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GEOTEXTILE TUBES, DESIGN, APPLICATIONS AND CASE HISTORIES

Geotec Associates
Jack Fowler, Ph.D.,PE
5000 Lowery Rd Vicksburg, MS 39180
Ph. 601-636-5475 jfowler@geotec.biz
Cell 601-831-3818 www.geotec.biz

What are Geotextile Container Systems?

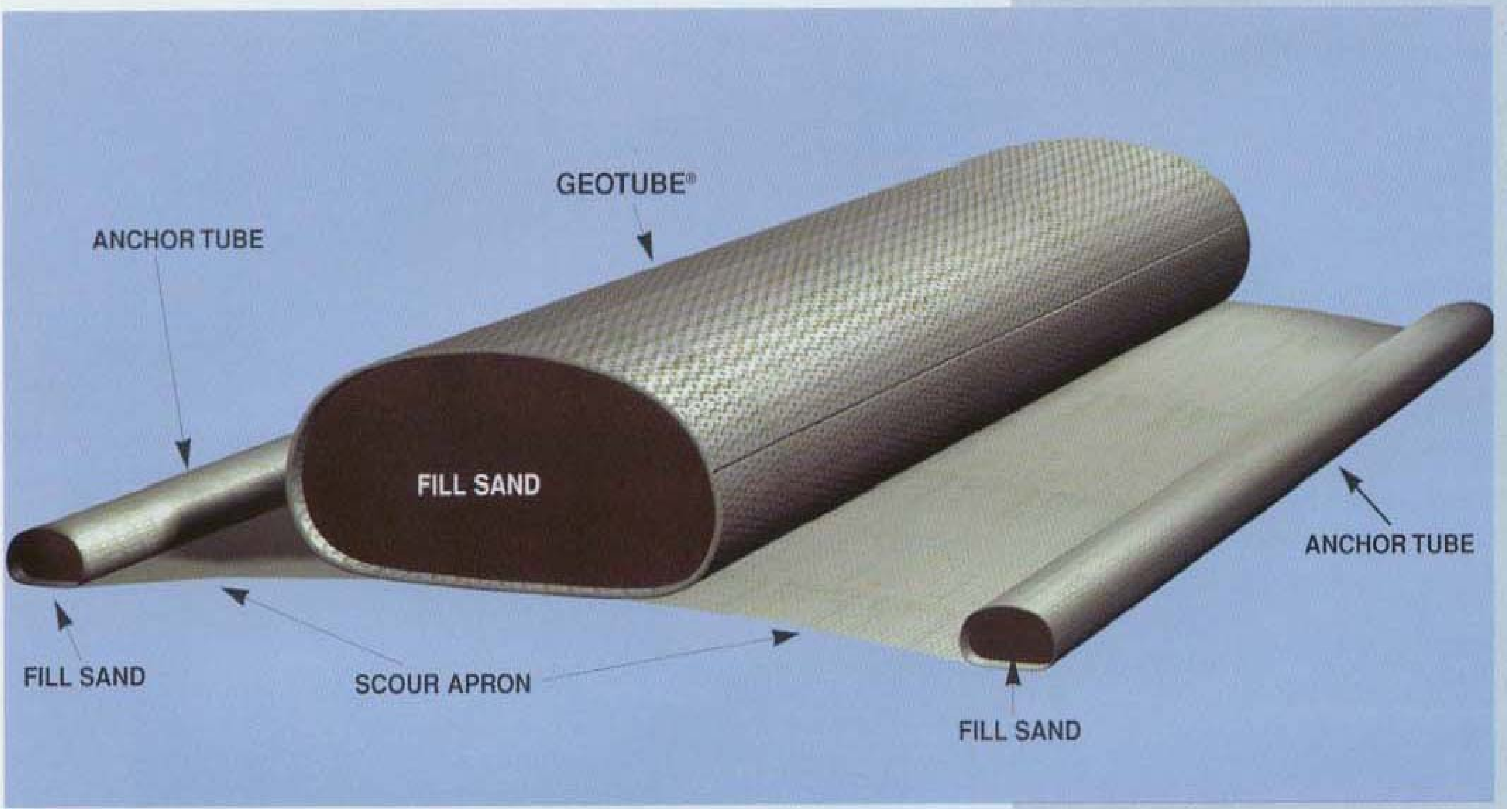
- Geotextile Bags
- Geotextile Tubes
- Geotextile Containers

GEOTEXTILE BAGS

GEOTEXTILE TUBES

GEOTEXTILE CONTAINERS

Typical Marine Installation



Manufactured by sewing multiple sheets of high strength woven polyester or poly-propylene fabrics with high strength seams

Panels Being Sewn

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Rolling Up Tube

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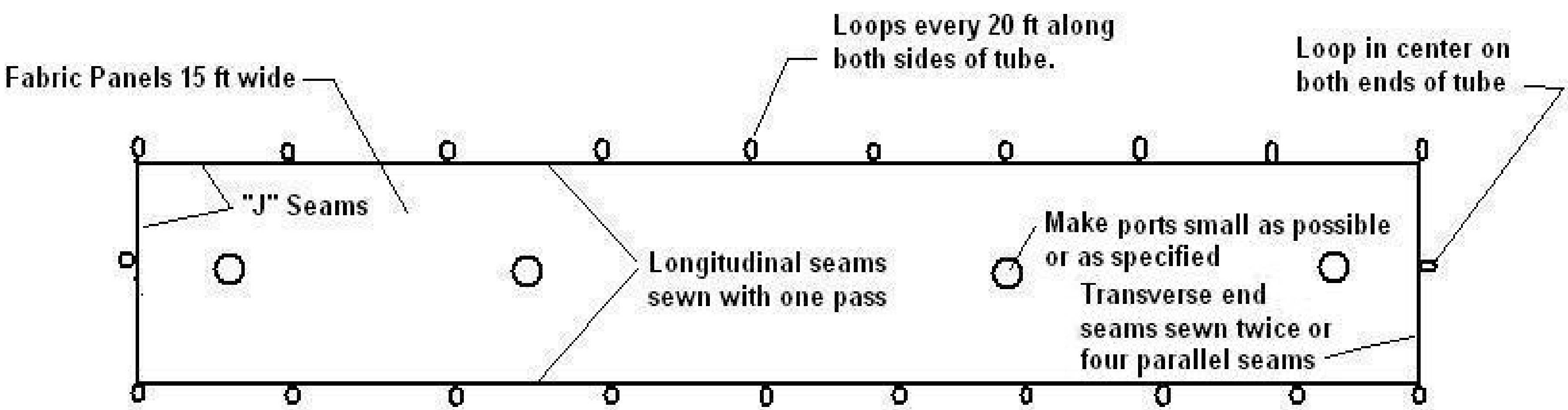
Tube Design Plan View

Circumference and Length as Required
Circumfernces are normally 15, 30, 45, and 60 ft

Loops are nylon or polyester
2 inch wide seated belt straps



All seams are sewn with one pass parallel to the longitudinal axis of the tube. End seams are sewn twice. All seams are "J" seams. The seams consist of type 401 double lock stitch that is sewn with a double needle Union Special Model #80200 Z sewing machine. The machine should be capable of sewing two parallel seams about a quarter inch apart. The thread is High Tenacity 12 ply 12,000 denier passing through the needles and 9 ply 9,000 denier passing through the loopers. Seams are 3.5 to 4.0 stitches per inch. Field Tech Pricise-Rick Smith-910-653-5200 yarn source in NC.

Note: Injection ports as required. Ports located 10 ft from each end and on 50 ft spacing for remainder of the tube or as specified

Typical Fabrication Plan

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GETube Design Software

Software is available to calculate fabric stresses during the critical time of filling and installation when the fill material is fluid.

Jack Fowler 601-636-5475
jfowler@geotec.biz

Typical Input Data for GETube Computer Program

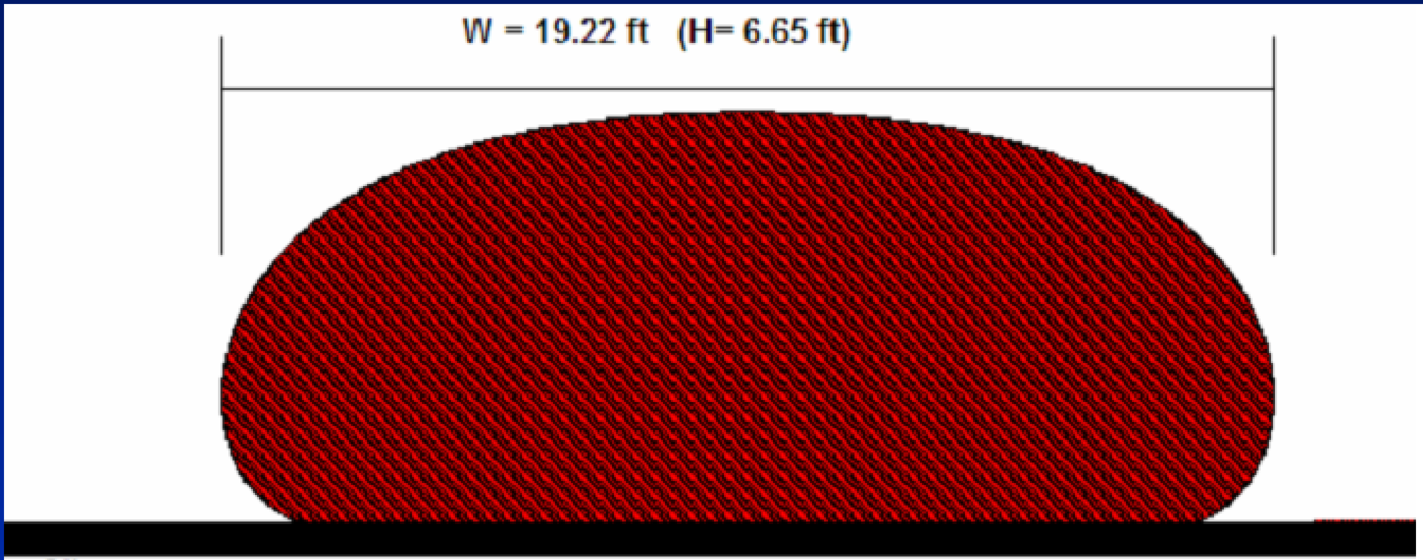
- Material Bulk Specific Gravity, 1.6 to 2.0
- Factor of Safety, 5.0
- Circumference, 30, 45, and 60 ft
- Tensile Strength, 500 to 1000 pli
- Area Opening Size, 20, 30 to 40
- Water Depth

GETube Input Parameters

Select any two Parameters and the others will be computed

- C = Circumference of the tube
- H = Height of the inflated tube
- T = Tensile Strength of the tube fabric
- V= Volume to which the tube is filled
- P = Excess Pressure above the top of tube
- R = Ratio of the fabric area to tube volume

Typical Output Data for 45 ft Cir Tube



GIVEN C = 45.00 ft T = 520.00 lbs/in SPG = 1.60 FS = 5.00

DENSITY OF SLURRY	=	99.84 pcf
TUBE CIRCUMFERENCE, C	=	44.98 ft
EX PRESS -TOP OF TUBE, P	=	0.7003 ft (water) 0.3035 psi
WORKING CIRCUM FORCE, Tcir	=	104.0 lbs/in 1248.0 lbs/ft
WORKING AXIAL FORCE, Tax	=	82.59 lbs/in 991.03 lbs/ft
TOTAL HEIGHT OF TUBE, H	=	6.651 ft
TOTAL WIDTH OF TUBE, W	=	19.22 ft
BASE CONTACT WIDTH OF TUBE	=	15.47 ft
END AREA OF TUBE	=	109.5 sq ft 68.04 % FULL
TUBE VOLUME, V	=	4.057 cu yd/ft 819.3 gal/ft
FABRIC AREA TO VOL RATIO,R	=	1.232 sq yd/cu yd
BASE PRESSURE	=	4.915 psi 11.34 ft (water)
REQ'D CIRCUM STRENGTH T	=	520.0 lbs/in 6240.0 lbs/ft
REQ'D AXIAL STRENGTH	=	412.9 lbs/in 4955.2 lbs/ft

Filling Methods

- Hydraulic
- Mechanical
- Positive Displacement

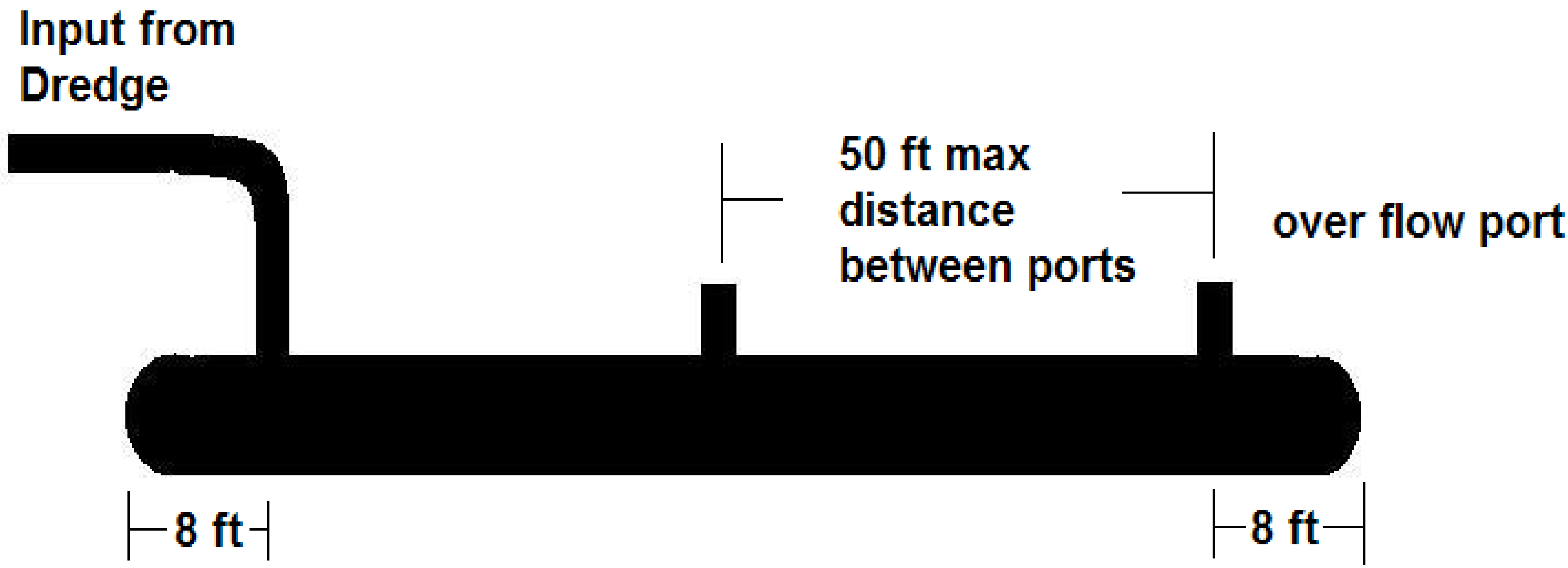
Hydraulic Dredges

- Suction Cutterhead Dredges
- Horizontal Cutterhead Dredges
- Submergible Pumps
- Eductor Dredges
- Positive Displacement Dredges

Mechanical Methods

- Mechanical placement of soft fluid mud using hoppers.
- Mechanical placement of sand into Tubes using hoppers and water flooding the hoppers.
- Mechanical conveyor belts and hoppers.

