshwater pool to hold the site's runoff for the purpose of providing fresh drinking water to edge-dwelling wildlife. This is to be accomplished by cutting the slopes back on the eastern side of the existing outfall ditch, and installing a collector ditch (lip) around the planned soil storage area, falling to a freshwater pool to be located above the brackish water interface (constructed above historical high tide).

The watercourse will then flow through a bed of locally available reed species to subject the freshwater to remedial microbial activity present around their rhizomes. This activity will also add a small amount of dissolved oxygen to the streamflow.

The water will eventually meander into the tidal wetland area, and will be planted with appropriate fresh/brackish vegetation species (mature plants and seedbank), such as umbrella-sedge, then cattail, and then cordgrass as it falls into the marine zone below mean high tide.

Secondly, an existing 0.15 acre freshwater wetland (to be avoided and enhanced) will be enlarged by excavating into the surrounding uplands to allow for **possible additional rainwater collection.** The upland area located directly adjacent to the far east boundary of the Tidal project will be lowered to a gentle slope downwards to the north; extending to the enlarged wetland such that rainwater will eventually collect in the excavated pool.

Upland (existing) Elevations: are to be avoided in order to provide a long "edge effect" to enhance biodiversity. Care will be taken to leave all of the standing mature trees and associated understory to aid the site establishment; by specifying constructed wetland locations to be in open, lower areas. This will ensure small, irregular, natural wetland shapes with complex, winding watercourses below the trees.

Small humps will be created, and islands left in the wetland project area (described as a **Channel-Pool-Mound Complex**). These will be planted with tree seedlings of floodplain species.

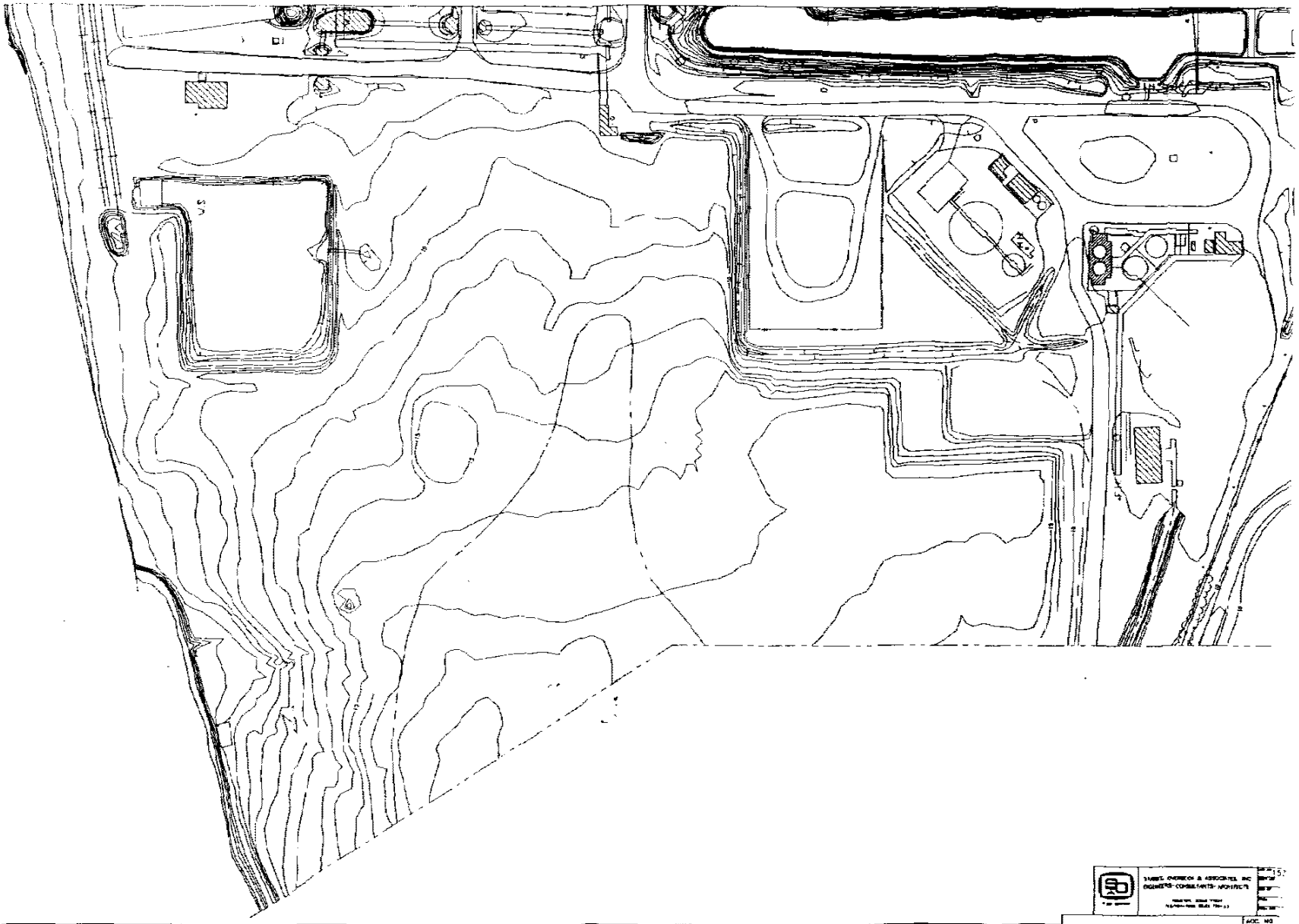
In addition to the above described tidal wetland construction project, the adjacent 16 acre upland tract will be added to the site's total restoration acreage by relocating the **MM & MC** plant outfall channel northward to supply a separate freshwater wetland construction project. This upland is differentiated from the very dense understory-overstory avoided upland; as it consists entirely of bermuda grass. Discrete stands of loblolly pines, live oaks, and other tree species will be planted to create a buffer between the freshwater section, and the **Planned** tidally influenced project.

Existing Conditions: This photo represents the center of the **Tidal Project** subject tract, across an existing 1 acre brackish water pool to the upland fringe of very high elevation. Some scattered mature trees of various species can be seen in the background and the Ship Channel is located directly behind the upland.

Close-up: A close-up of the tidally influenced edge of the existing wetland. 1.) Various plant species appear to be in poor health. 2.) Evidence of low oxygen level due to recent algae bloom left on the mud flat by receding tide.

Existing Conditions Detail

Proposed Work Area: High resolution aerial photo of the Freshwater project work area.



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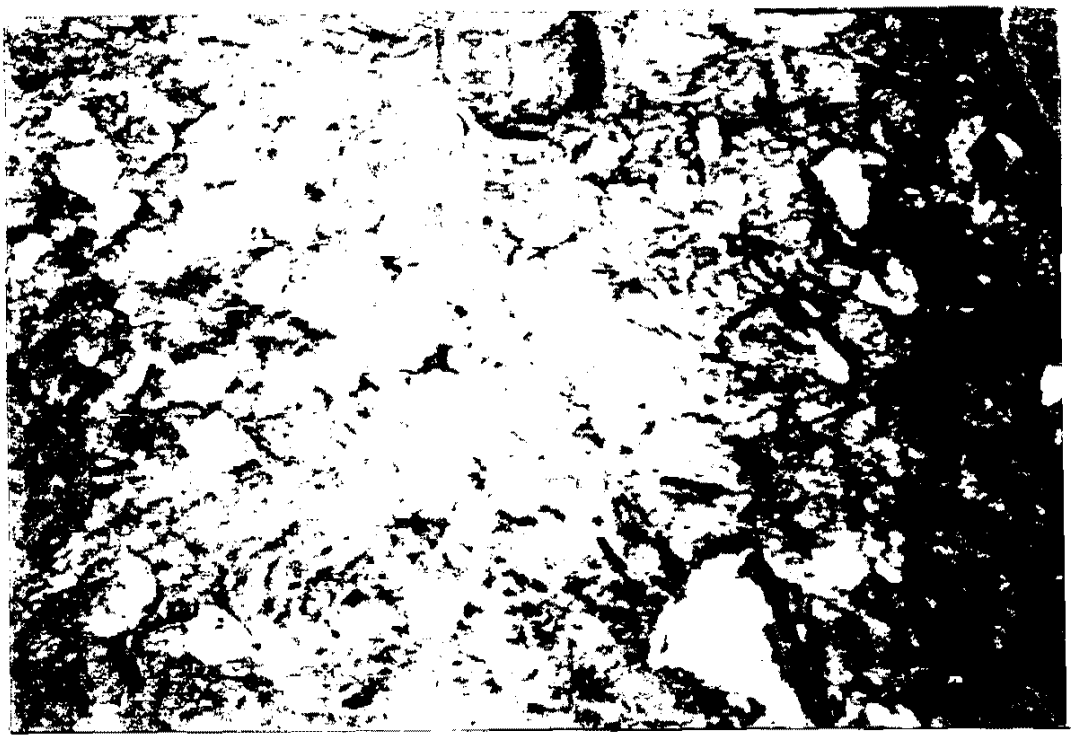
				PLANT PASADENA	DWG NO P-13616-0		