Installation Techniques



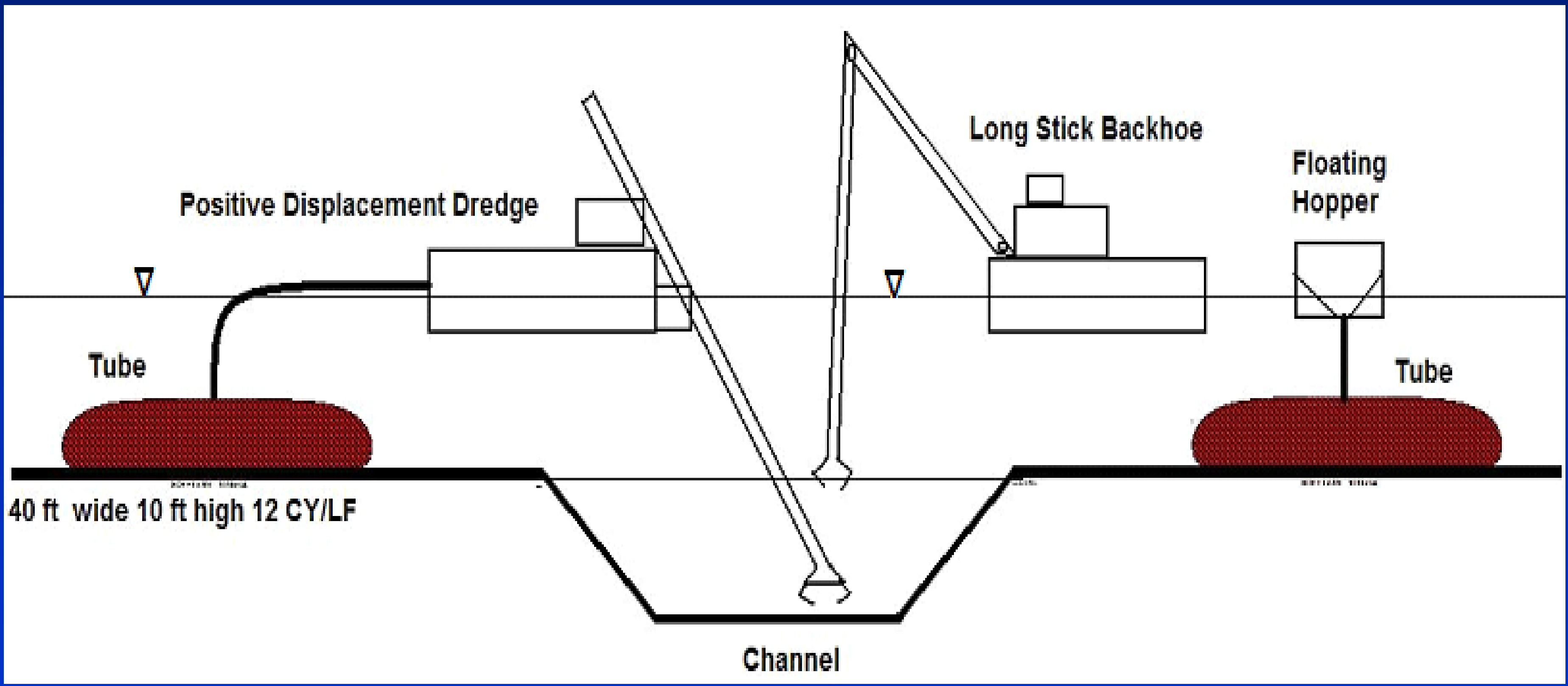
Typical Geotextile Tube being filled

Overview of Various Dredging and Tube Filling Methods

Hopper Method

When fill material is not available at site, sand can be imported and installed using hopper methods.

Filling Tubes Underwater



Dredge Method

Most common method of filling Tubes.

Hand Dredge Method

Where large pumping equipment is not available small hand held equipment can be used for filling Tubes.

Alternate Pumping Methods

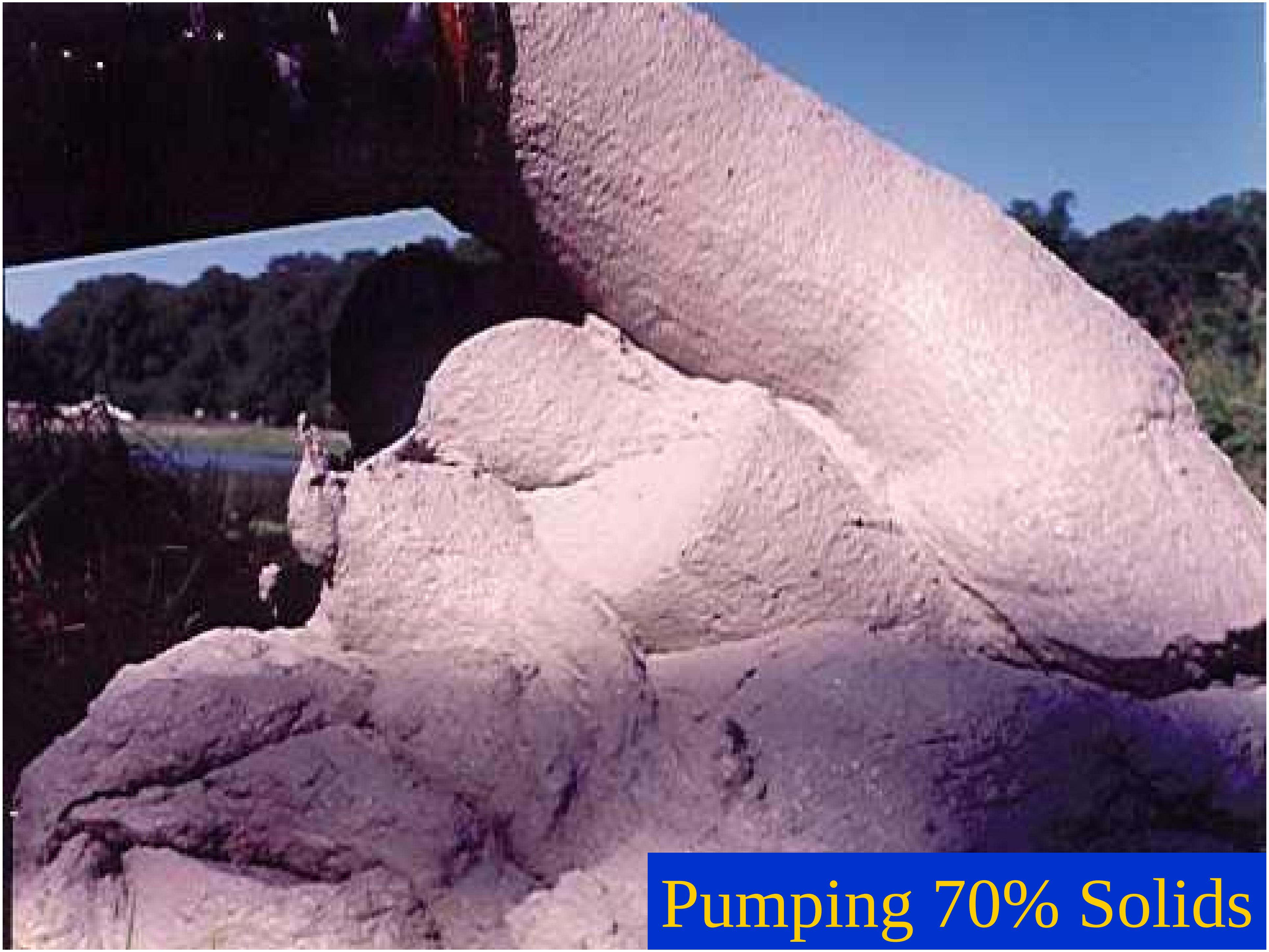
Pumping methods can be modified to comply with local permits or site limitations.

Dry Fill Method

Mechanical means of filling Containers or Sand bags.


The Dry DREdge™

Pumps Material at In-situ Density With No Free Water



Pumping 70% Solids

Potential Dewatering Applications

- Fine Grained Dredged Material
- Municipal Sewage Sludge
- Agricultural Waste
- Pulp and Paper Mill Sludge
- Fly Ash
- Mining and Drilling Waste
- Industrial By-Product Waste
- Coal Sludge

CONTAINMENT AND DEWATERING

CONTAINMENT AND DEWATERING

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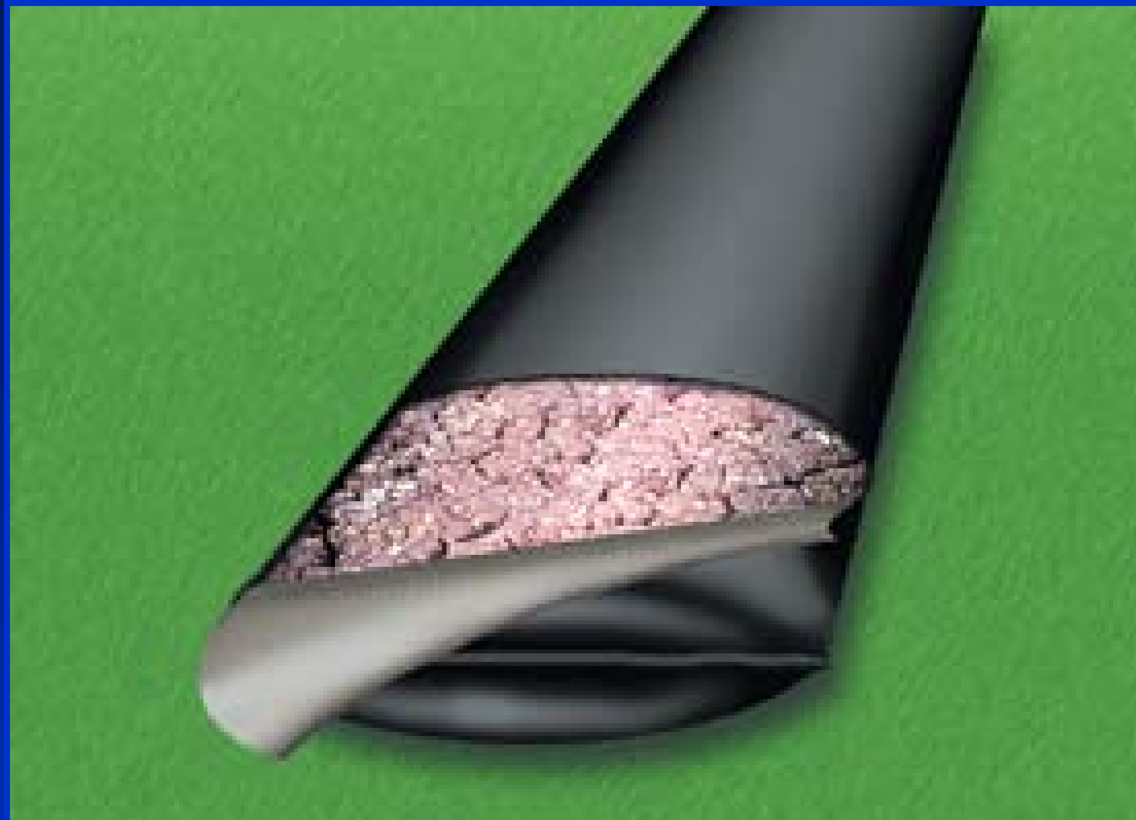
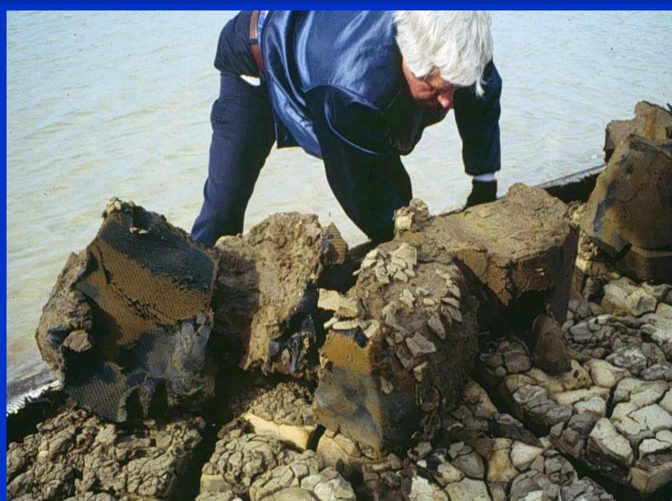
CONTAINMENT AND DEWATERING



CONSOLIDATION PHASE



Gaillard Island, AL

Mobile District
Corps of Engineers
Geotextile Tubes filled with fine grained dredged material

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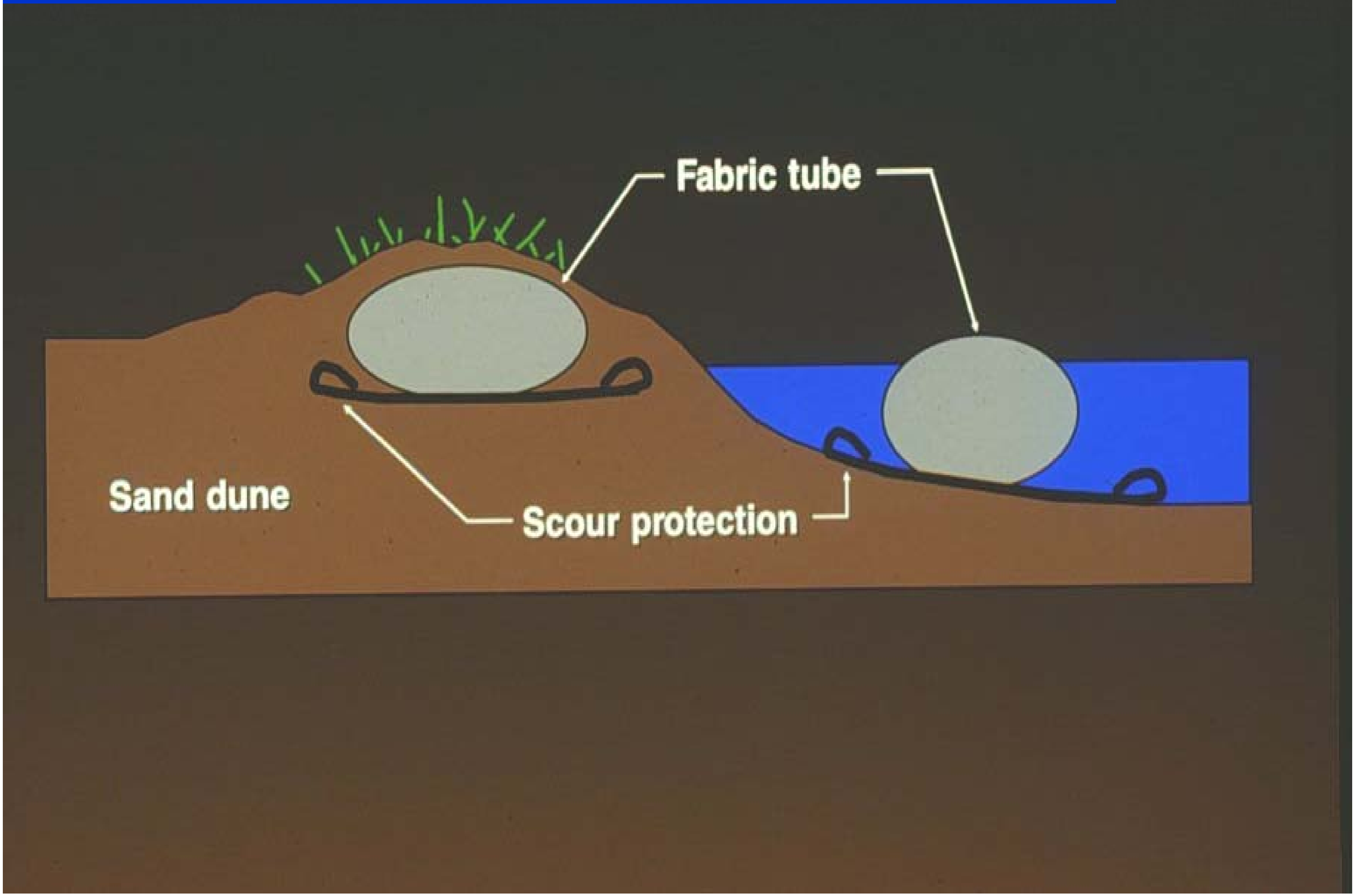
30" Diameter Pipe, Dave Blackman 6' suction cutterhead dredge

In-situ Slurry Density = 1.3 gr/ml

500 ft long tubes after filling

Slurry Filled Tube Design



Slurry Filled Tubes


Tubes after one year

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Dried slurry after one year

Dried slurry after one year

Vegetation growth after 30 days

CULKIN WATER DISTRICT

Dewatering Alum Sludge

Vicksburg, MS

Culkin Water

Alum Sulfate
Pond
Desiccation
Cracks

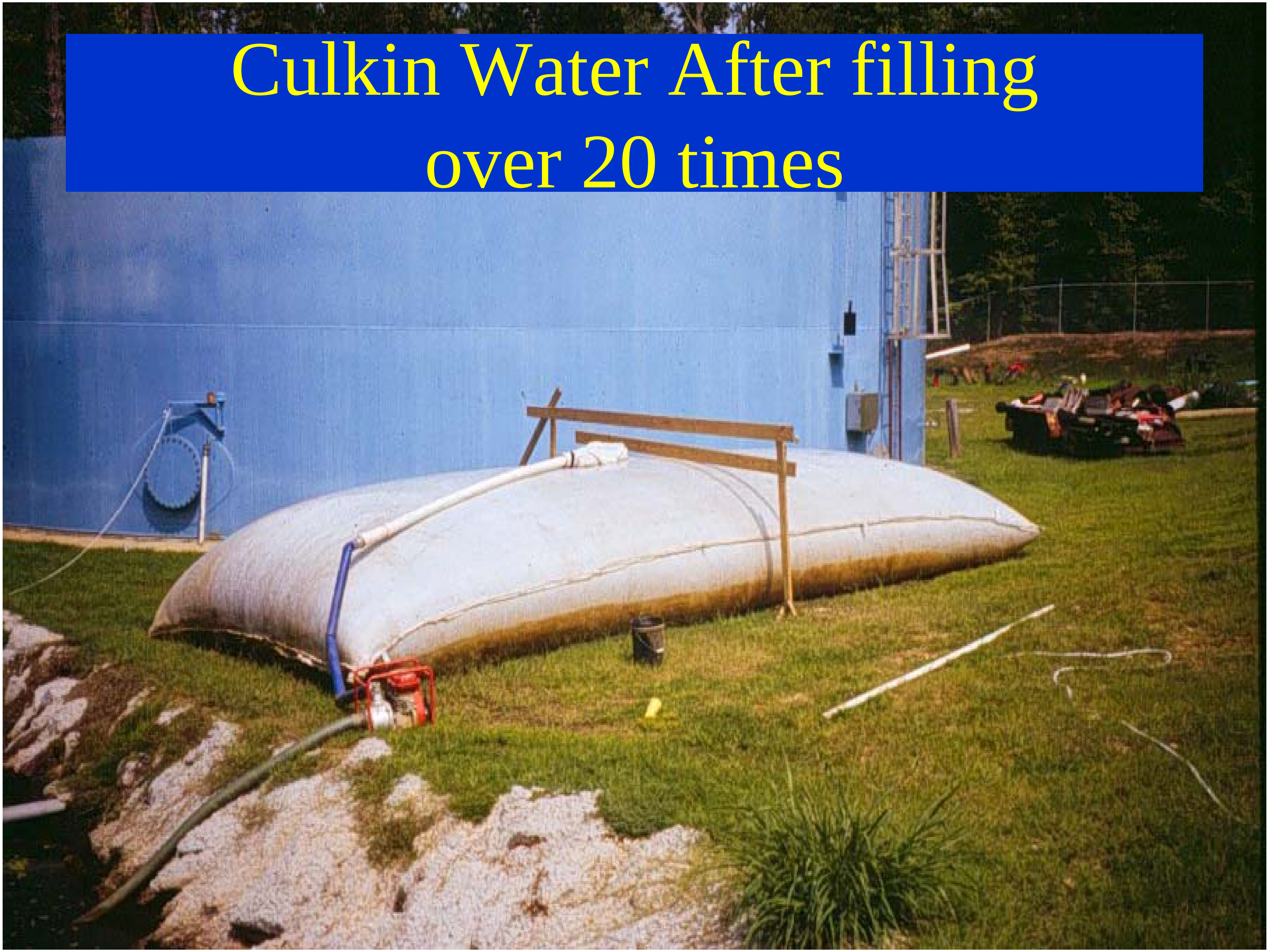
Culkin Water

Alum
Sludge
In Hanging
Bag Test
Showing
Clear Water
Effluent

Culkin Water
Hanging
Bag Test

Alum Sludge
Effluent
Water

Culkin Water After filling over 20 times



Culkin Water Measuring Consolidation

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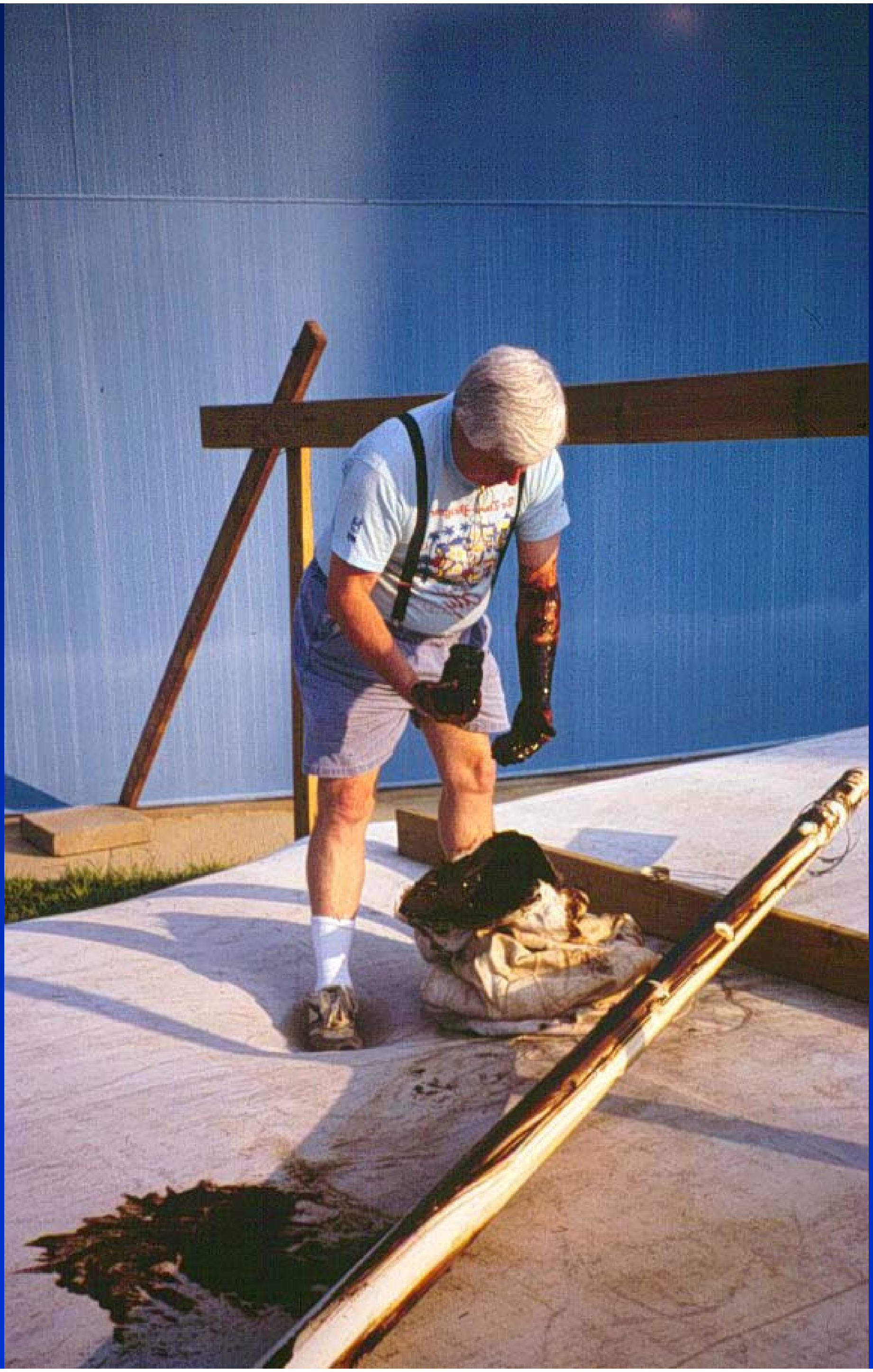
Culkin Water Quality