WETLANDS EXISTING CONTOUR MAP FRESHWATER SECTION

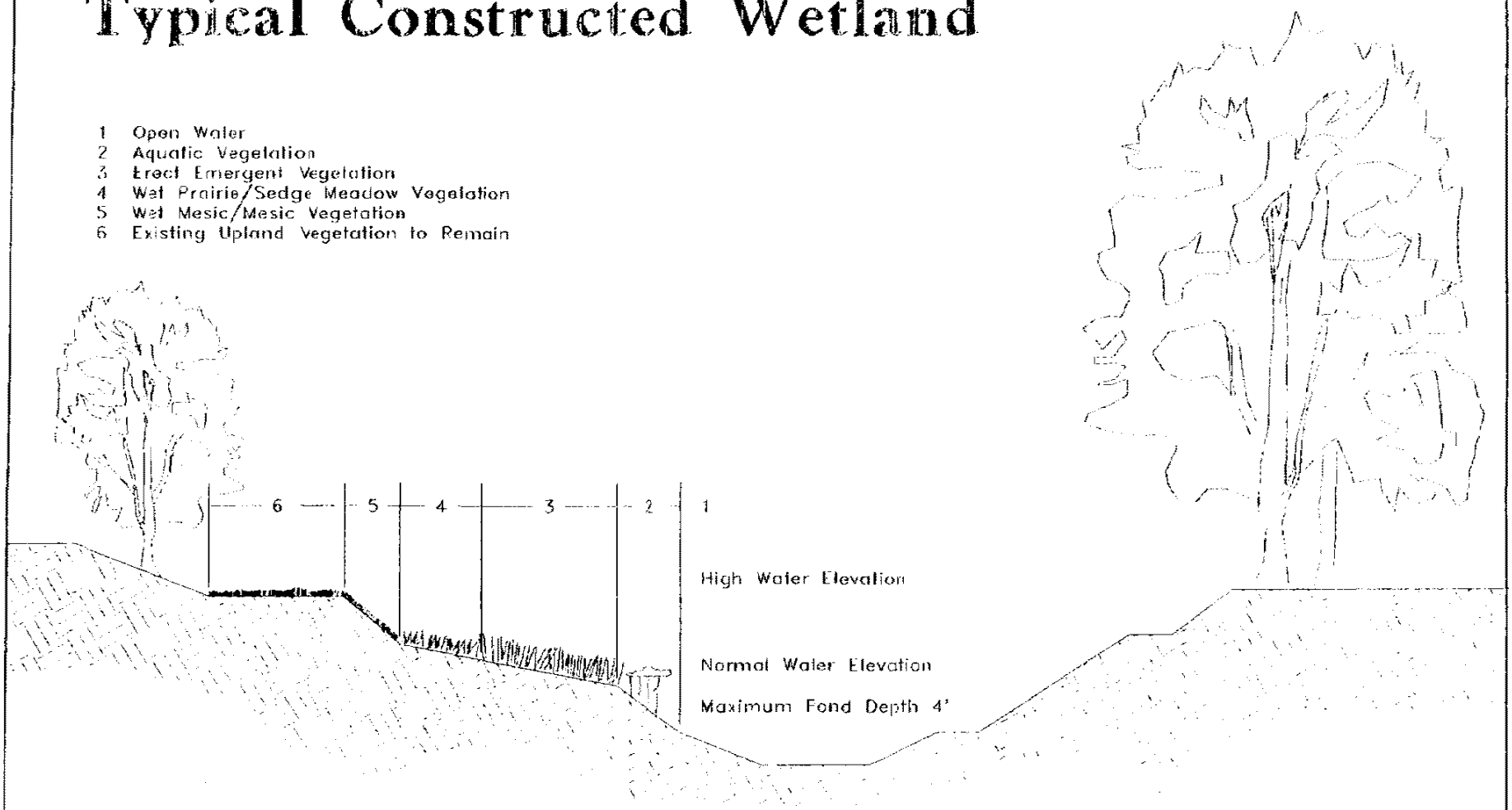


Interface Area: This is the interface area where the current outfall streamflow meets the tidal line; algae growth is reduced as it is diluted by Ship Channel waters, therefore the existing effluent contributes more nutrients than is contained in the receiving waters.

Treatment Plant Outfall: The current outfall channel and small wetland areas develop thick algae mats due to constant nutrient input. This area is directly adjacent to the treatment plant outfall, and algae accumulation is observable on the stream bottom downslope to the tidal line.

Typical Constructed Wetland

1 Open Water
2 Aquatic Vegetation
3 Erect Emergent Vegetation
4 Wet Prairie/Sedge Meadow Vegetation
5 Wet Mesic/Mesic Vegetation
6 Existing Upland Vegetation to Remain



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Typical Constructed Wetland Cross Section
MOBIL MINING & MINERALS CO.
Tidal Wetland Creation Project
Pasadena, Texas

Drawn By: SG
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New Inlet Location: View from existing culvert through current plant outfall to the Ship Channel. This area will be deepened to provide tidal influence to the rear of site. The new depth will be at least 2' below mean low tide to provide finfish escape during extreme low tide. One other new inlet will be dredged to the minimum 2' depth level to provide a tidal flush across newly created brackish water wetlands.

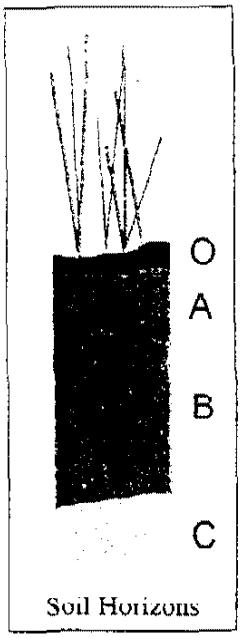
Close-Up of Typical Project Work Area: This photograph is representative of the 17 acre tidal project work area. Vegetation breakline in the background marks the edge between lower elevations to be excavated, and the higher uplands to be left as-is (avoided).

Construction Details

Soil Manipulation Methodology

This Section consists of significant construction details; as follows:

Excavation:



Soil Horizons

a.) Existing desirable plants will be removed by hand, watered, and stored until planted, and then

b.) removal and storage of the "O" horizon (organic layer) which consists of the very thin (½ to 2") layer of living plant material, decayed organic matter and most importantly the **seedbank**, and then

c.) removal and storage (piled separately) of the biologically living **topsoil** containing soil microorganisms ("A" horizon just below the "O" horizon), and then

d.) preliminary contours are to be excavated into the remaining soil **substrate** within the **Marsh Project** area (and if designated to be a planting shelf) to a level about 6" below the designed final grade, all of which is to be removed from the construction site.

These **substrate** materials are to be hauled to the **Freshwater Project** area, **Project** area, and utilized for construction of it's preliminary contours where appropriate.

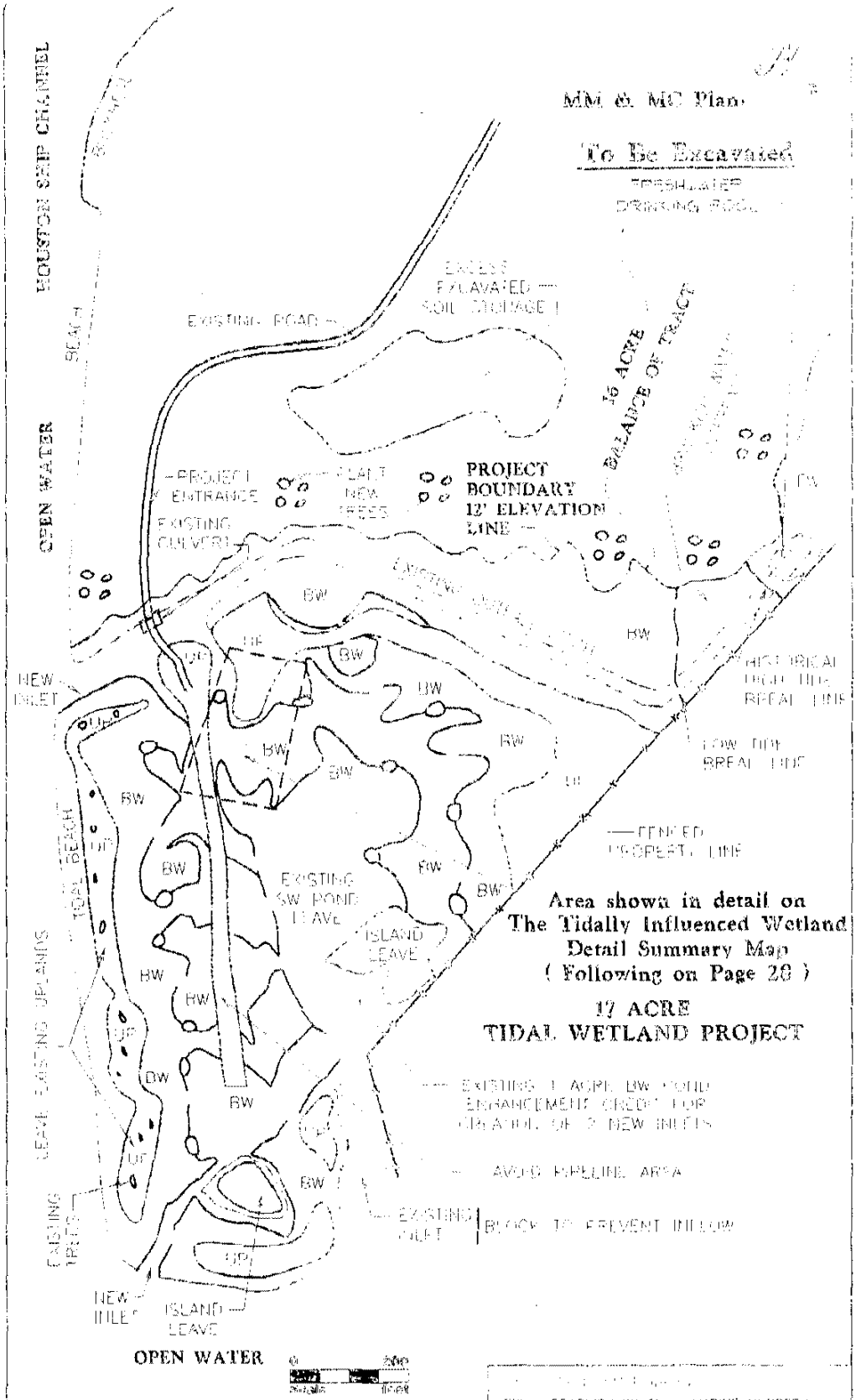
Fine Grading:

a.) Where a planting shelf is specified to be constructed, the biologically living **topsoil** ("A" horizon) material is to be **lightly** replaced to a depth of about 6", spread **without any additional leveling that may cause compaction**, and

b.) the "O" horizon containing the very important **seedbank** material is **lightly** replaced on the **topsoil without any additional leveling that may cause compaction.**

c.) During preparation of the detailed **Work Plan**, a representative sample of each of the above described **seedbank** materials is to be deposited at the intended **tidal elevation** in order to determine from it's subsequent germination whether the plant species is appropriate for the **Marsh Project**.

When possible, undesirable and invasive plant species will be noted and the **seedbank** "donor area" rejected if it fails to meet project criteria related to these species.



Wetland Technologies Corp. 1831 Pinewood Court (713) 242-0734 Sugarland, Texas 77478	**MOBIL MINING & MINERALS CO.** Tidal Wetland Restoration Plan **FINAL DESIGN**	Drawn By SG Date 1-11-95 Proj / File MM/CREATION	Sheet 24 of 48 Project # MM01

Tidal Vegetation Planting Detail

Methodology: Existing mature wet meadow, aquatic, and emergent brackish water wetland plants will be lifted by hand prior to soil manipulation and excavation, and transported to a prepared trench where they will be watered daily if necessary. Seedbank material containing seeds of site-adapted plant species will also be utilized.