Culkin Water

Soil Samples
Above 50%
Solids within
3 to 4 weeks

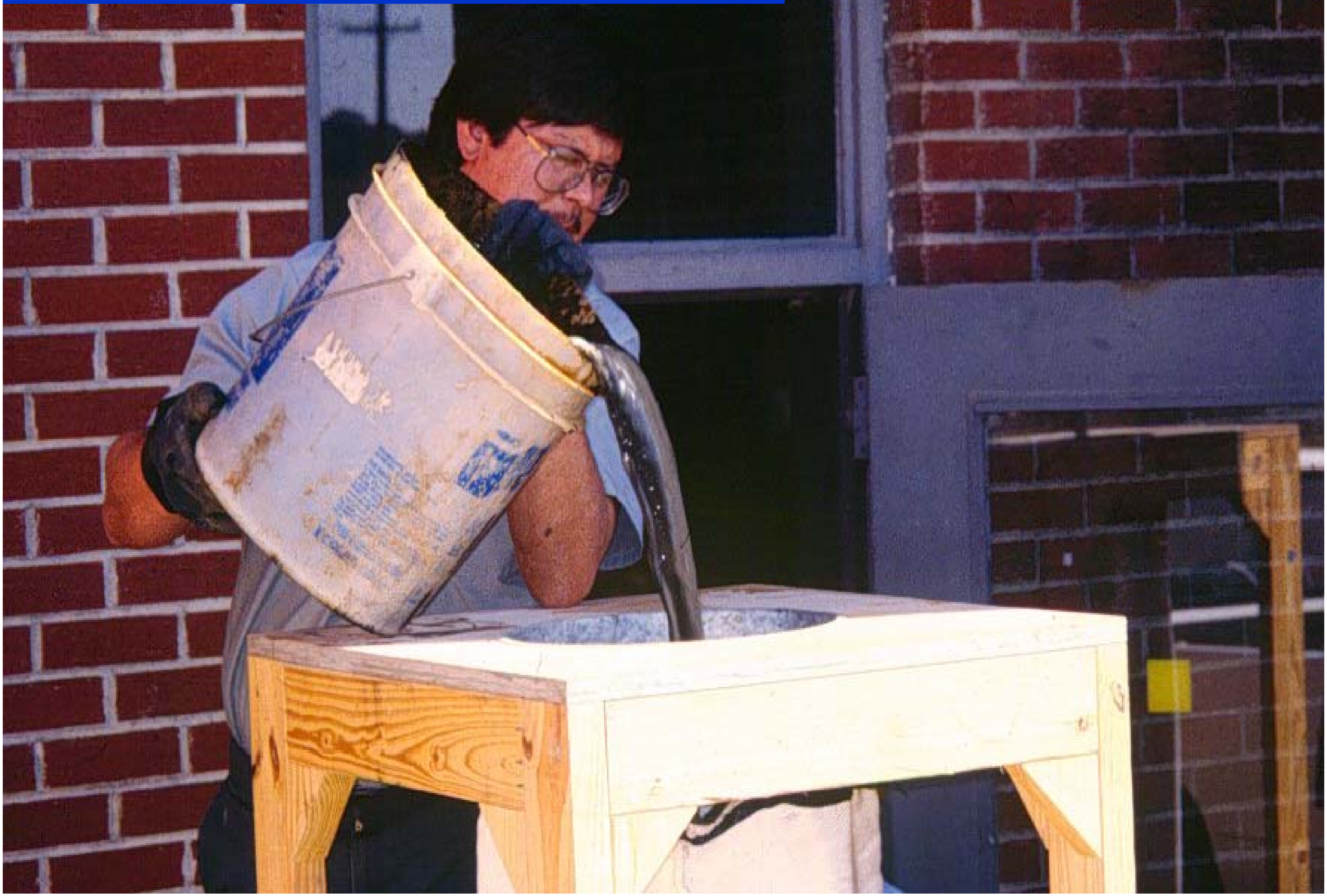


Sewage Sludge Dewatering

Vicksburg, Mississippi
Sewage Treatment Plant

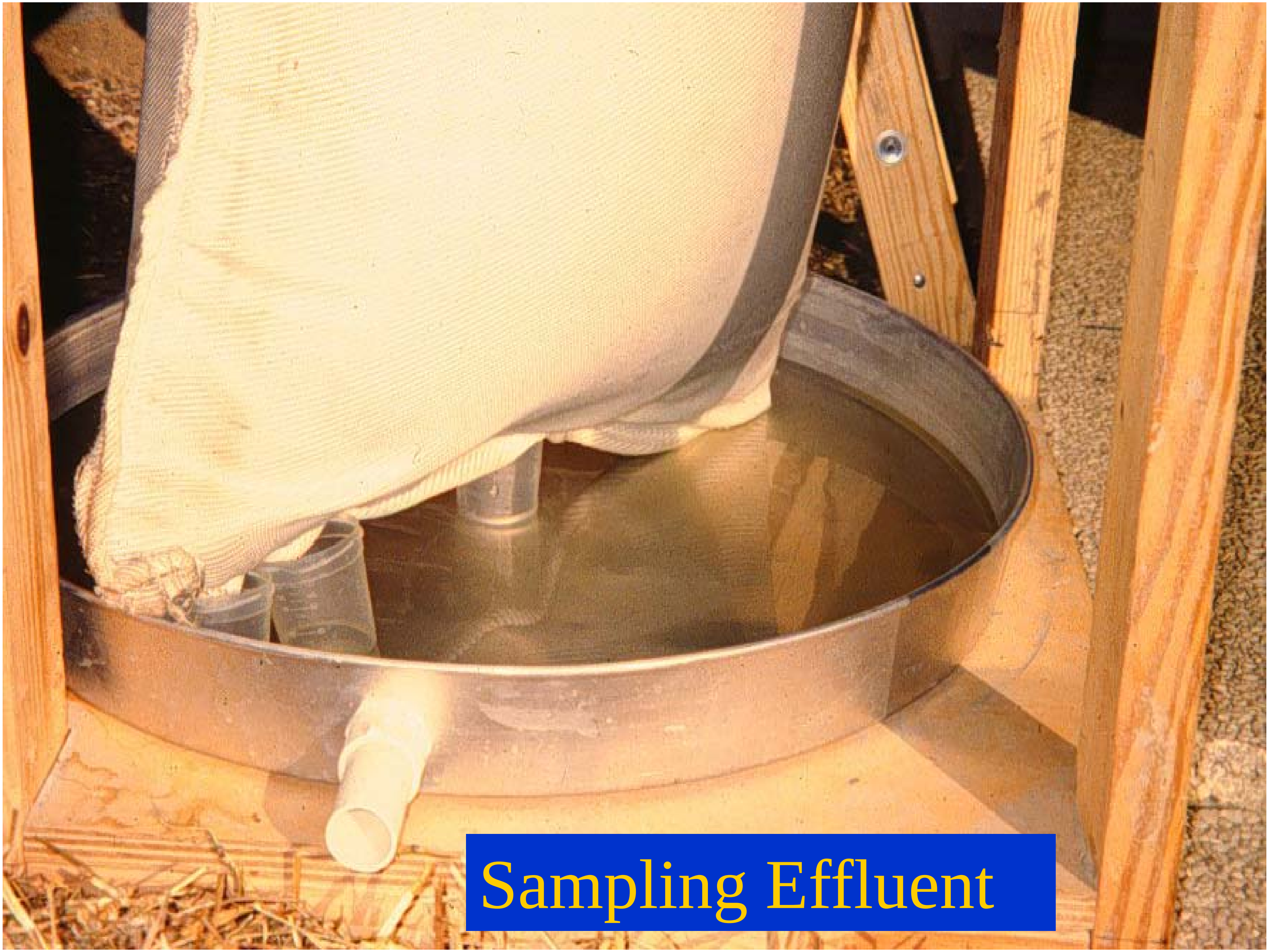
Hanging Bag Test

Fine Grained Sediment



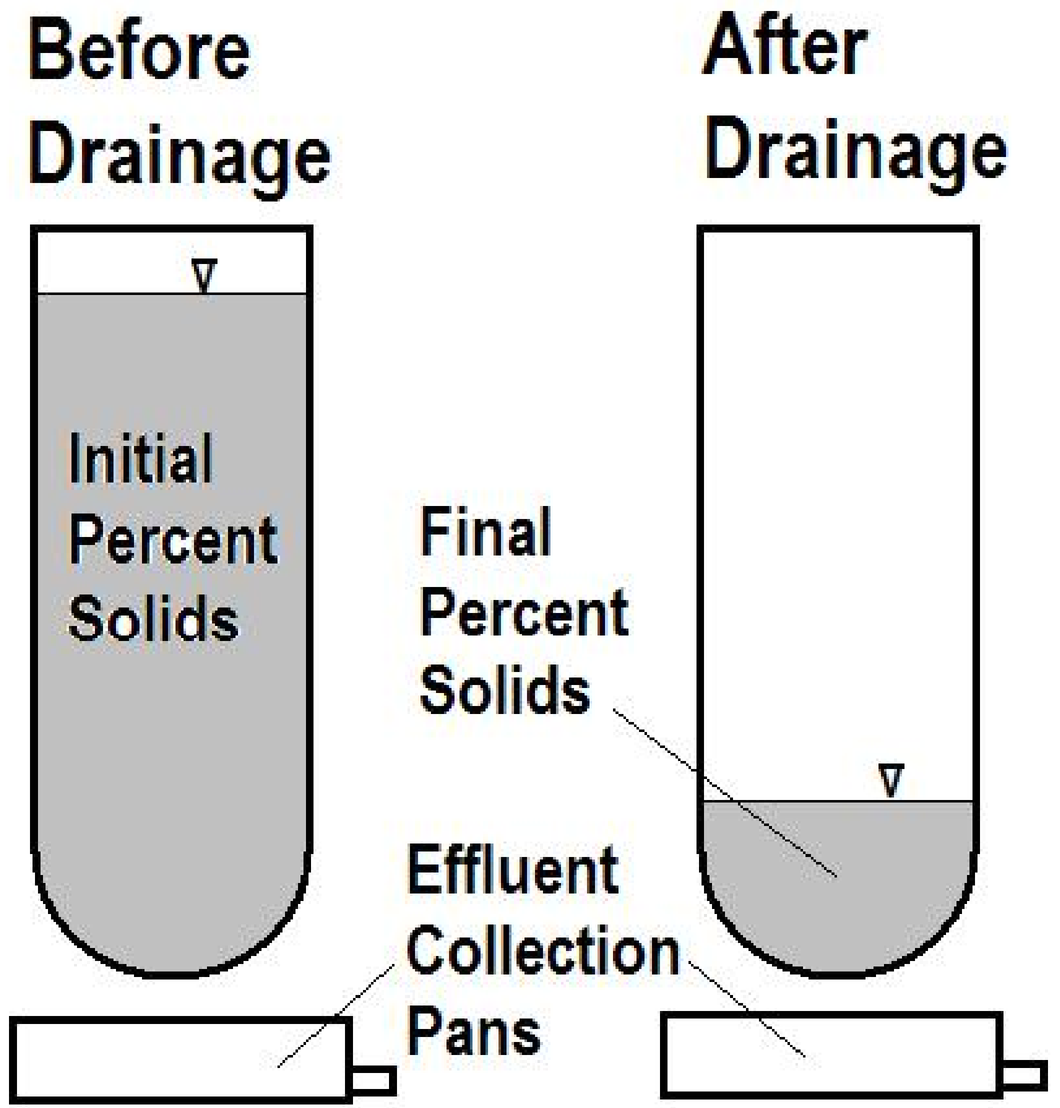
Sediment Height


Effluent Collection



Sampling Effluent

Hanging Bag Test Method



5 ft Long Hanging Bag Test

Required Geotechnical Fill Material Properties (Complete)

- Gradation
- Atterberg Limits (LL, PL & PI)
- Geotechnical Classification
- Settling Time
- Determine Polymer Requirements

Example Calculation for the Shrinkage Factor

$$\text{Shrinkage Factor} = \frac{V_{dw}}{V_o} = \frac{e_{dw} + 1}{e_o + 1} \quad \text{or} \quad \frac{\gamma_0 - 1}{\gamma_{dw} - 1}$$

$$\text{Shrinkage or reduction Factor} = \frac{1.4 - 1.0}{1.2 - 1.0} = 2.0 \text{ or } 200\%$$

Tube 30 ft Circumference 5ft High

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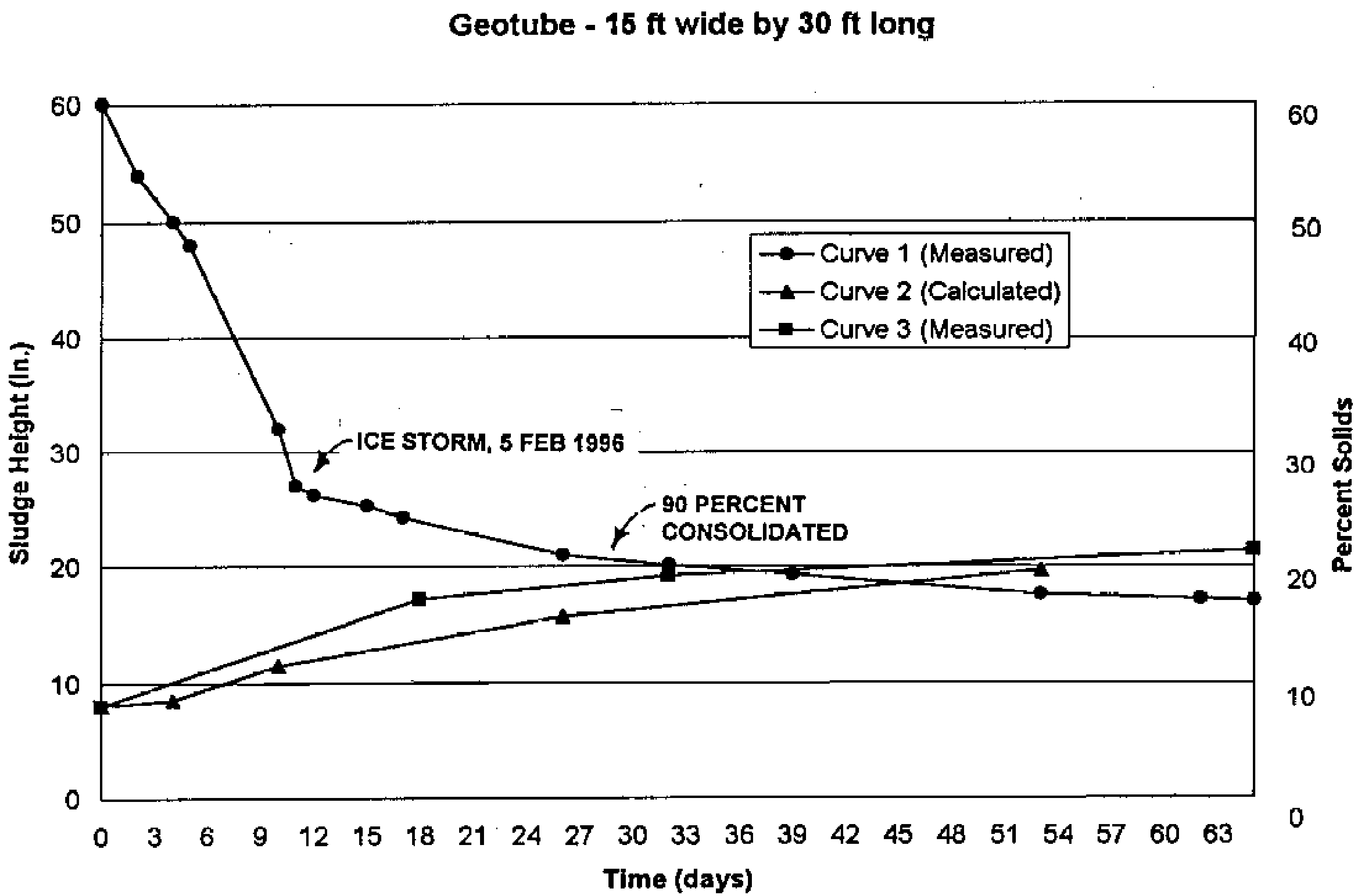
Target Percent Solids



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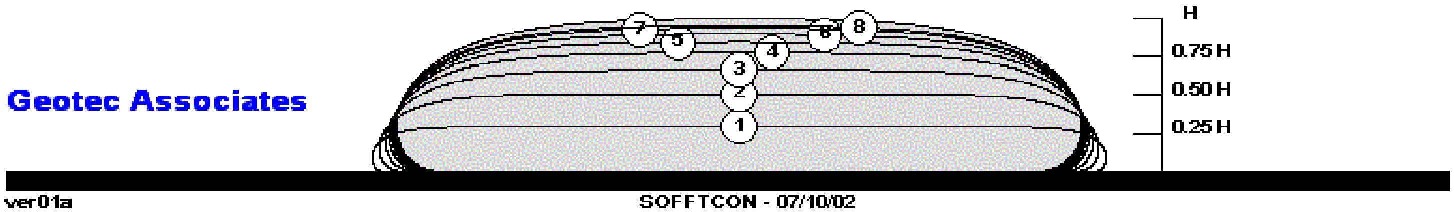
CONSOLIDATION STAGES



Geotube Circumference=60.00 ft (18.29 meters) - Geotube Pump Height=6.00 ft (1.83 meters)
Incoming Slurry Solids=27.00 % - Density=1.20 gm/cc (74.87 pcf) - Water Content=270.37 %
Selected Final Solids =60.00 % - Density=1.59 gm/cc (99.07 pcf) - Water Content=66.67 %
Initial Volume of Geotube=5.38 Cu yd/ft (13.49 Cu meters/meter) - Specific Grav of Solids=2.61

End Cons. Stage #	Height,Hc of Geotube ft (meters)	Width,Wc of Geotube ft (meters)	Volume,Vc at Stage End Cu yd (Cu m)	Percent Original Volume %	Pumped Vol to get Next Stage Cu yd (Cu m)	Cumulative Drained Volume Cu yd (Cu m)
1	1.75(0.53)	29.17(8.89)	1.83(4.59)	34.01	3.55(8.90)	3.55(8.90)
2	3.05(0.93)	28.57(8.71)	3.04(7.63)	56.55	2.34(5.87)	5.89(14.77)
3	3.98(1.21)	28.08(8.56)	3.83(9.61)	71.22	1.55(3.88)	7.44(18.65)
4	4.64(1.42)	27.76(8.46)	4.36(10.93)	81.05	1.02(2.56)	8.46(21.21)
5	5.08(1.55)	27.60(8.41)	4.70(11.78)	87.34	0.67(1.69)	9.13(22.90)
6	5.38(1.64)	27.46(8.37)	4.93(12.36)	91.61	0.44(1.11)	9.57(24.01)
7	5.62(1.71)	27.30(8.32)	5.09(12.77)	94.71	0.29(0.74)	9.87(24.75)
8	5.72(1.74)	27.31(8.32)	5.17(12.98)	96.23	0.19(0.49)	10.06(25.23)