When excavation is complete and planting shelves are prepared, seedbank material will be spread over planting shelves, and mature plants will be transported back to the work area and hand planted at the correct elevations.

Stands of loblolly pines, live oaks, and other native tree species will be planted to create a buffer between the 16 acre freshwater section, and the tidally influenced project.

Brackish Water Plant Species List

The following list of the existing site-adapted plant species are to be planted both as seedbank material and mature plant transplantation. We expect the bulk of successful plant species to come from seedbank material. Percent survival of those plants germinating from seedbank material is expected to be about 80%, and those mature plants to be transplanted should achieve approximately 25-30% survival.

Within the next 3 years, areal coverage of those plants planted from seedbank, along with transplanted mature plants should cover 60% of the project area. Full 100% coverage within the next 5 years may be possible.

Suitable Plant Species Available On-site

Setaria lutescens (yellow foxtail)

Spartina patens (cordgrass)

Pluchea purpurascens (saltmarsh fleabane)

Juncus roemeranus (needlerush)

Scirpus maritimus (saltmarsh bulrush)

Cyperus spp. (umbrella-sedge)

Ptilimnium capillaceum (mock bishop's weed)

Additional Plant Species: In addition to the above existing plant source, mature *Spartina alterniflora* will be obtained from an off-site origin and planted in those areas flooded daily; eventually transitioning to the existing site-adapted species such as *Spartina patens*, all to be planted in the zone from mean high water level to the maximum height of spring and storm tides. *Spartina alterniflora* rhizomes will be planted at a maximum of 12" x 12" spacing (minimal root material), and is to be no less than a 36" x 36" spacing depending on the size of plant root mass.

A native plant landscaping company who has an authorized source of *Spartina alterniflora* is specified; consequently, obtaining this particular species of cordgrass **will not result in the destruction of a *Spartina* saltmarsh.**

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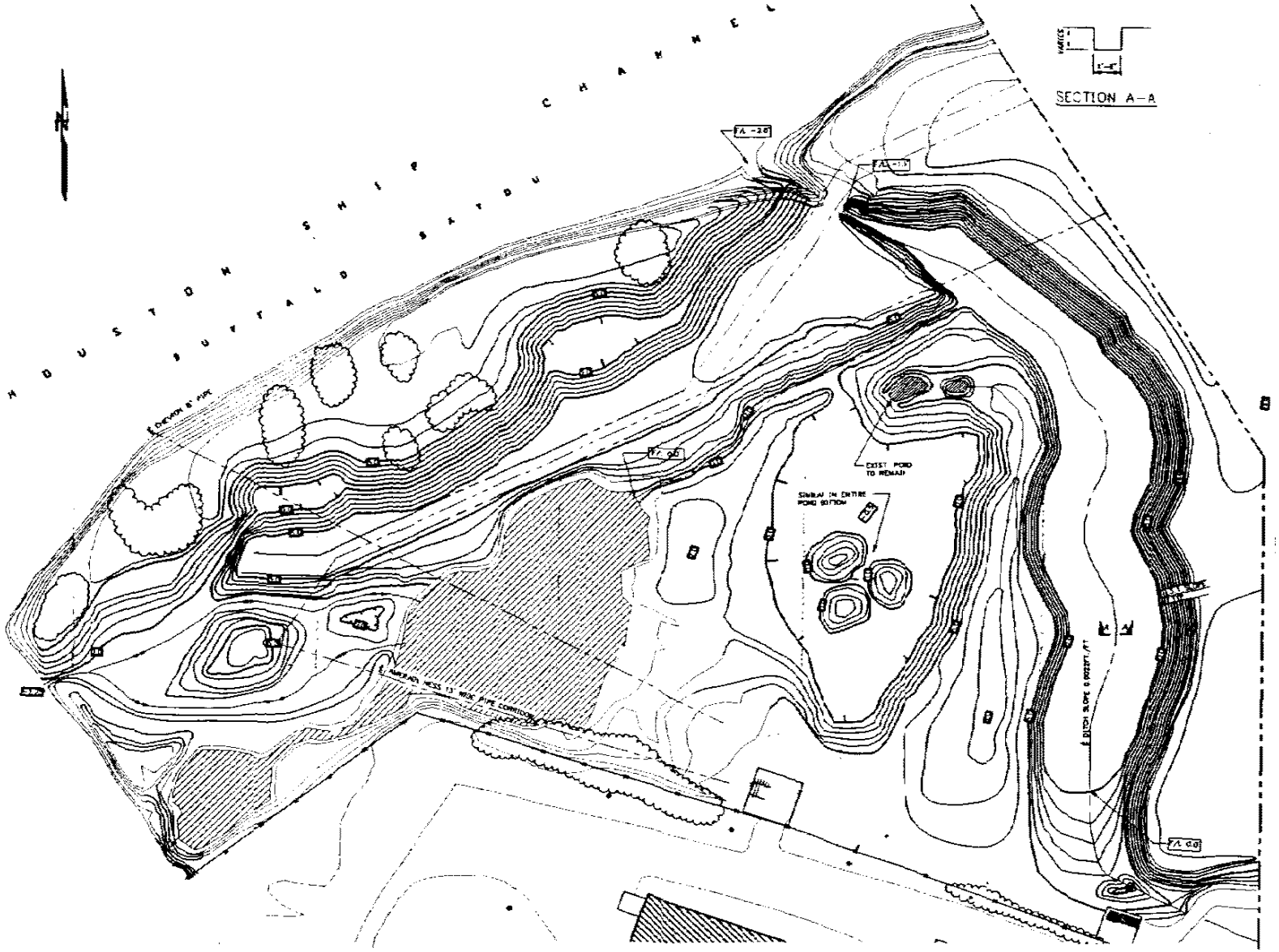


		Mobil Mining and Minerals Company	DRAWN BY CAD	DATE 10-18-93	Engineering Approval	DATE	SCALE 1"=50'	JOB NO.	FILE NO.	WETLANDS EXCAVATION MAP SALTWATER SECTION	PG. 25
			CHECKED BY Y	DATE	Operations Approval		PLANT PASADENA	DWG NO. P-13614-0			

Channel-Pool-Mound (C-P-M) Design Detail

The previously described **tidal wetland** design is intended to duplicate the natural **c-p-m** complex as exists in salt marshes in the area. Channels will be cut into the tidally influenced area beginning from two separate infalls at the Ship Channel, and terminating within the center of the work area. They will weave similar to natural channels at a depth varying from 1 to 2 feet. Small "sedimentation" pools of at least 6' in depth will also be dug contiguous to the channels imitating natural eddies.

First, any of the "O" horizon (organic layer) of the soil to be removed that is vegetated will be saved as seedbank/topsoil material. Then, a large trackhoe will cut the channels and pools.

Current elevations will remain in the mound areas where the extant contours are very near those of the final grade desired. The objective is to increase aquatic habitat complexity (which also aids in stability) of the new wetland system resulting in a unique and valuable habitat.

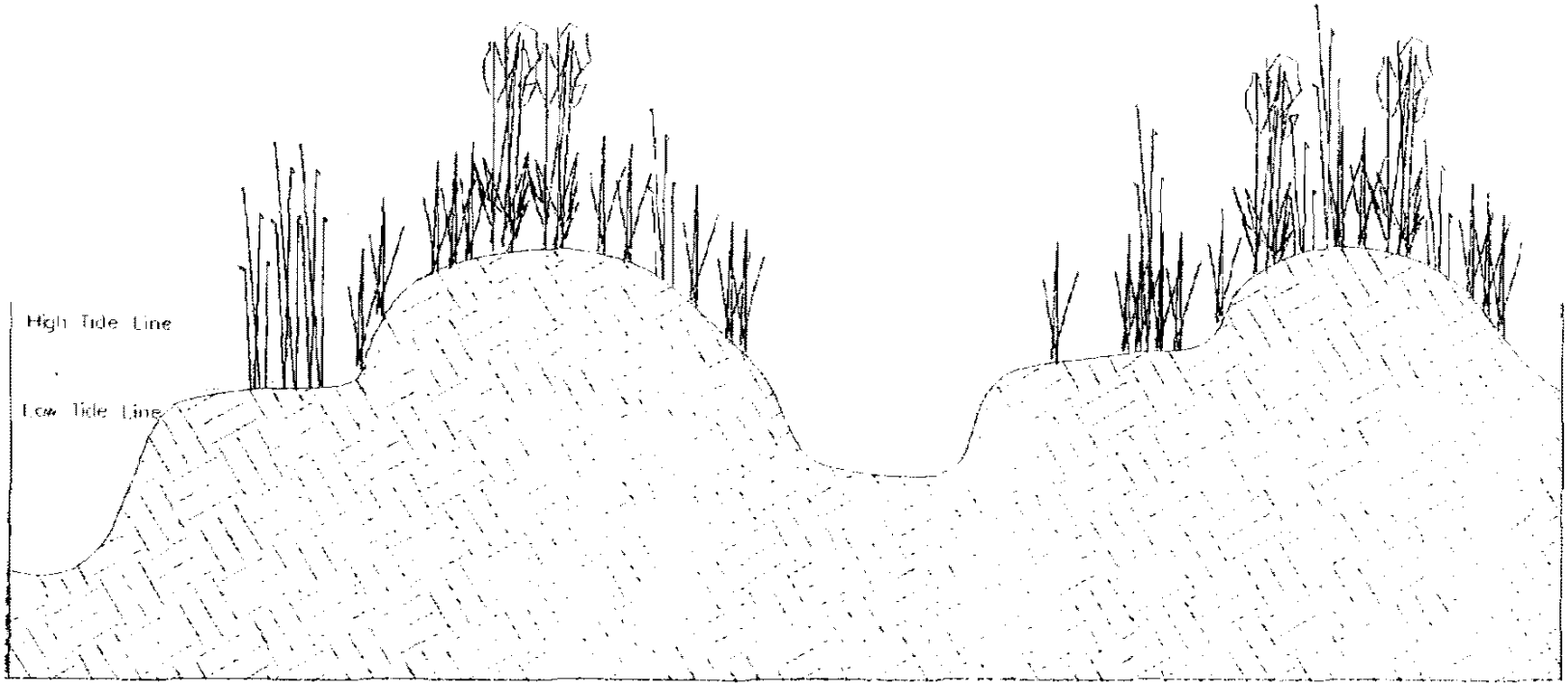
As the **C-P-M Cross Section** drawing (directly following on page 27) indicates, each side of the channel will have a final elevation approximating the low tide line. This will result in less volume of open water and a greater amount of planted wetland shelf.

The previously removed "O" horizon will be placed upon the mounds and shelves and then replanted by hand with *Spartina alterniflora* and various mature plants from within the tract boundaries. These higher mounded areas may provide bird nesting habitat through protection from predation.

Summary: The **c-p-m** criteria specifies future sedimentation capacity, correct elevation of planting shelves, and central cores of "avoided" parent soil material where possible in order to prevent erosion.

Quality of Tidal Waters: Additional Restoration credit of 1 acre is calculated due to the specification included for blocking the current tidal inflow of low quality brackish water from the adjacent shipyard. The new inflow point directly from the Ship Channel will be duplicated at the opposite end of the enlarged tidal zone, in order to provide circulation for enhancement of dissolved oxygen.

Constructed Channel Cross Section



NOTES:

1. TWO CHANNELS TO BE CUT FROM THE EXISTING SHIP CHANNEL IN THE NORTHWEST CORNER EASTWARD TO AS NEAR THE PIPELINES AS PRACTIBLE.
2. CHANNEL WILL VARY IN DEPTH FROM 1' TO 2', AND IN WIDTH FROM 5' TO 20' WITH SMALL POOLS TO BE EXCAVATED ADJACENT TO THEM.
3. MOUNDS AND SHELVES WILL BE REPLANTED BY HAND WITH MATURE PLANTS AFTER RECEIVING DEPOSITED SEED BANK.

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Tidally Influenced Project
Channel-Pool-Mound
Cross Section Detail

Drawn By	Sheet
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11-14-94	MM-3

Pipeline Work Plan Details

During design consideration of the 33 acre wetland construction site, two adverse conditions existed; namely the presence of some metal scrap, and of pipelines crossing the 17 acre tidally influenced project site.

A suitable **Work Plan Methodology** to incorporate surface removal where planned, and avoidance and/or crossing of the pipelines; is as follows:

Description of Work Plan Details--

Stored Metal Material: Most of the primary 17 acre site contains little or no stored metal material; however the upland area adjacent to the current outfall ditch, and some of the Freshwater project site contains metal piping, vessels, and other buried metal materials.

Construction Work Methodology: Large metal items on the surfaces to be excavated (work area) will be removed and hauled away from the constructed wetland sites prior to beginning excavation to design elevations.

Pipeline Locations: The primary (**17 acre Tidal Project**) work area is crossed in two directions by chemical product pipelines; one set of pipelines is administered by **Chevron Pipeline Company,** and the other by **Amerada Hess Corporation** as shown on the attached map (page 34).

The Chevron set extends from the south boundary directly across the planned work area adjacent to the existing tidal pool. The Amerada set follows the south boundary to the existing inlet channel, crosses under the channel, then continues on the same line to the existing upland area, and then dog-legs northward to the Houston Ship Channel.

Construction Methodology for the Chevron Pipeline Set: The multiple lines enter the ground at the eastern edge of the tidal pool, and travel northward directly from the pool edge under the existing outfall channel to the Ship Channel beach. This area falls within the section designed to be left at the current elevation as an island. As Chevron previously excavated to a depth that located the lines under the current tidal pool level, no special methods are required to avoid them after they are marked by Chevron personnel (provided that the buried depth of the lines does not rise within the work area).

Construction Methodology for the Amerada Pipeline Set: Where the Amerada lines follow the south boundary and cross under the existing saltwater inlet; no special work methods are needed other than to avoid the lines as located by Amerada personnel.

However, where the lines dog-leg northward crosses a major excavation area of the designed project. As indicated on the following attached map, the area of concern rises in elevation to the extent that soil removal to design elevations will either expose the lines or bring the surface level very close to them.

These impacts were discussed by telephone several times with Mr. Vance Rannells of Amerada, including providing him with a copy of the color map showing the intended work area. He subsequently referred to Mr. Andrew Zizinia who provided the details necessary to determine the final work methods. According to Mr. Zizinia, Amerada personnel will locate the exact pipeline placement by inserting rods into the ground until they strike the pipes to find the exact depth. They will then stake the locations, and mark the depths on the stakes.

The heavy construction equipment used for excavation will be directed to work at the sides of the pipeline set, without traveling on or excavating across them. The linear area covering the Amerada lines is planned to be left at current elevation by careful excavation along its' edges (operators are to be supervised by Amerada). The lines are buried at a depth such that the remaining higher ground may become the future access roadway. The weight limit of the roadway will be restricted to pick-up sized trucks and small maintenance equipment.

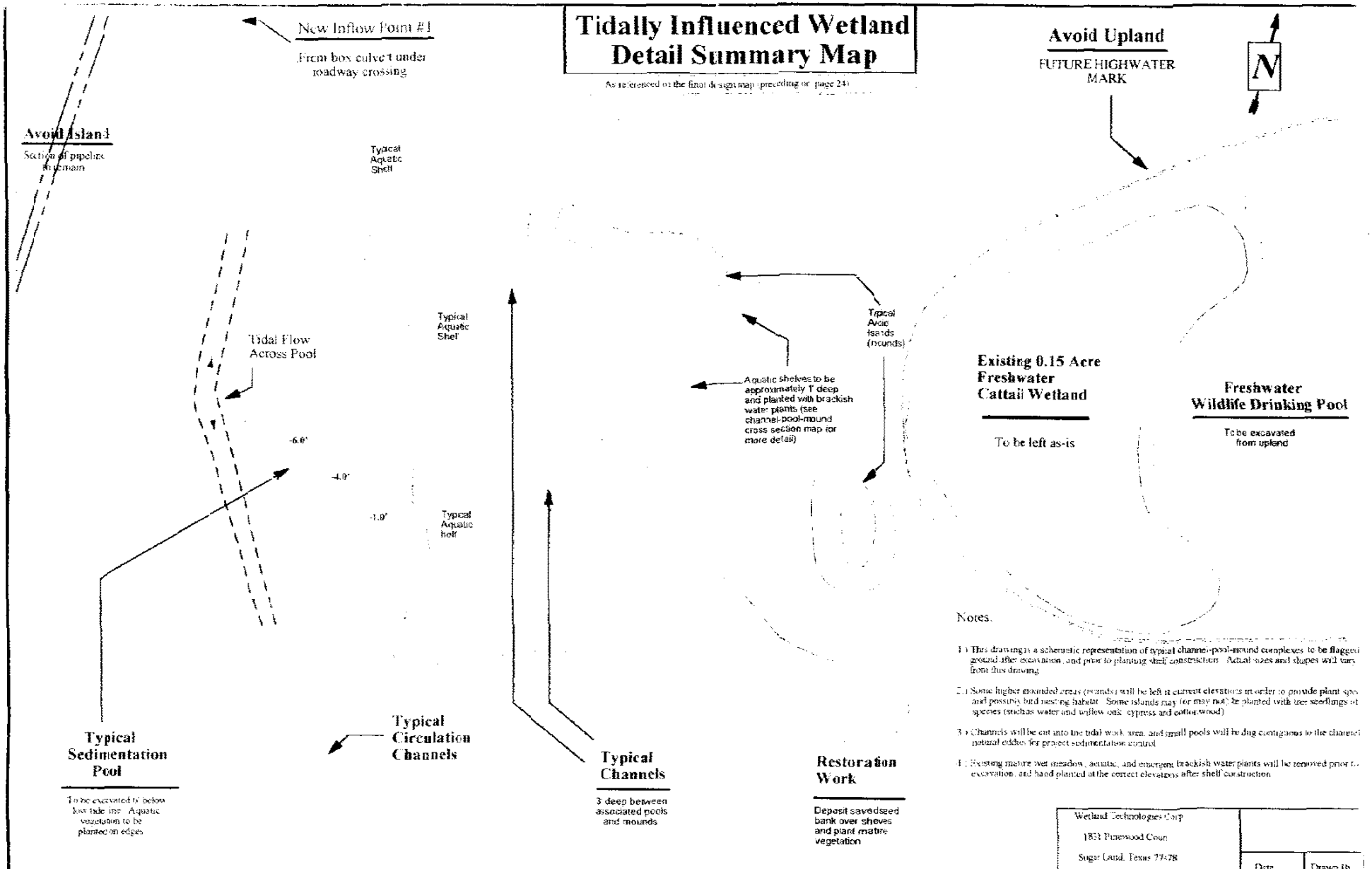
Only under extreme circumstances would it be necessary for small equipment such as a backhoe to cut a crossing either under or over the lines (whichever is the safest method). If so, a culvert will be laid over the lines if they are several feet under the final surface elevation; and a "u" culvert will be installed under them if they are at the surface (under direct Amerada supervision).

This easement is well marked on the ground by Amerada signage, which was walked in its entirety to assess the probable impact on the project as designed. Photographs of the subject areas are included.

Summary: After staking, the Chevron lines may be avoided entirely without impacting the planned design. The Amerada lines may be carefully excavated up to their edges, and culverts placed across or under them according to supervision to be provided by Amerada.

Tidally Influenced Wetland Detail Summary Map

As referenced on the final design map (preceding or page 24)



Notes:

1.) This drawing is a schematic representation of typical channel-pool-mound complexes to be flagged on ground after excavation, and prior to planting shelf construction. Actual sizes and shapes will vary from this drawing.

2.) Some higher mounded areas (mounds) will be left at current elevations in order to provide plant species and possibly bird nesting habitat. Some islands may (or may not) be planted with tree seedlings of species (such as water and willow oak, cypress and cottonwood).

3.) Channels will be cut into the tidal work area, and small pools will be dug contiguous to the channel network either for project sedimentation control.

4.) Existing mature wet meadow, aquatic, and emergent brackish water plants will be removed prior to excavation, and hand planted at the correct elevations after shelf construction.