NOTE: All Volumes are for each Linear Unit (foot or meter) of Geotube

Dewatering Sewage Sludge

New Orleans Sewage Treatment Plant

New Orleans, LA

January, 2000-2004

Aerial View of Sludge Filled Tube

Sewage Sludge Filled Tube

Aerial View of New Orleans Sewage Treatment Plant

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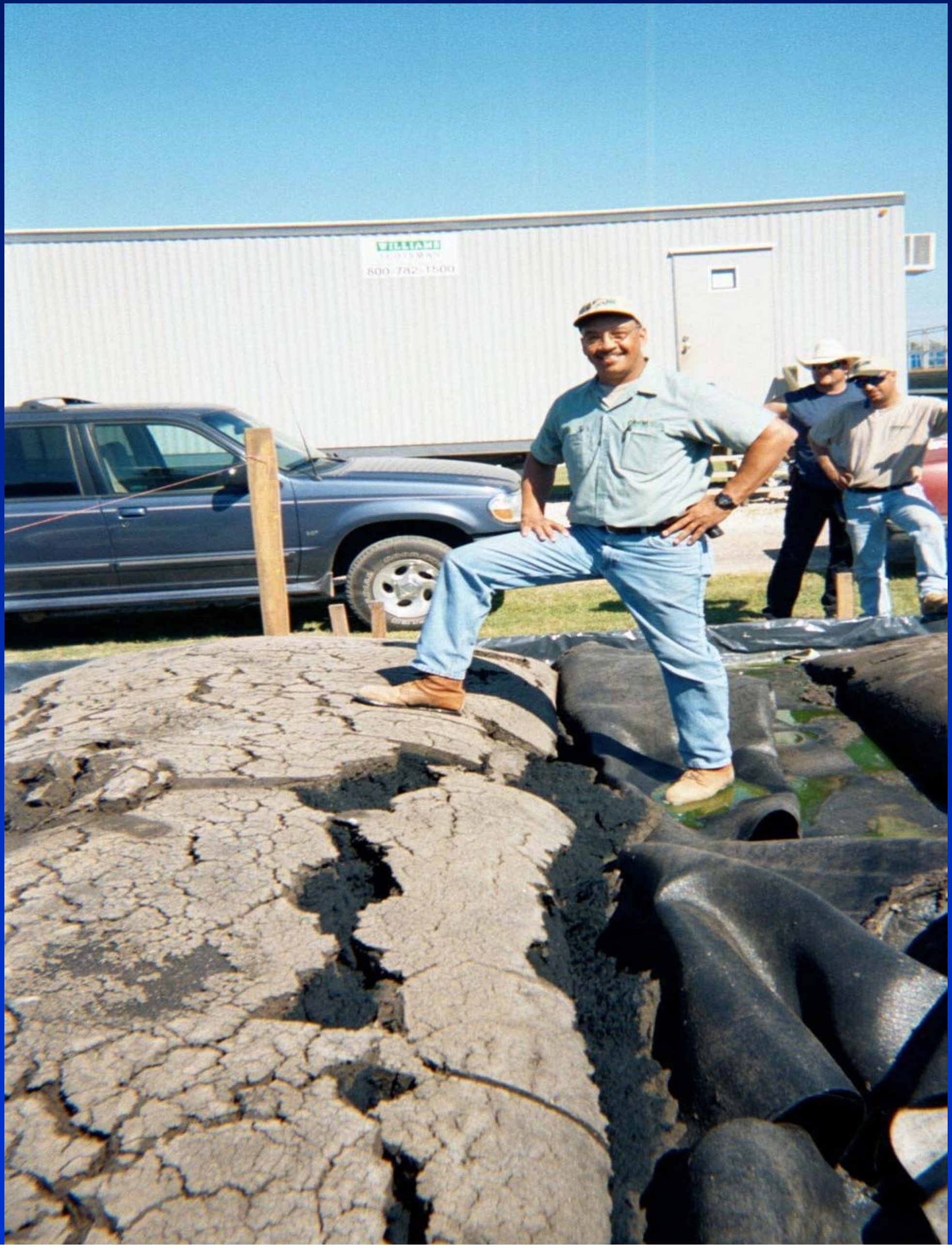
Desiccated Sewage Sludge



Desiccated Sewage Sludge

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MILLENNIUM PLANT, BALTIMORE, MD

Geotextile Tubes used to dewater industrial by-product waste from sludge lagoon.

Installed 2001

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MILLENNIUM PLANT

215 HP Nomad III Horizontal Cutterhead dredge pumping at a rate of 3,000 gpm at 10% solids.

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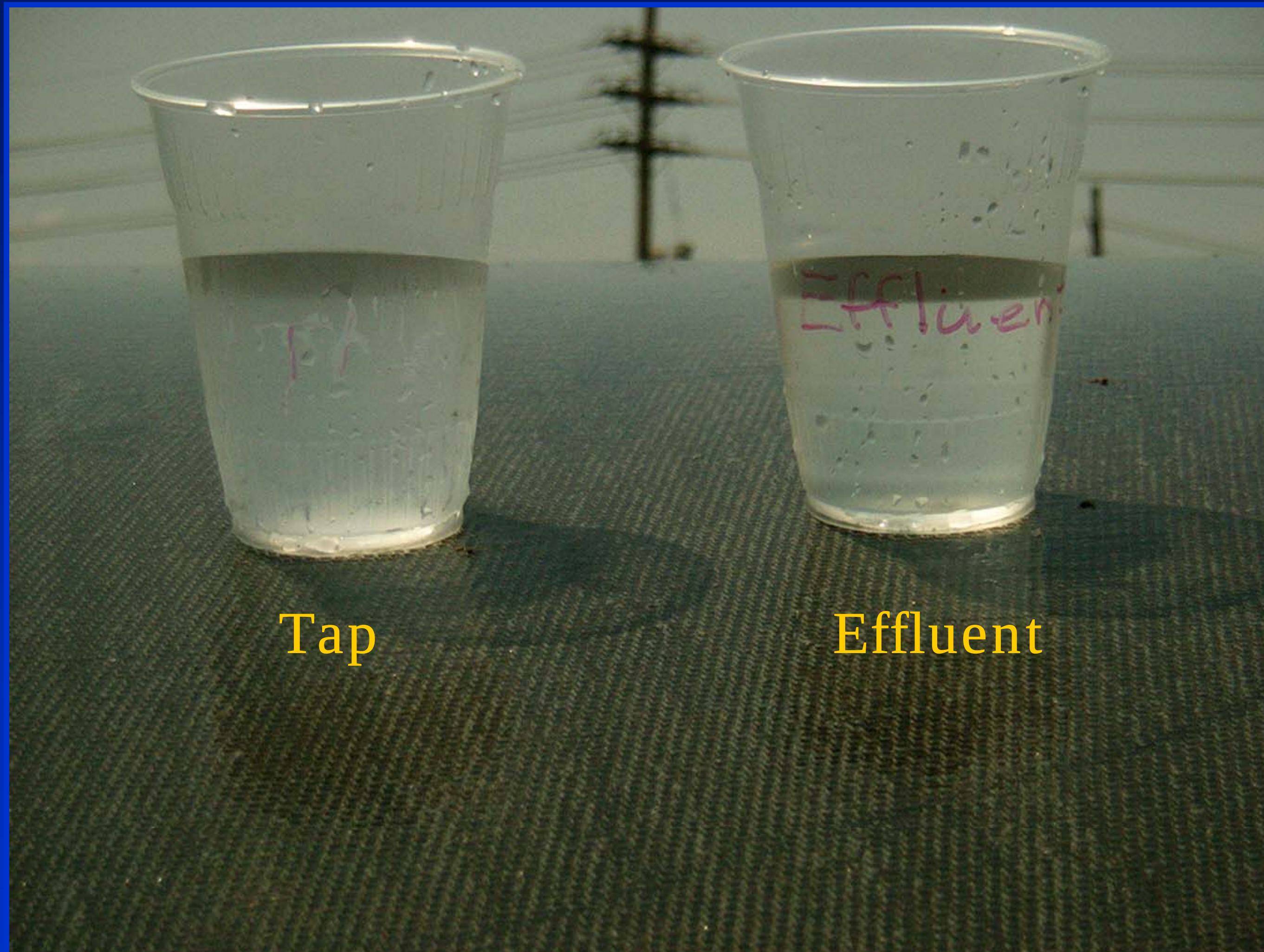
MILLENNIUM PLANT

After filling

and During Drainage

MILLENNIUM PLANT

Tap water on left compared to effluent water on right immediately following collection from Geotextile Tube



MILLENNIUM PLANT

Titanium

Sulfate Dioxide

65% Solids

MILLENNIUM PLANT

Notice sediment layers over 6 ft high over 65% Solids

Wellston,
Ohio Coal
Sludge
30 ft Cir
100 ft Long
Geotextile
tube
Showing
Elevation

Century Mine Hanging Bag Test

Water effluent quality very clear with polymers

Century Mine Hanging Bag Test

Slurry at 63.5% Solids second day of drainage with polymers

20 ft Long Bag Prior to Filling

Filling Roll Off Box Bag

Effluent from Roll Off Box

5 CY Roll Off Box Bag

20 CY Roll Box Bag Prior to Filling

20 CY Roll Off Box Filled

Geosynthetic Reinforced Inflatable Tube Simulator (GRITS)

Developed by John B. Palmerton (Deceased Spring 2006)

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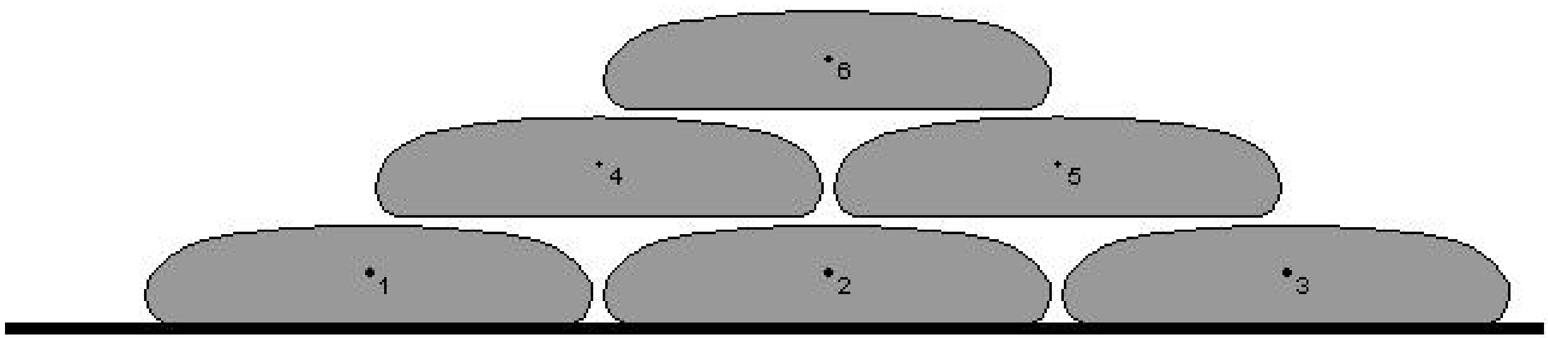
```
Command ? (enter @ for available list)
```

Tube 1 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el=6.322 ft	Tube 2 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el=6.322 ft	Tube 3 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el=6.322 ft	Tube 4 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el= 12.82 ft	Tube 5 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el= 12.82 ft
Tube 6 Info GFC area= 143.0 sq ft Orig Area= 143.0 sqft Height=5.986 ft Max Ten=0 lb/in Top tube el= 19.32 ft				

Time=0 sec
SPG LowRow=1.600
SPG Mid Row=1.600
SPG Upr Row=1.600
Circum=60.00 ft
Base Fric=10.000 deg
Tube Fric=10.000 deg
Base Shear=0 lb/in
Base Normal=0 lb/in
Phi Require=0 Deg
StackTop el=0 ft

Friction angle between tubes and base = 10 degrees

friction angle between tubes also = 10 degrees.



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Command ? (enter @ for available list)

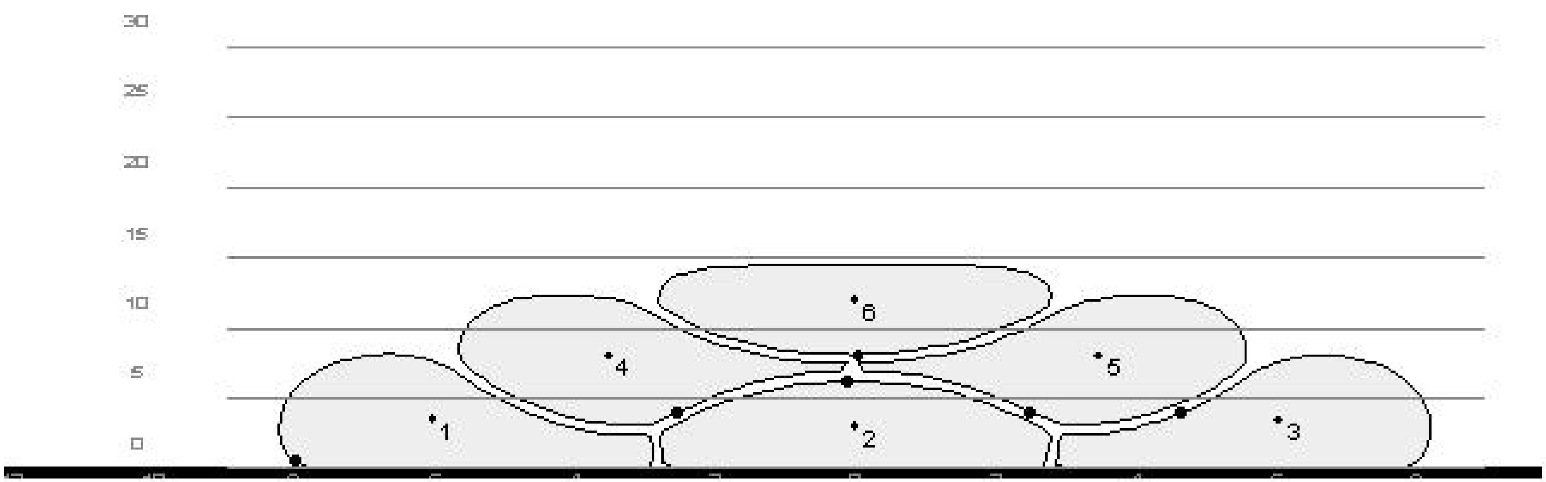
Tube 1 Info	Tube 2 Info	Tube 3 Info	Tube 4 Info	Tube 5 Info
GFC area= 142.0 sq ft	GFC area= 139.1 sq ft	GFC area= 142.0 sq ft	GFC area= 142.8 sq ft	GFC area= 142.7 sq ft
Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft	Orig Area= 143.0 sqft
Height=8.179 ft	Height=6.210 ft	Height=8.079 ft	Height=9.327 ft	Height=9.244 ft
Max Ten=213.7 lb/in	Max Ten=379.0 lb/in	Max Ten=262.0 lb/in	Max Ten=296.3 lb/in	Max Ten=295.6 lb/in
Top tube el=8.512 ft	Top tube el=6.542 ft	Top tube el=8.412 ft	Top tube el=12.77 ft	Top tube el=12.72 ft

Tube 6 Info
GFC area= 143.1 sq ft
Orig Area= 143.0 sqft
Height=6.481 ft
Max Ten=87.22 lb/in
Top tube el=14.91 ft

Time=4.432 sec
SPG LowRow=1.600
SPG Mid Row=1.600
SPG Upr Row=1.600
Circum=60.00 ft
Base Fric=10.000 deg
Tube Fric=10.000 deg
Base Shear=-264.6 lb/in
Base Normal=3573 lb/in
Phi Require=4.234 Deg
Stack Top el=14.91 ft

Friction angle between tubes and base = 10 degrees

friction angle between tubes also = 10 degrees.