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Date 1-13-95

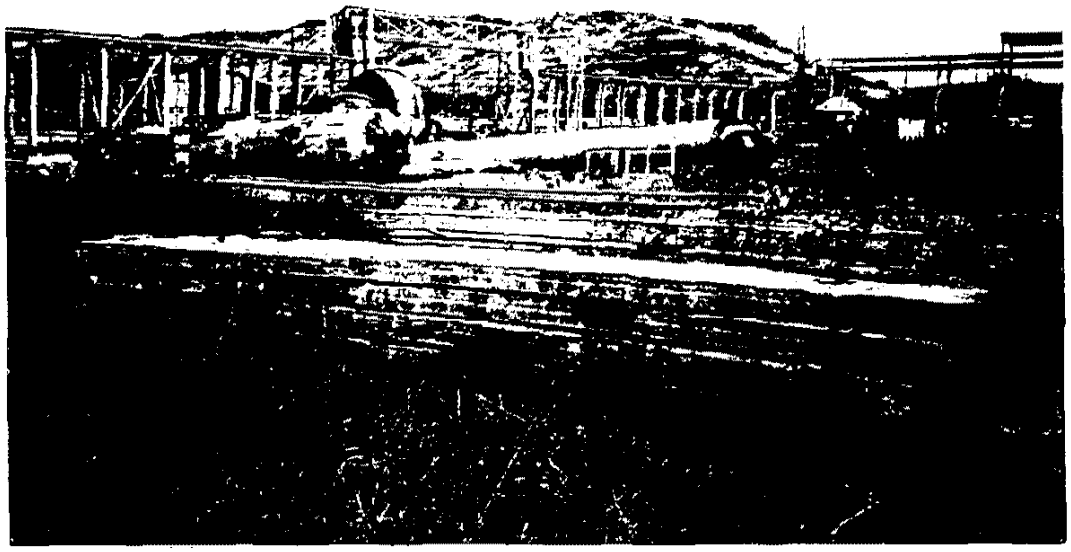
Drawn By Alex J.

Representative Area: This photo represents the natural channel-pool-mound complex as exists in salt marshes indicative of the Galveston Bay area; **however, brackish water species are to be planted primarily, as well as the *Spartina alterniflora* shown in this photograph.**

Close-up of intended channel-pool-mound complex: Channels will be cut into the tidally influenced area at a depth from 1 to 2 feet. Small pools for sedimentation capacity will be dug to a depth of 6'. Higher mounded areas will be left at current elevations to provide potential bird nesting habitat.

Amerada Pipeline Exit Point: The beach in the center foreground is the area where the Amerada Hess Pipeline set exits northward from the site into the Ship Channel.

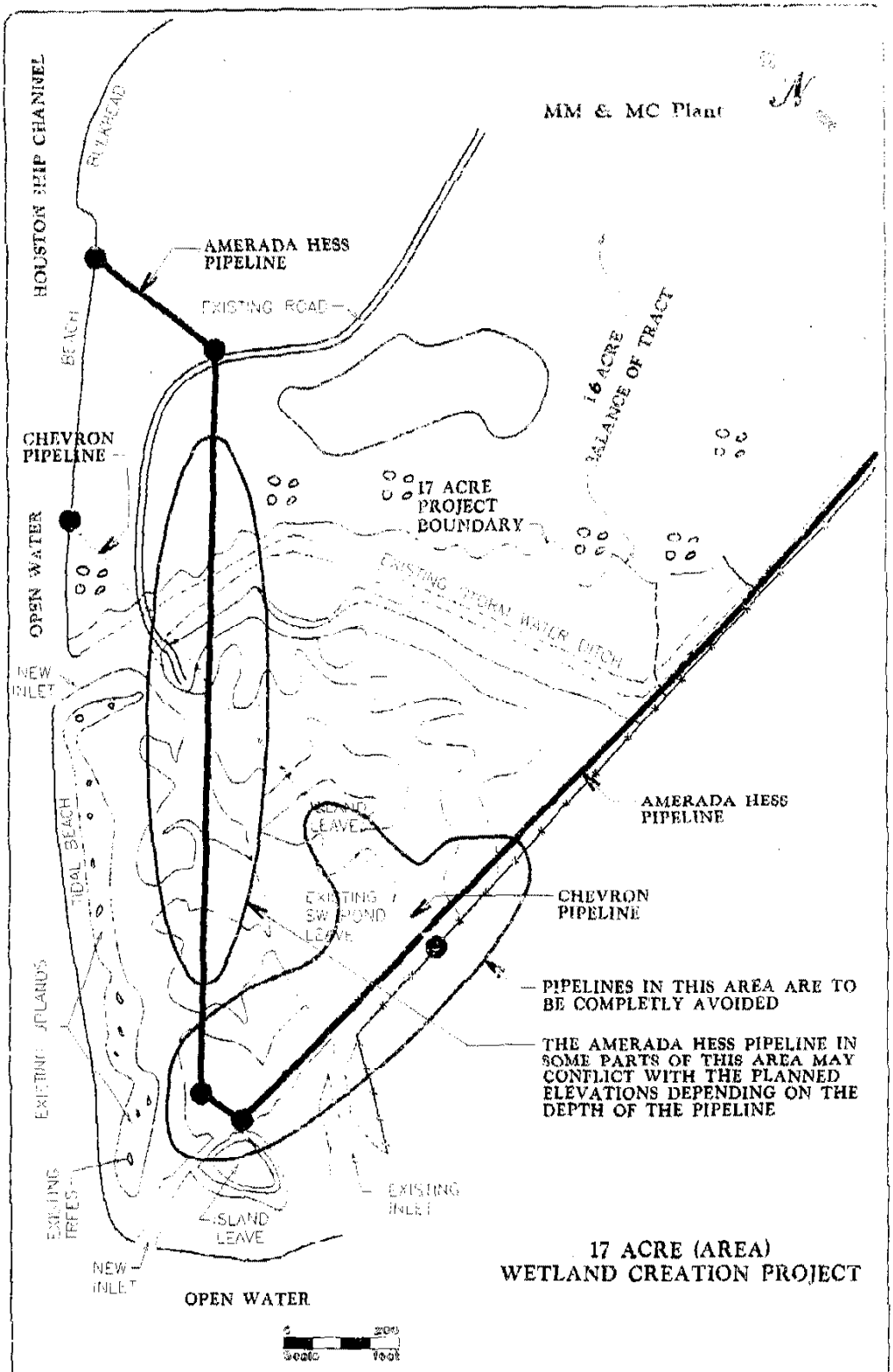
The lines extend from top center down the slope into this area.



Metal Storage Location: A close-up of the proposed work area in Section Two containing a large amount of metal to be hauled away. Note the open ended piping and vessels which appear to have contributed **no chemical residues** to the project area.

Pipelines Crossing the Planned Work Site: View of the proposed tidal project work area. The Amerada pipeline set extends downslope across the planned work area to the turn point shown below. Shallow wetlands are to be excavated carefully along it's edge. Heavy equipment will avoid the set of lines and their remaining surface will be used for future light vehicle access.

Pipeline Turn Point: A close-up of the area where the Amerada lines approach along the south boundary, cross under the existing pond edge, and turn northward in the immediate left foreground.



Wetland Technologies Corp. 1831 Pinewood Court (713) 242-8734 Sugarland, Texas 77478	**MOBIL MINING & MINERALS CO.** PIPELINE LOCATION MAP Pasadena, Texas	Drawn By: SG	Sheet: 34 OF 48
		Date: 2-10-93	Project #: MM01

Section II: Freshwater Wetland Creation

Planned Construction Methodology

Plant Species: Large reed species prefer nutrients to a greater extent than lower growing wetland vegetation. *Typha angustifolia* (narrow-leaved cattails) dominate in stormwater ditches directly adjacent to the tailings piles; and a large reed grass dominates the existing outfall ditch from the **MM & MC** treatment plant. Use of these and other site-adapted species in the constructed wetlands are specified.

Microbial Remediation: Large reed species will uptake a small amount of nutrients; however their main purpose is to survive in the rich waters and provide within their root zone a suitable habitat for those microbes known to modify effluent nutrients.(2)

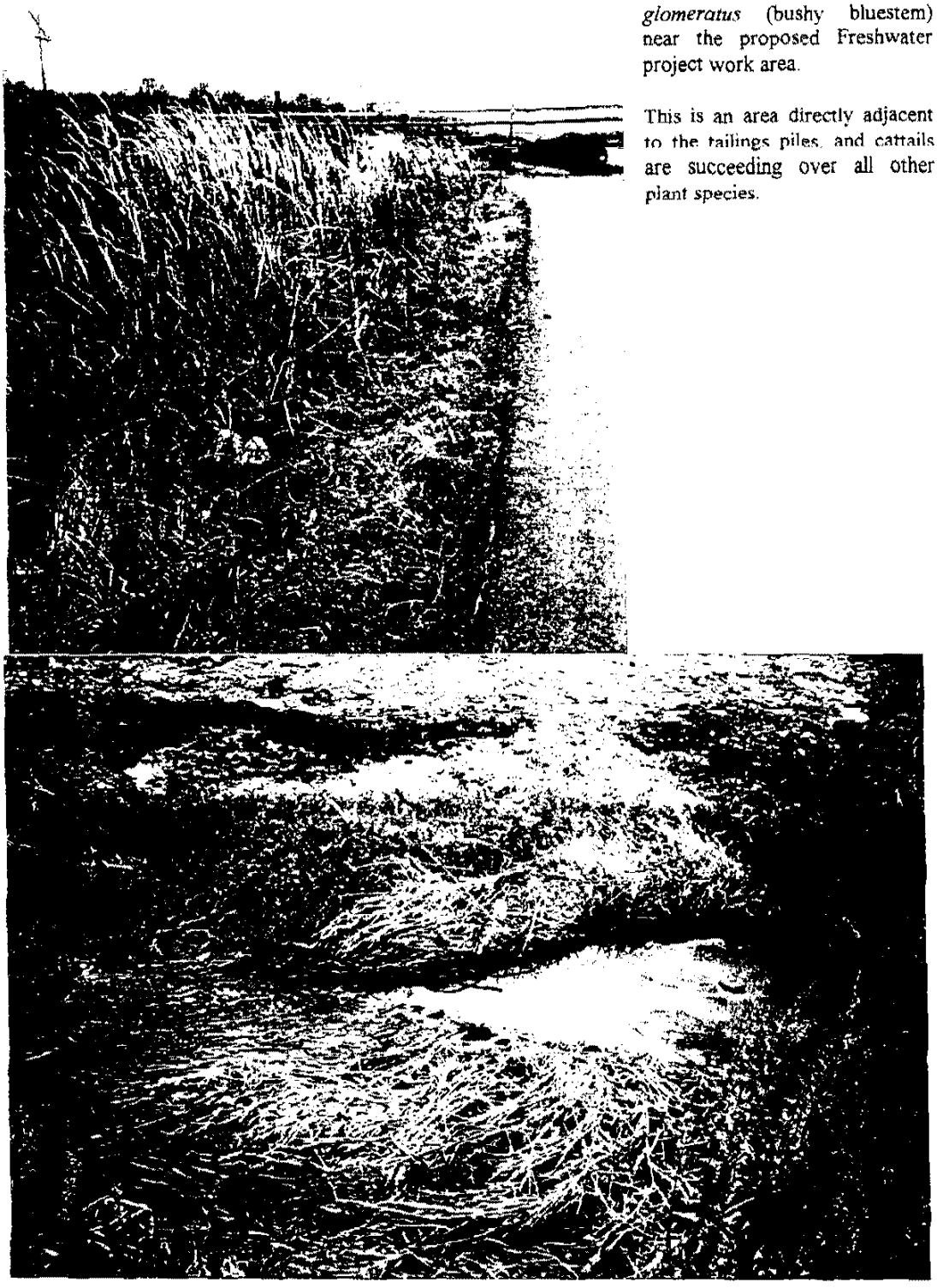
Contact Time: Contact time is controlled by the serpentine waterflow path through the project site planted with large reed species. Specifically, nutrient containing water will flow into a surge pond containing previously cleansed water, and then fall into meander ditches and associated shallow wetlands pushing clean water downstream into the balance of the system.

Small areas directly adjacent of the **Project** will have water collection ditches installed around them to flow into the next section of the treatment system. Consequently, small inflows of stormwater will be introduced into the main channel (central drain) for dilution and treatment at all stages prior to final outfall.

Therefore, nutrient containing waters flow from the treatment plant outfall through a ditch system planted with large reed species, into one large shallow wetland; the entire system being capable of detaining the **MM & MC** treatment plant discharge for a period of approximately 48 hours, and no less than 24 hours (except when receiving stormwater).

Cattails/Bushy Bluestem: A "donor site" of *Typha angustifolia* (narrow-leaved cattails) and *Andropogon glomeratus* (bushy bluestem) near the proposed Freshwater project work area.

This is an area directly adjacent to the tailings piles, and cattails are succeeding over all other plant species.



Reed Grass: A close-up of the large reed grass (species not identifiable on inspection date) dominating the existing oufall ditch edge. The seedbank from these sites is to be planted in association with cattails where specified.

SOUTHERN HALF OF FRESHWATER PROJECT
ADJACENT TO TREATMENT PLANT OUTFALL

The treatment plant west outfall point will be re-located to it's north side where it will connect with the constructed wetland system. The existing drainage ditch will be re-graded northward into the new system collector on two triangular tracts, and a rectangular tract currently fenced for material storage as is shown on the attached Freshwater Wetland Final Design Map on page 44.

Inflow Surge Pond: The first wetland system component is a small triangular tract directly north of the treatment plant. It will be excavated to a flood pool depth varying from 4' to 8' as the initial surge pond. It's edges will be planted with the reed grass, however it will serve mainly to attenuate inflow velocity.(5) A considerable amount of standing water will be maintained in order to dilute new inflow prior to entry into the meander system.

Serpentine Meander Ditch: The next component will be located on a much larger triangular site. Water will flow from the surge pond into the serpentine meander ditch system. The meander ditches and shallow wetlands will be planted with a mixture of cattail and reed grass. Reed grass may dominate the first part of the system while cattails may begin to succeed at the point where nutrient levels are somewhat lowered downstream.

The serpentine meanders will continue on to a larger fenced rectangular tract slightly below the outfall of the second tract. It will also receive stormwater from new collection ditches installed around adjacent higher ground. These multiple inflows will collect within these meanders (including a certain amount of storm surge capacity); and it's edges will be planted with site-adapted reed species.

This rectangular site will contain an extensive meander ditch system with some shallow wetlands covering some 75% of the rectangular area. The meander channel will widen a few times into shallow constructed wetlands (that mimic natural wetland systems) as it courses across the tract.

The edges of meanders and shallow wetlands will be planted with site adapted *Carex spp.* (sedges) and *Andropogon glomeratus* (bushy bluestem) transitioning into *Cyperus spp.* (umbrella sedges) and *Eleocharis spp.* (spikerushes) which may survive if the water's nutrient level is appropriate. The ditch system will continue to flow through a larger adjacent rectangular tract and meander north towards the **MM & MC** plant site.

Serpentine Meander: The large triangular tract where the first "serpentine meander" is planned. A *meandering shallow channel planted with cattail and reed grass will receive effluent from the surge pond* (area shown below). **Most nutrient modification will occur here; and in the large shallow wetland to be constructed on the fenced rectangular site to the extreme upper right corner.**

Primary Surge Pond: A small triangular site adjacent to the treatment plant to be excavated for the first inflow surge pond. The planned new plant outfall location is in the upper left corner.

NORTHERN QUARTER OF FRESHWATER PROJECT ADJACENT TO MM&MC PLANT SITE

The first section falls downstream into this quarter of the project which consists primarily of meandering ditches flowing northward (along the edge of the **MM & MC** plant site towards the existing large storm surge pond). These meanders also receive stormwater from collector ditches installed into the interior of the higher land adjacent to the west as shown on the attached Freshwater Wetland Final Design Map on page 39.

Work Area Conditions: Piping, vessels, and other large metal items currently lay on the project work area. All large metal items will be removed and hauled away from the constructed wetland sites.

Serpentine Meanders: A meander system similar to those contained in the previous (southern) half of the tract will slow streamflow velocity. The meanders will flow northwest and connect to the aeration chute located in the northwest quarter of the project.

Water Quality Enhancement: *Although consumption of dissolved oxygen by algae blooms may be performed upstream due to nutrient removal by system processes; a need to inject oxygen still remains. The considerable elevation fall from the adjacent northern quarter of the project to the northwestern quarter is to be utilized to aerate water by outfalling over a chute of broken concrete.*

Beneficial Effects of Higher Diversity of Modifying Bacteria: The variety of bacteria species identified by the literature in the type of wetland system specified is typically five times the number of species found in a wastewater plant. In turn, the greater microbial diversity defines a larger variety of nutrients that can be subjected to **beneficial water and soil chemical processes in a combined aerobic/anaerobic environment.**(2)

Secondary Infall Point: The ditch to center left is the Planned outfall from the southern half into the northern quarter. The ditch from top center will be extended outward into the adjacent higher land, in order to collect it's runoff for insertion into the new water treatment system.

Secondary System Location: A close-up of the Planned work area in Section Two containing a large amount of metal to be hauled away. Note the heavy algae bloom on free-standing water from nutrients left in materials stored in the site underlying the Planned project area.

NORTHWEST QUARTER LOCATED
ADJACENT TO THE HOUSTON SHIP CHANNEL

The final quarter serves a **"polishing"** function as well as treatment of stormwater runoff from adjacent areas. However, it's main purpose is to receive all streamflow of the sites' various collector ditch and wetland systems as shown on the attached Freshwater Wetland Final Design Map.

Erosion Control: Close inspection of the area adjacent the northside beach revealed it to be directly in the path of high streamflows during major storm events. This exposure would eventually promote break-through of any tidal barrier constructed to protect the system outfall; thereby exposing the final collection pool to degrading waters of the Ship Channel. Consequently, the final system pool is to be dug into the area directly behind (south of) the surviving bulkhead section in order to protect it's improved water quality.

Flood Pool Design: The final pool will be constructed with very broad shelves varying between 10" to 24" below normal pool level. This particular design focuses on habitat for aquatic vegetation known to generate large quantities of dissolved oxygen that chemically bonds with water. This "natural" incorporation process is of such efficiency that it does not suffer the degredation effects of mechanical aeration.

Water Quality Improvement: The application of successful planting methodologies (which are imperative to establishing vegetation growth) plays an important role in improving water quality; such as:

1.) obstructing the flow of fast moving water; thus reducing it's velocity, which in turn enhances the **Project's** sedimentation rates, and

2.) extremely efficient conversion of nitrogen and phosphorus as nutrient removal for biomass production, and

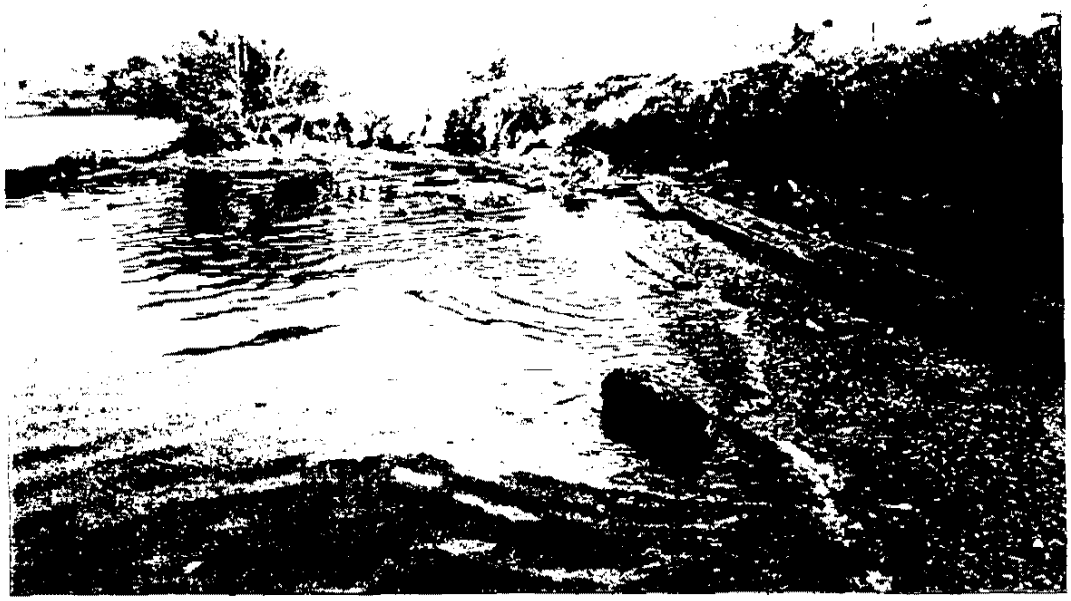
3.) increasing the surface area within the water column for the attachment of microbes, thereby multiplying the number of different microbial species, and their overall populations, and

4.) providing an aerobic environment around their roots for those microbes which require the presence of oxygen to conduct modifications of effluent nutrients and other compounds.(3)

Consequently, focusing on the establishment of a broader diversity of wetland plants translates into a higher diversity of microbial species (treatment bacteria) populations.

Final System Outfall Point: The old bulkhead is permanently in place at this point, and will support the final outfall pipe in the area shown.

This is an area some 100' from the beachfront erosion shown below.



Active Erosion: An example of beachfront erosion at the point where major stormflows strike the edge of the property. This area will have a minimum of 25' setback to the project final surge pond site to protect the integrity of it's banks and quality of outfall waters.