Ashtabula, OH

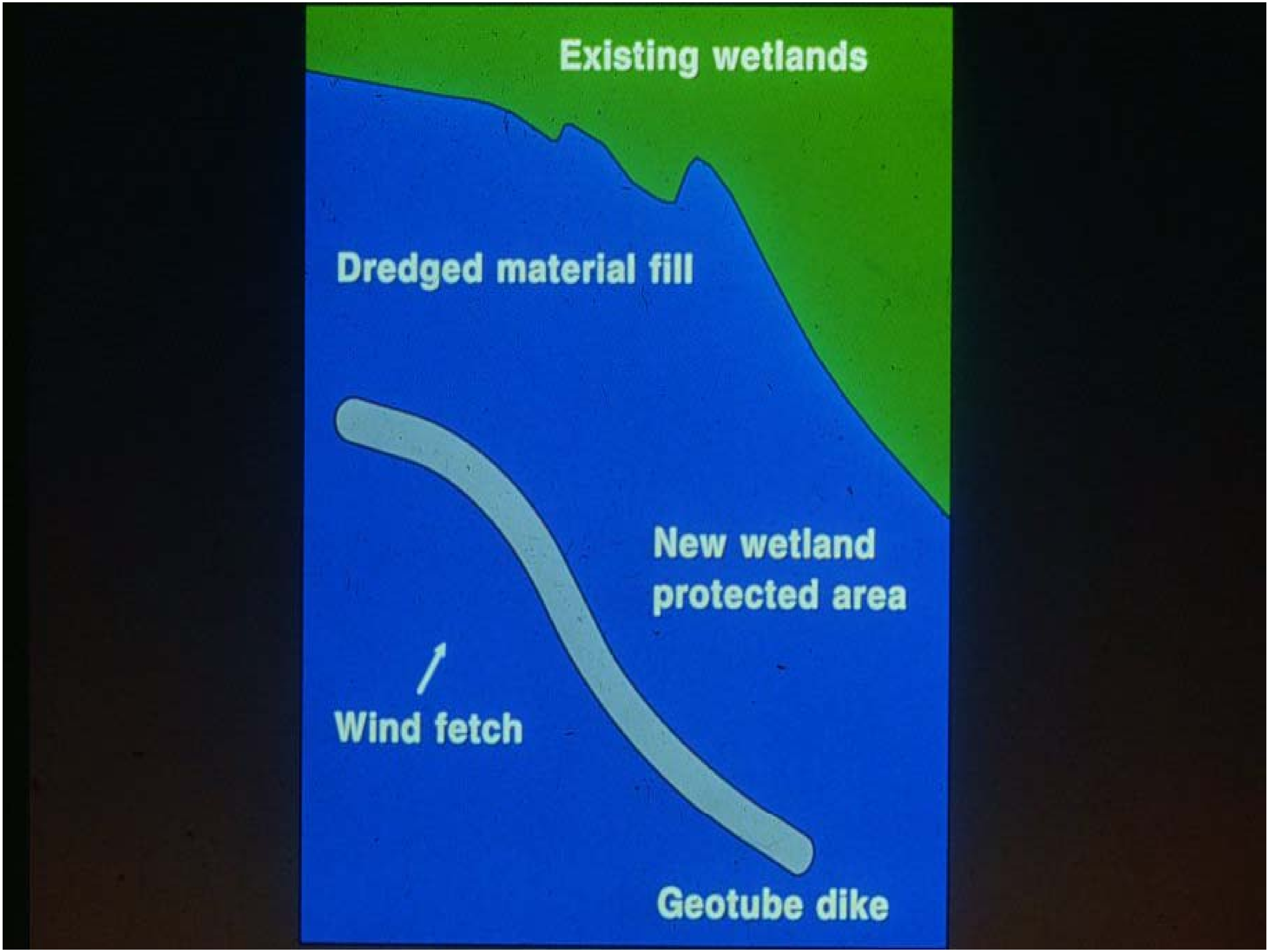
Stacked Tubes, Fly Ash

Beneficial Uses Of Dredged Material Filled Geotextile Tubes

Coastal and Riverine Applications

Marine Applications

- Core of a sand dune
- Creation of Wetlands
- Core of Rip Rap Breakwaters
- Core of Rip Rap Jetties
- Underwater Structures
- Diversion Dikes
- Dredge Material Containment

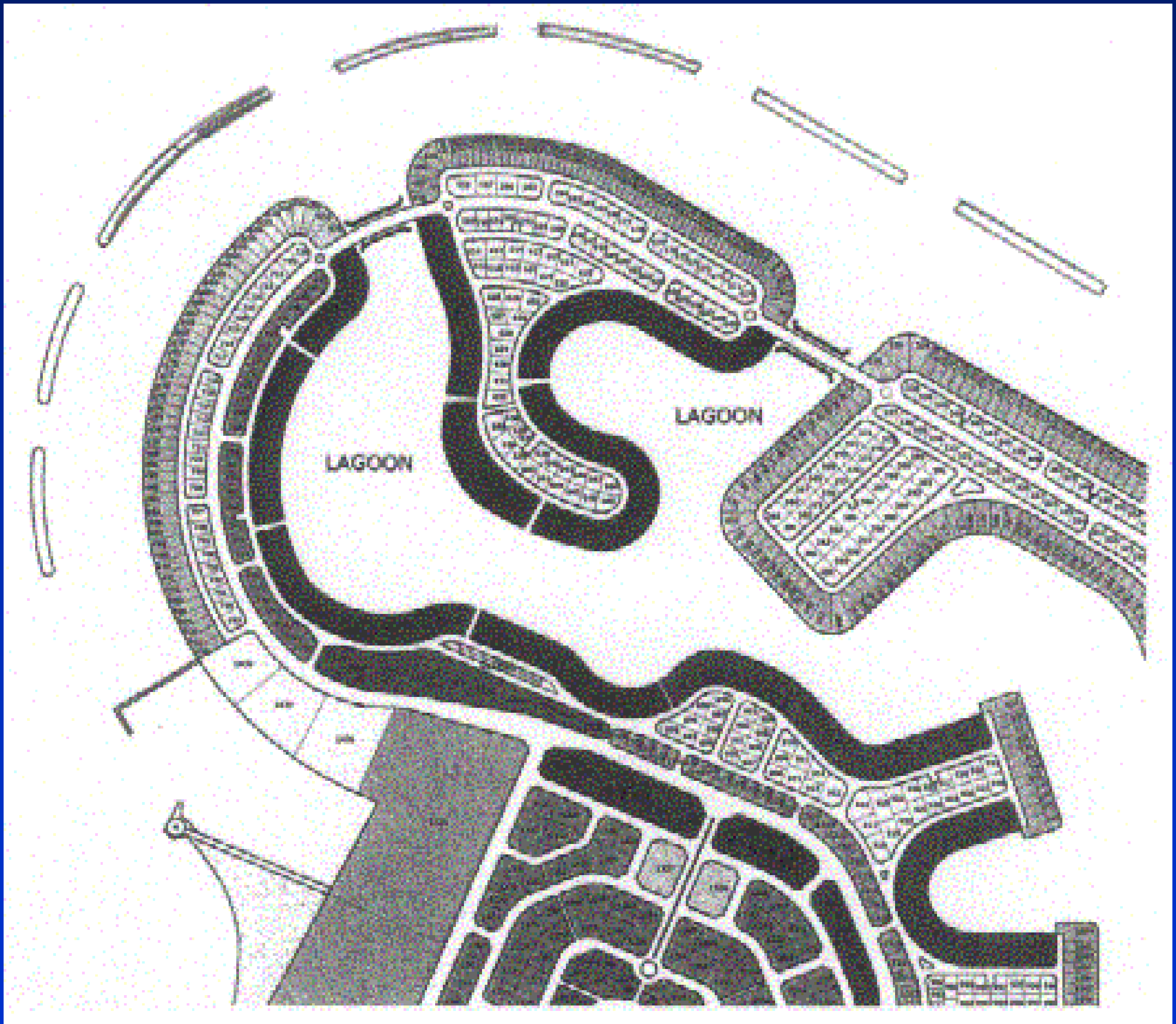

Existing wetlands
Dredged material fill
New wetland
protected area
Wind fetch
Geotube dike

Shoreline Protection

Shoreline Protection

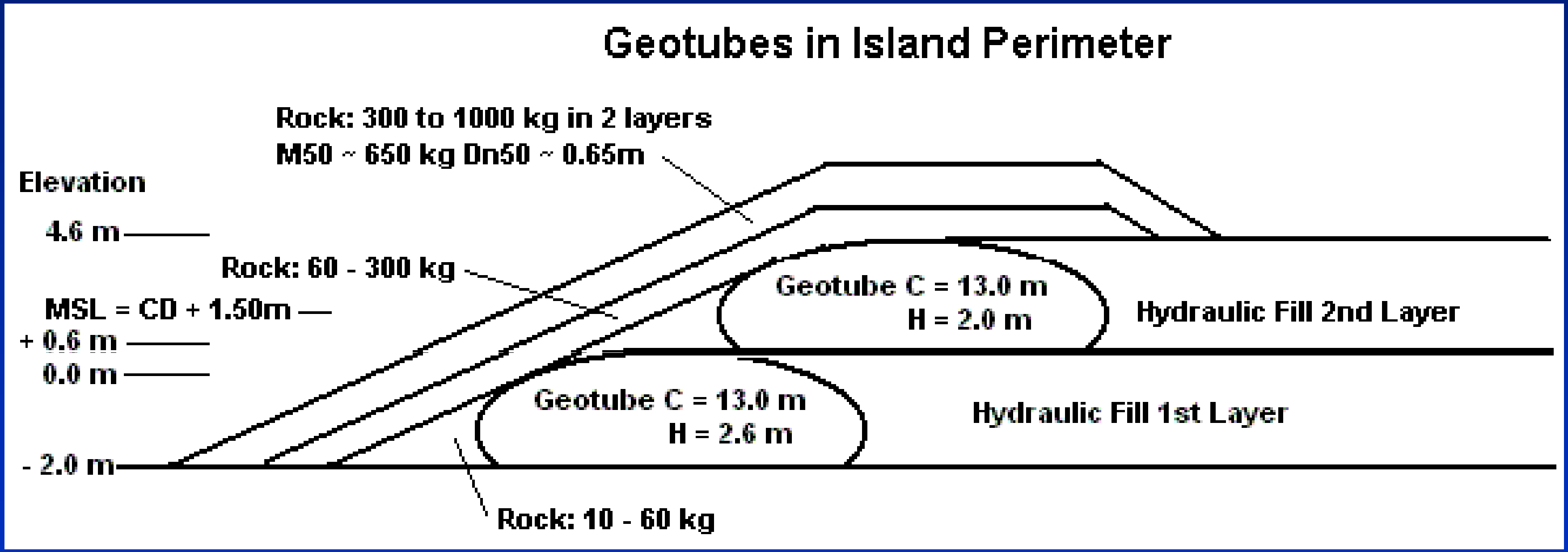
Shoreline Protection

Offshore Breakwater Protection, Amwaj Island



Tube During Filling, Amwaj Is

Outside Perimeter Design, Amwaj, Island



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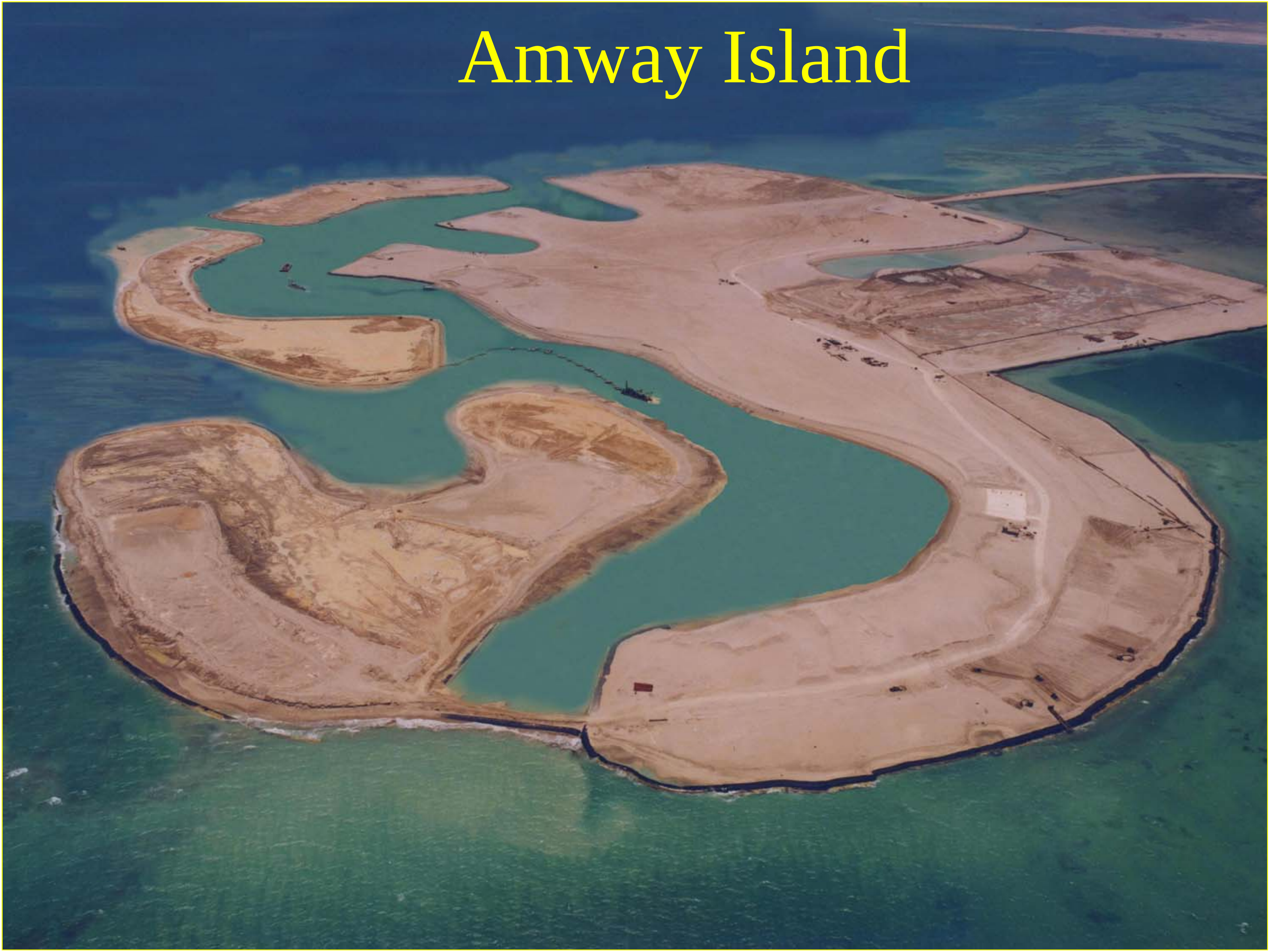

Atlantic City
New Jersey

Tubes used in sand dunes to protect Atlantic City Boardwalk

Pumping sand from the beach with a hydraulic submergible pump

Visqueen used to prevent erosion

Tube after filling with sand

Sand filled tube

Tubes covered with sand

Tubes exposed after hurricane


TRUMP REGENCY
Erosion after storm

Tubes after cover vegetation

Sea Isle City, New Jersey

Backhoe and Hopper Fill Method
Flooded with Water

Sea Isle City, NJ

Tube being filled by hopper method with imported sand.