Freshwater Vegetation Planting Detail

Methodology: Soil manipulation techniques performed in the Freshwater project will be similar to those used in the tidal project. Seedbank from the area will be removed and saved until such a time as grading of the planting shelves is complete and the seedbank can be placed at the appropriate elevations. The seedbank will include those seeds site-adapted to this particular area such as cattails, sedges, reed grasses, and several species of aquatic plants.

Qualified personnel will indicate to the installation crew the different types of vegetation they are planting--upland plants as well as three types of wetland plants: **wet meadow, emergents, or aquatics.** The underlying "seedbank" (designated as the "O" horizon) includes most plant types that occur naturally in the area, and within about 6 weeks each individual area will revegetate itself with the correct plant type.(4) The appropriate "seedbank" material must be deposited in the correct (as specified) areas to ensure their survivability.(4)

Freshwater Plant Species List

Typha angustifolia (narrow-leaved cattail)

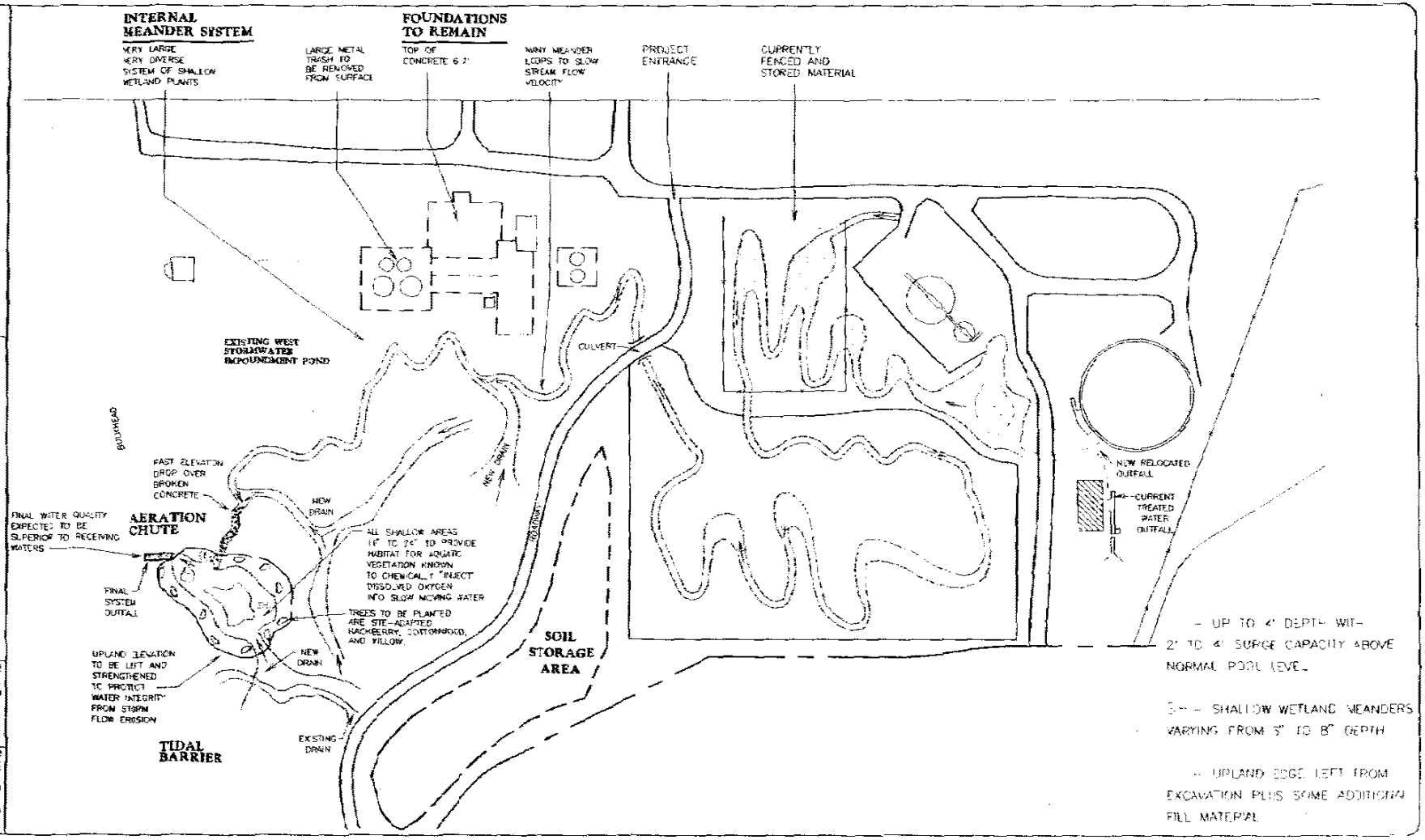
Rhynchospora spp. (beakrush)

Andropogon glomeratus (bushy bluestem)

Cyperus spp. (umbrella-sedge)

Ptilimnium capillaceum (mock bishop's weed)

Additional Plant Species: Ponded water species such as *Sagittaria spp.* (arrowhead) and *Pontederia cordata* (pickerelweed) will be imported from off-site. Site-adapted floodplain tree species located near the **Restoration Project** area will also be planted to uptake some persistent nutrients during their transpiration cycle. *Salix nigra* (black willow), *Celtis laevigata* (sugarberry) and *Populus deltoides* (cottonwood) seeds and/or seedlings will most likely be collected with the above plant's seedbank and establish themselves randomly throughout the project area.



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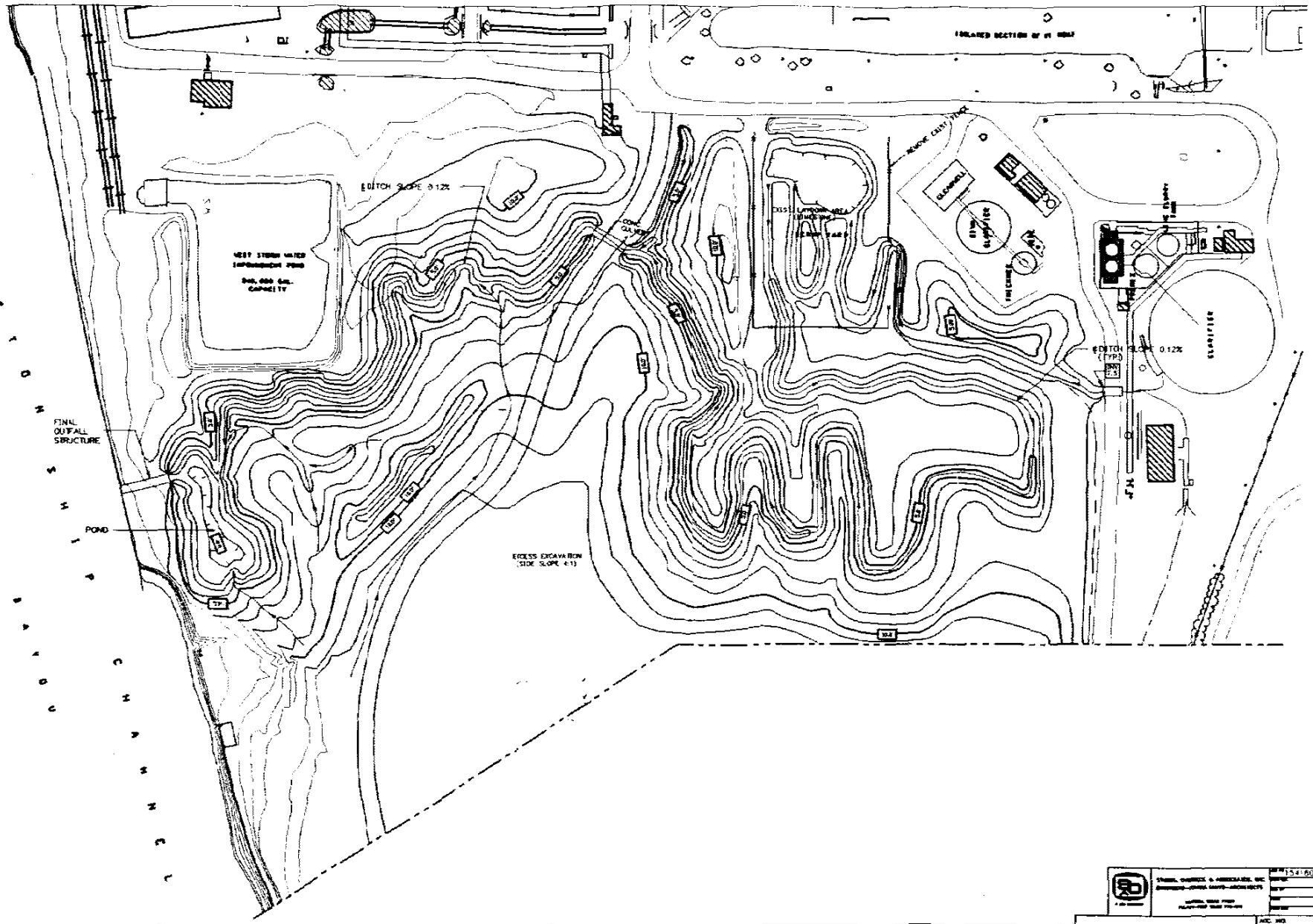
Mobil Mining & Minerals Co.
Freshwater Wetland Creation Project

FINAL DESIGN

Drawn By: SG
Date: 1-4-95
Prnt / Rev: MM/CONCEPT
Sheet: 44 of 55
Project #: MM03



Mobil Mining and Minerals Company

WETLANDS EXCAVATION MAP

Project Performance Criteria

Tidal Marsh Restoration:

Purpose: The primary criterion is specified to be a local increase in finfish nursery areas due to **the creation of new tidally influenced aquatic habitat** by:

1.) **excavating to the elevations shown on the Wetland Excavation Map, page 25,**

2.) **constructing planting shelves as described in the Construction Details section, page 21, and**

3.) **planting appropriate vegetation at the elevations shown in the Channel-Pool-Mound detail drawings, pages 26 to 28.**

A secondary purpose is to increase the water quality of inflow from the Ship Channel during it's "stand" in the **Tidal Marsh Project (Marsh Project)** area due to sedimentation, some addition of dissolved oxygen, and modification of pollutants by contact with the vegetation.

Marsh Project Performance Standards

The **Marsh Project "performance standards"** developed by the **Trustees** to ensure compliance with the above described **Criteria** are agreed to be as follows:

1.) Excavate to the elevations shown on the **Wetland Excavation Maps** to be attached to the detailed **Work Plan**, with certification of critical final elevations of the **Marsh Project** by a registered surveyor.

2.) After construction, work shall be performed as necessary in order to:

- **a.)** maintain a tidal connection at mean low tide to the Houston Ship Channel, and
- **b.)** maintain inlets and culverts to ensure proper flushing so that the **Marsh Project** area does not become isolated from adjacent water bodies, and
- **c.)** maintain channel depths so they remain flooded at mean low tide, and
- **d.)** maintain average water depths of the **Marsh Project** area at mean low tide so that they are reduced by no more than **30%** from final design specifications.

3.) At the end of the **Certification Period** (more fully defined in the following **Monitoring Plan** section), vegetative coverage of intertidal wetland areas shall exceed **60%** (measured as foliar coverage and expressed as percent of ground surface covered), and

- **a.)** vegetation in these areas must be characterized by a healthy and positive trend for desirable and target species, and
- **b.)** vegetative coverage of undesirable and invasive plant species must not exceed **10%** within the **Marsh Project** area (an invasive plant species list is to be attached to the detailed **Work Plan**).

Freshwater Wetland Creation:

Purpose: Water quality (particularly the ammonia nitrogen level) within the **Freshwater Project** is expected to improve by enhancing nitrification and/or denitrification processes due to extended contact with wetland vegetation, and detention time within the system by:

1.) **excavating to the elevations shown on the Freshwater Wetland Excavation Map, page 45,**

2.) **constructing planting shelves as described in the Construction Details section, page 21, and**

3.) **planting appropriate vegetation at the elevations shown in the Freshwater Wetland Design Map, page 44.**

Freshwater Project Performance Standards

The **Freshwater Project "performance standards"** are agreed to be as follows:

1.) Retention capacity of the constructed **freshwater wetland treatment system** shall not decrease by greater than **20%** of design specifications, and

2.) vegetative coverage of the **Freshwater Project** shall exceed **70%,** to be measured as foliar coverage and expressed as percent of ground surface covered at the end of the **Certification Period**, and

3.) vegetative coverage of undesirable and invasive plant species must not exceed **10%** within the **Freshwater Project** area (an invasive plant species list is to be attached to the detailed **Work Plan**).

Monitoring Plan

After Construction Monitoring Plan

The **Objectives of the Monitoring Plan** are to:

1.) evaluate and document the success, viability and sustainability of the **Restoration Project**, and

2.) provide a mechanism for determining when **Restoration Project Performance Criteria** are met, and

3.) provide timely identification of problems which may be rectified through corrective action during the **Certification Period** and/or through the use of the **Restoration/Maintenance Fund** after **Certification**.

The **Project Monitoring Plan** will be implemented during the initial **Certification Period** and for an additional three years after certification of completion of the **Project**. The **Natural Resource Trustees** will be responsible for oversight and management of the **Monitoring Plan**. The **Trustees** will limit personnel to the minimum required to adequately implement the Plan.

Certification Period

The Certification Period is defined to be complete when the **Marsh Project** achieves 60% vegetational coverage, the **Freshwater Project** achieves 70% vegetational coverage, both **Projects** meet the invasive plant species limitations and all other project criteria such as tidal connection, water depths, elevations and retention capacity are met. This **Period** is expected to occur about 2 years after completion of construction, but the **Project** may meet these requirements at an earlier (or later) date.

Tidal Marsh Component

Monitoring of the **Tidal Marsh** portion of the **Project** will focus on:

1.) percent coverage of vegetation, and

2.) species composition of vegetation, and

3.) water circulation/flushing of **Marsh Project** area.

Part I-Vegetation-

Percent Coverage and Species Composition of Vegetation: A quantitative vegetative inventory, and also a qualitative analysis will be performed in order to describe the composition and structure of vegetation present at the **Marsh Project** site. The extent of vegetative coverage will be assessed, and areas with different types of dominant vegetation will be identified, as follows:

1.) **Aerial Photography:** Color aerial photographs at a scale equal to 1"=200' will be taken biannually during spring (April/May) and fall (September/October) months during the initial **Project Certification Period** and annually thereafter.

Total dominance of plants will be evaluated in terms of foliar coverage and expressed as a percentage of ground surface covered.

2.) **Primary Inspection:** Aerial surveys will be ground-truthed by a concurrent **site inspection program** to monitor growth and development of dominant or important species. Photgraphic and visual estimate of percent of vegetated cover will be made within permanently marked 1 m^2 vegetated quadrats located on transects radiating from open water to upland areas. Secondly, plant species will be identified in the quadrats, and the relative density of each species will be tabulated for the transects.

These assessments will be supplemented by other general field observations to verify and document vegetational characteristics of the **Project** area as is more fully described below.

3.) **Secondary Inspection:** A **field study** may be performed quarterly during the initial **Certification Period**, and biannually after **Certification**, in order to determine the presence of conditions which may limit vegetative growth in the **Project** area; and to determine the presence of nuisance species, and identify other conditions responsible for unhealthy or unbalanced plant communities at the **Project** site.

When feasible, this activity will be performed concurrently with other aspects of the monitoring program.

Part II-Water Circulation-

Flushing of Marsh Project Area: Water circulation of the **Project** area will be assessed as follows:

1.) **Primary Inspection:** A bathymetric survey of the **Project** area (focusing on tidal inlets and major channels), will be performed biannually during the initial **Certification Period** and annually thereafter, to identify problems in circulation associated with siltation, scouring or other depth altering processes.

In order to compare such elevation changes, a permanent **staff gauge** shall be installed in a subtidal area to create a stable datum from which to compensate for variations in tidal height at the time of each survey.

When installing the **staff guage,** mean low tide **(MLT)** is to be marked as 0.0' elevation where indicated by existing **tidal vegetation,** irrespective of it's level as recorded on standard Surveyor's topological maps of the area.

2.) **Secondary Inspection:** Basic water quality parameters (temperature, dissolved oxygen, pH, salinity) will be measured as indicators of poor water circulation and/or altered hydrology of the **Marsh Project** area. Samples will be collected mid-depth between surface and bottom at three locations:

a.) in one of the primary inlets, and

b.) in the northern corner of the ponded tidal pool, and

c.) in a side channel in the northeast portion of the **Project** area.

A significant part of the **field survey** will also be devoted to inspection of tidal inlets and internal culverts for plugging, and to identify other conditions responsible for improper or irregular hydrology at the **Project** site.

The water quality measurements and general **field survey** may be performed on a quarterly basis during the initial **Certification Period**, and biannually after **Certification**. When feasible, these activities will be performed concurrently with other aspects of the monitoring program.

Freshwater Component

Monitoring of the freshwater, water-polishing portion of the **Project** will focus on:

1.) percent coverage of vegetation, and

2.) species composition of vegetation, and

3.) retention capacity of the system, and

4.) nutrient reduction and improvement of water quality.

Part I-Vegetation-

Percent Coverage of Vegetation and Species Composition: Vegetative coverage will be assessed by the same methods and to the extent possible on the same dates as are more fully specified in the **Marsh Component** of the **Project**. A quantitative vegetative inventory and analysis will also be performed by the same methods and to the extent possible, on the same dates as the **Marsh Component** of the **Project**.

Part II-System Capacity-

Retention Capacity of the System: The retention capacity of the system will be assessed as follows.

1.) **Primary Inspection:** A bathymetic survey of the **Project** area will be performed biannually during the initial **Certification Period** and annually thereafter, to identify problems in system retention capacity associated with siltation, or other depth altering processes.

In addition, a **dye study** may be implemented on an annual basis to evaluate changes in retention capacity and contact time of the Project. The appropriate amount of an approved, non-toxic dye would be released at the initial plant outfall point. The time elapsed between release of the dye and the time at which it appears at the final outfall would be used as an indication of changes in system retention time.

2.) **Secondary Inspection:** A **field study** may be performed quarterly during the initial **Certification Period** and biannually thereafter, to inspect for and identify conditions responsible for alterations of established retention capacity; and for any other improper or irregular hydrology at the **Project** site.

Part III-Water Quality-

Nutrient Reduction and Improvement of Water Quality: To monitor the nutrient stripping capacity of the **Project**, the following activities will be conducted as follows:

1.) Water samples will be collected and analyzed for total phosphorus, orthophosphate, total nitrogen, total ammonia nitrogen, total nitrate nitrogen, total nitrite nitrogen, total Kjeldahl nitrogen, total dissolved solids, and total suspended solids.

Samples will be collected at mid-depth between surface and bottom at three locations:

a.) at the initial treatment plant outfall,

b.) in the meander ditch midway between inflow surge pond and final collection pool, and

c.) at the final system outfall.

2.) **Samples** for the purpose of analyzing basic water quality parameters (temperature, dissolved oxygen, pH, and perhaps salinity) will be collected at the same three sites as indicators of the general **water quality** of the **Project**.

Water quality samples will be collected and analyzed on a quarterly basis during the initial **Certification Period**, and biannually after **Certification**.

Monitoring Plan Timeline

Dates of inspection to be performed after construction according to requirements of the Monitoring Plan

Item Description	Yearly-Prior to Certification apprx. 2 yrs.		Yearly-After Certification 3 yrs.	
Primary Study	**# times**	**season**	**# times**	**season**
❶ Color Aerial	2	spring/fall	1	spring
❷ Vegetation (s/w and f/w) a.) % Coverage b.) Species Composition	2	spring/fall	1	spring
❸ Bathymetric (s/w and f/w)	2	spring/fall	1	spring
❹ Dye Study (f/w) only	1	spring	1	spring
Supplementary Study				
❺ Vegetation (s/w and f/w) a.) Observe General Conditions	4	all	2	spring/fall
❻ Water Quality (s/w and f/w)	4	all	2	spring/fall
Report Preparation				
❼ Yearly Report	1	following spring	1	following spring

References

Wet Tech has referred extensively to material in the following publications:

1.) Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, J. C. Sifneos. 1993. *An Approach to Improving Decision Making in Wetland Restoration and Creation.* Edited by A.J. Hairston. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

2.) Hammer, Donald A. 1989. *Constructed Wetlands for Wastewater Treatment.* Lewis Publishers, Inc. Chelsea, Michigan.

3.) Horan, N.J. 1990. *Biological Wastewater Treatment Systems.* John Wiley & Sons Ltd. West Sussex, England.

4.) Kusler, Jon A. and Mary E. Kentula. 1990. *Wetland Creation and Restoration.* Island Press. Washington, D.C.

5.) National Research Council. 1992. *Restoration of Aquatic Ecosystems.* National Academy Press. Washington, D.C.