Sea Isle City, NJ

Sand being placed in hopper with backhoe. Note that hopper discharges directly into Tube.

Sea Isle City, NJ

Tube withstands heavy wave impact at high tide.

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Sea Isle City, NJ

Tube and scour apron intact after extreme high tide and heavy wave attack.

Land Reclamation on the North Sea in the Netherlands

Filling Geotextile Tube at Low Tide

Filling Geotextile Tube at High Tide

Parallel Geotextile Tubes in Perimeter Dikes

High Tide after filling Geotextile Tubes

Sand Fill behind Geotextile Tube Dike

Geotextile Tubes For Inlet Jetties

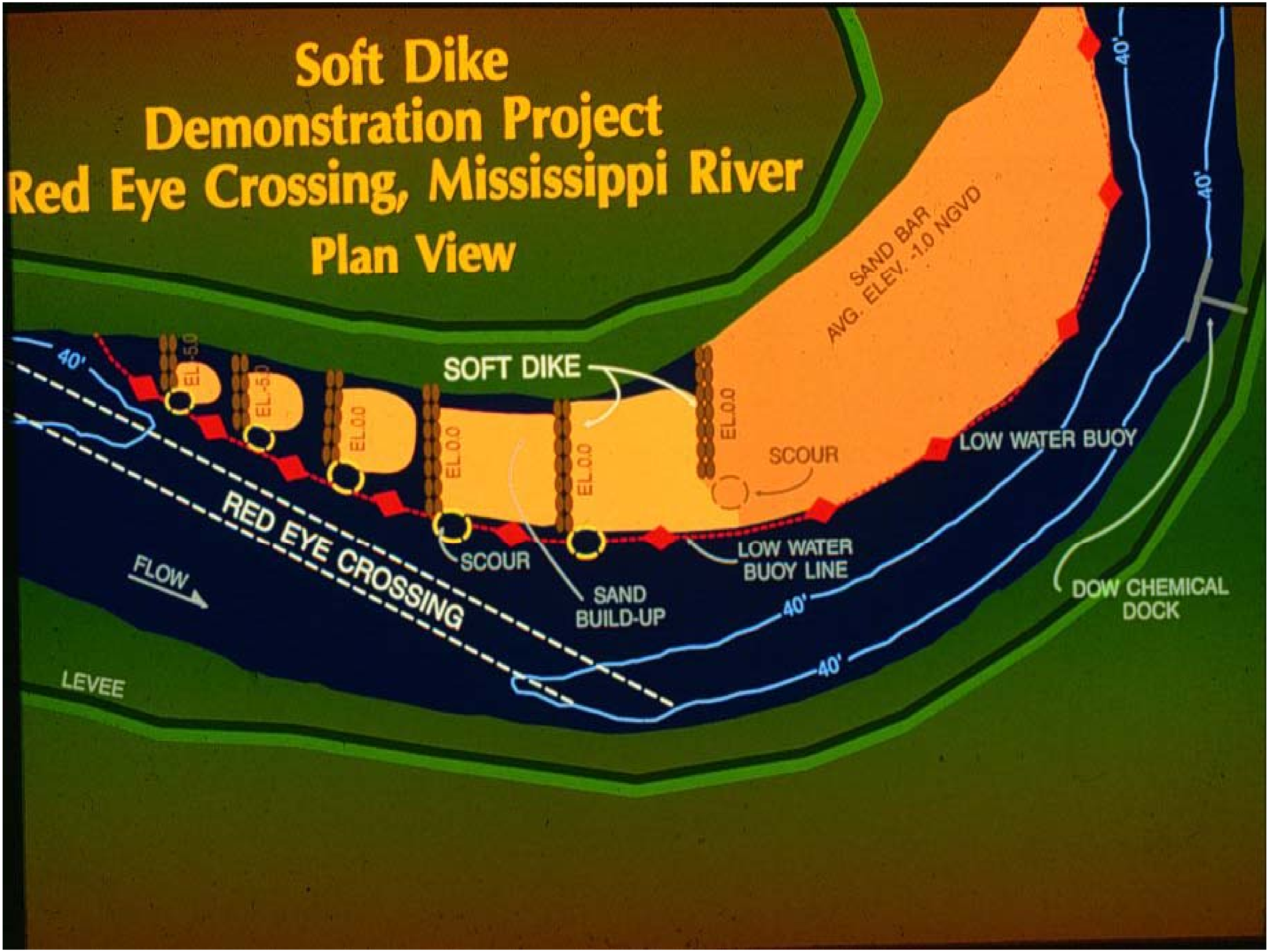
Shrimp Farm Inlet Structure
Pacific Coast
Mexico

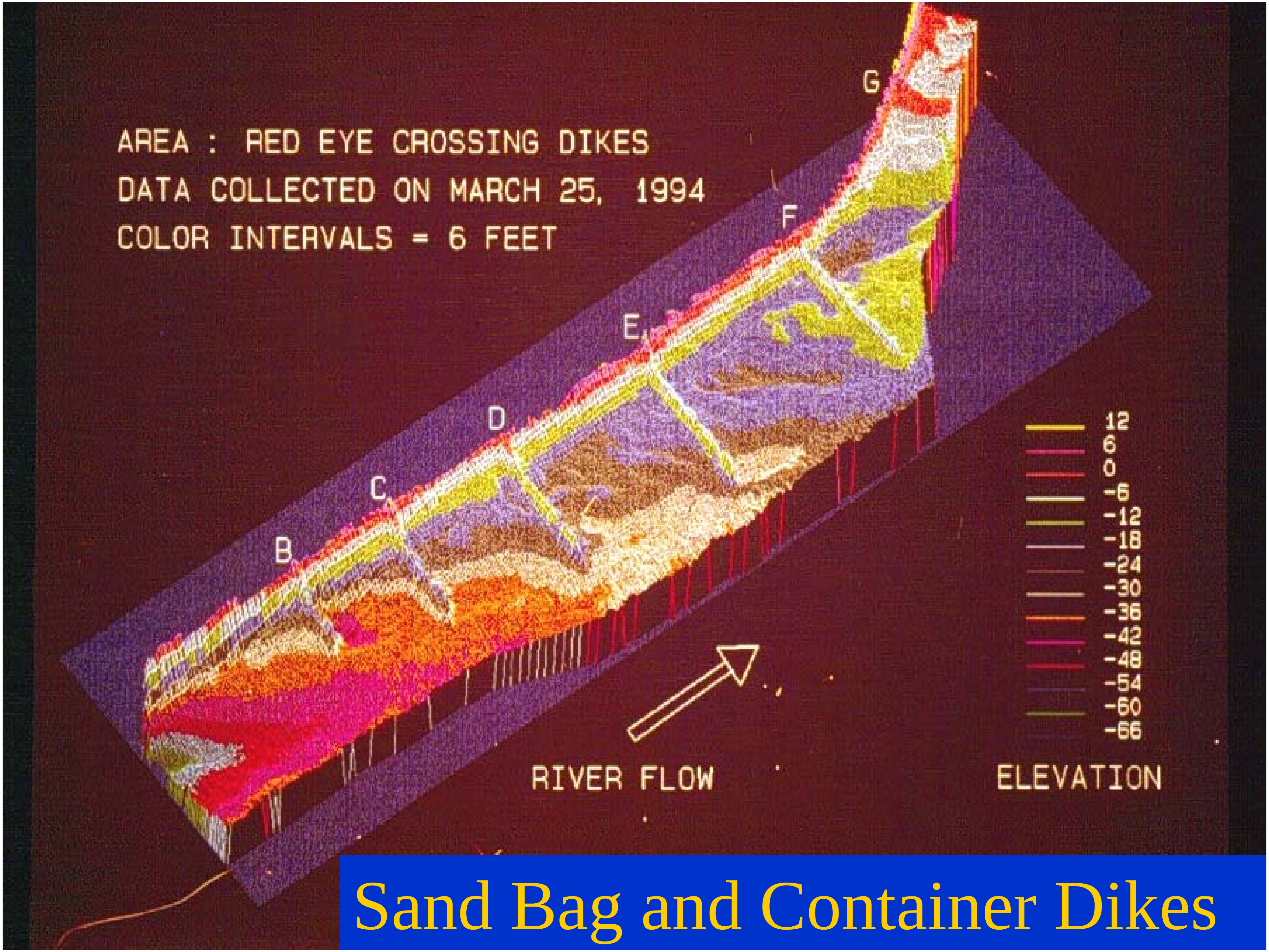
Tube Jetty

Sand Bag and Container Application to Control River Sediments

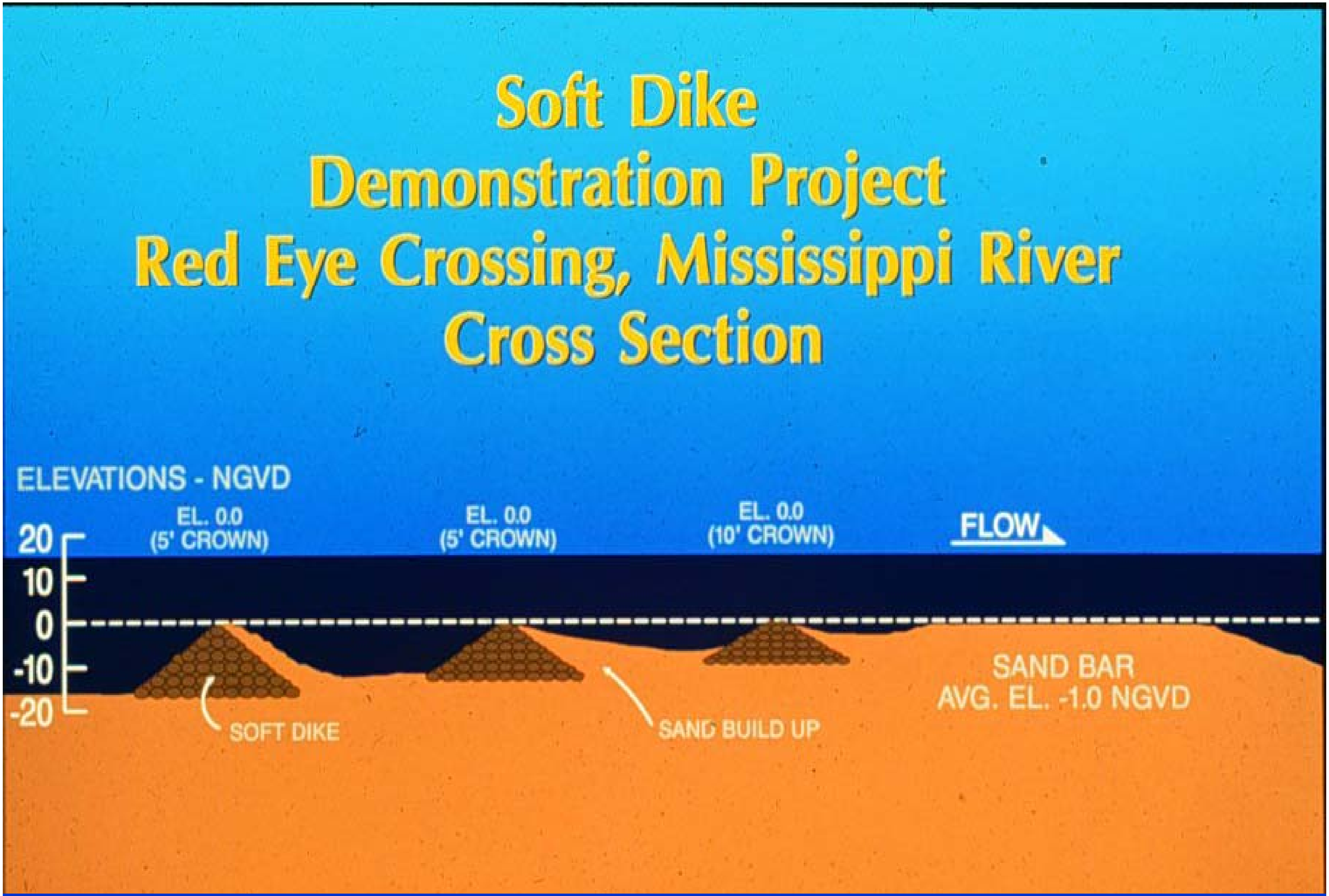
Red Eye Crossing, Mississippi River

Baton Rouge, LA 1993 to 1994


Soft Dike
Demonstration Project
Red Eye Crossing, Mississippi River
Plan View
SAND BAR
AVG. ELEV. -1.0 NGVD
SOFT DIKE
EL-5.0
EL-5.0
EL.0.0
EL.0.0
EL.0.0
EL.0.0
SCOUR
LOW WATER BUOY
40'
40'
40'
40'
40'
RED EYE CROSSING
FLOW
SCOUR
SAND
BUILD-UP
LOW WATER
BUOY LINE
DOW CHEMICAL
DOCK
LEVEE



Sand Bag and Container Dikes



Three bag dikes and three container dikes

Filling Sand Bags

Instrumented sand bag

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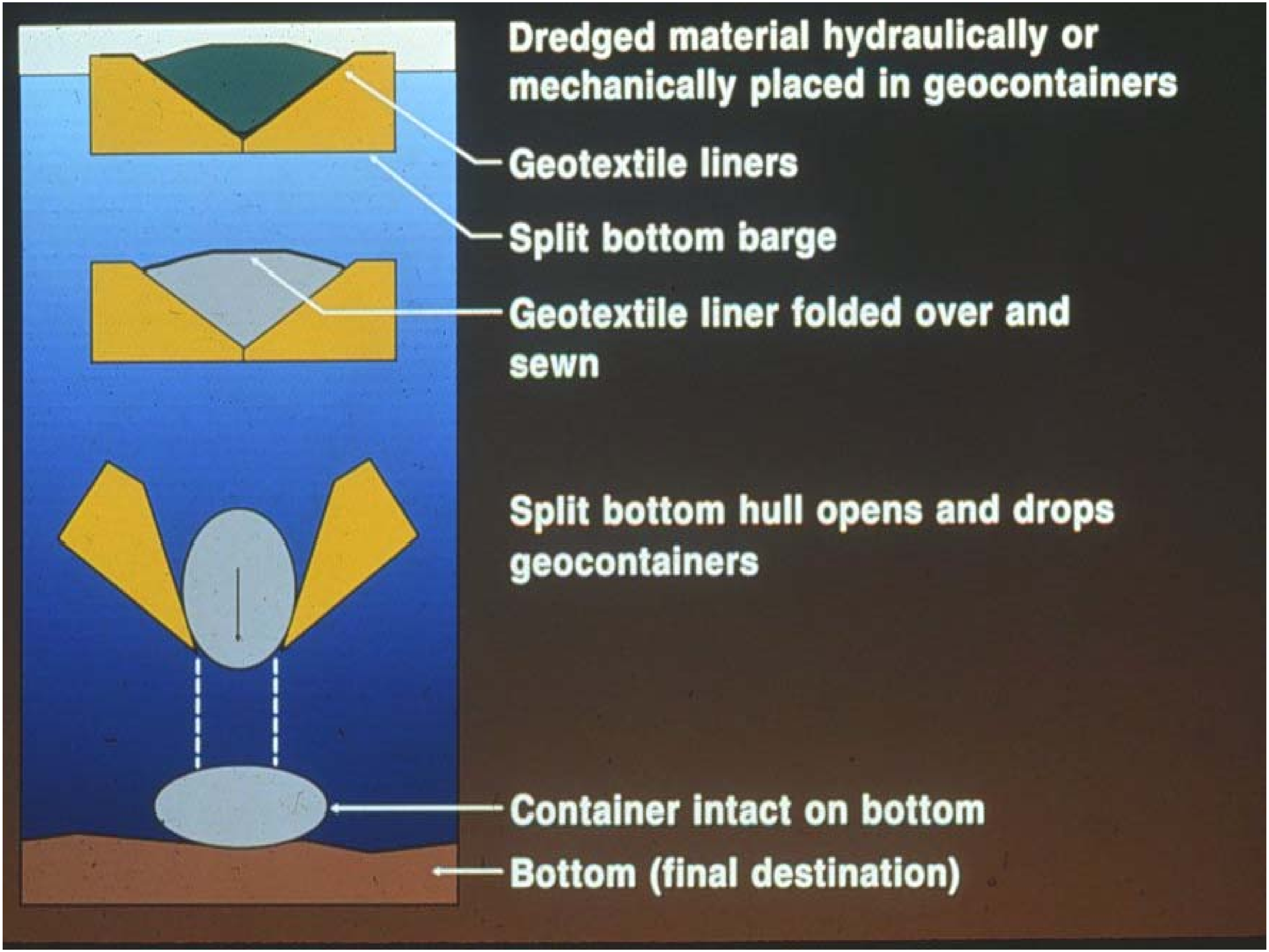
Sand Bag Placement

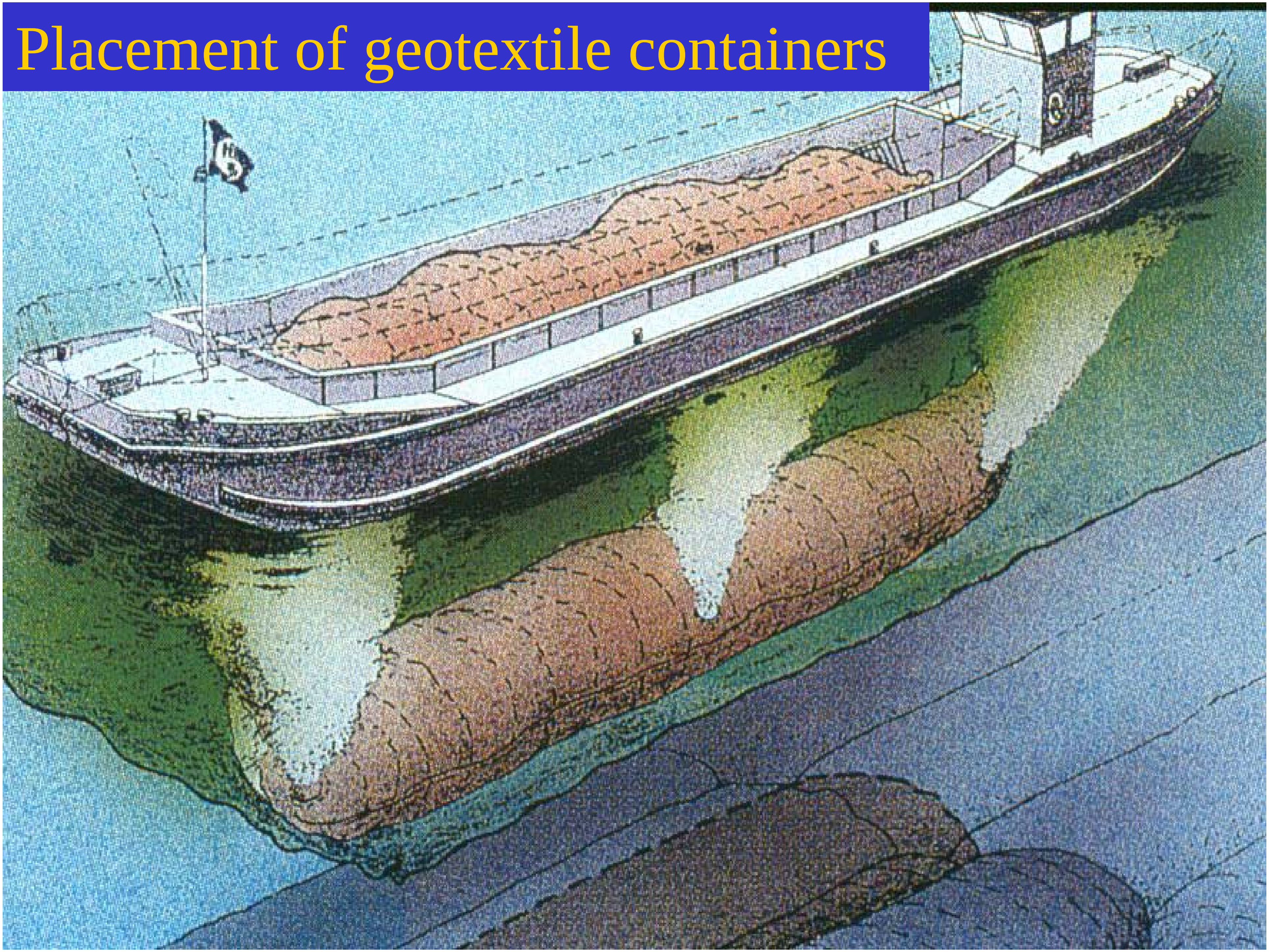

Dredged material hydraulically or mechanically placed in geocontainers
Geotextile liners
Split bottom barge
Geotextile liner folded over and sewn
Split bottom hull opens and drops geocontainers
Container intact on bottom
Bottom (final destination)

Filling Containers

Sewing Containers Closed

Placement of Containers

Placement of geotextile containers



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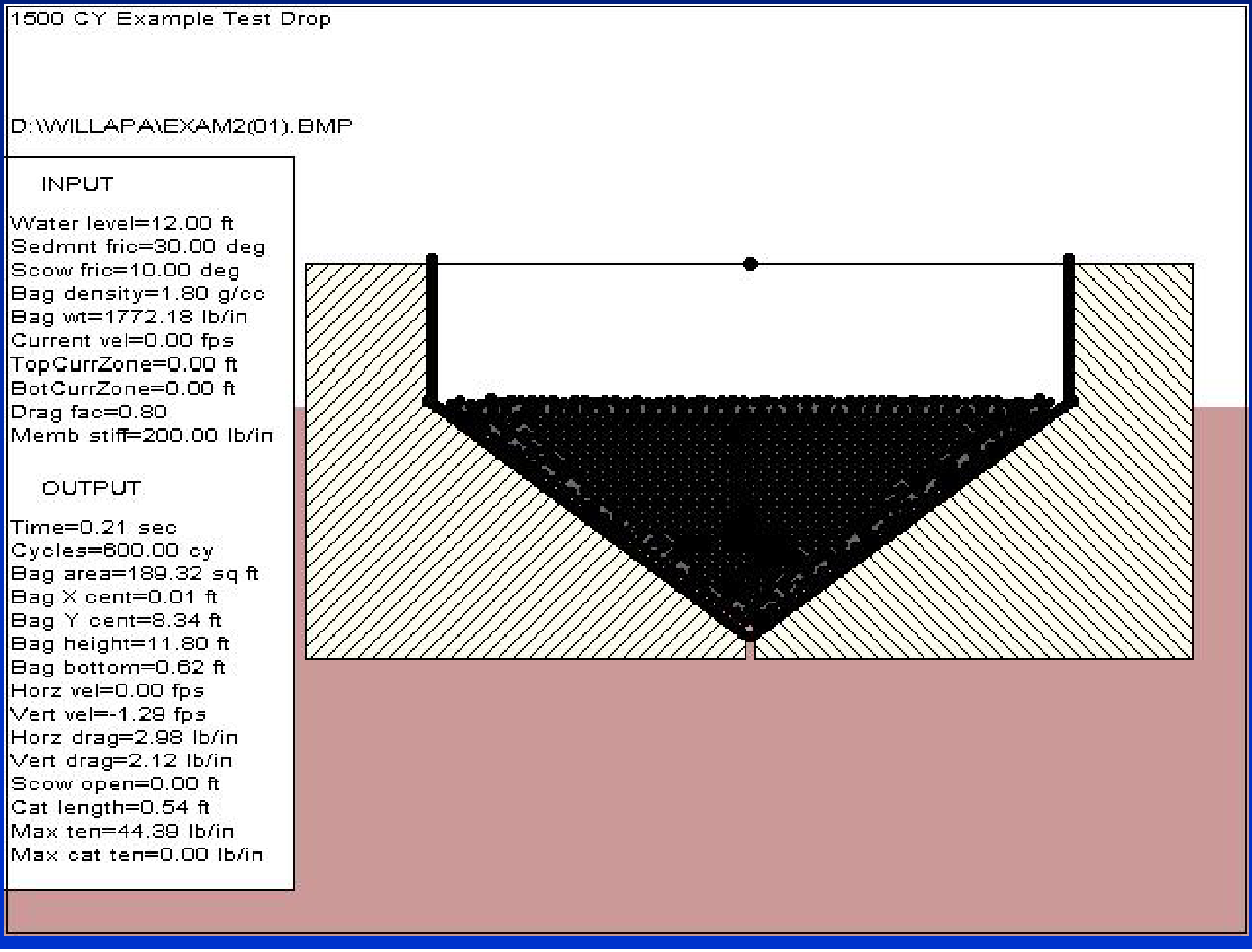
Split Hull Barge Distinct Computer Model Application

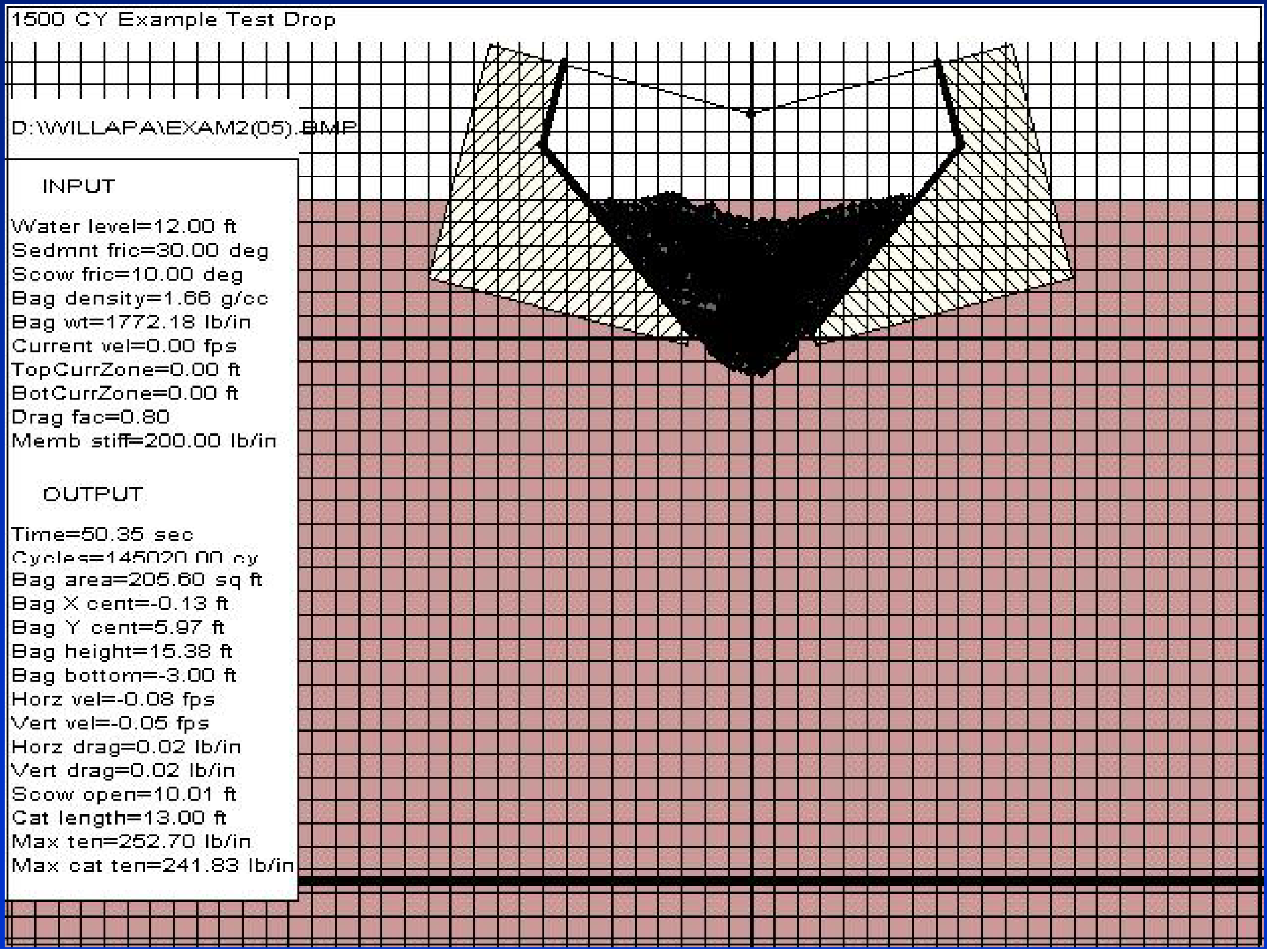
John Palmerton
601-638-3334
jbpalmer@bellsouth.net


Geocontainers Model Tests

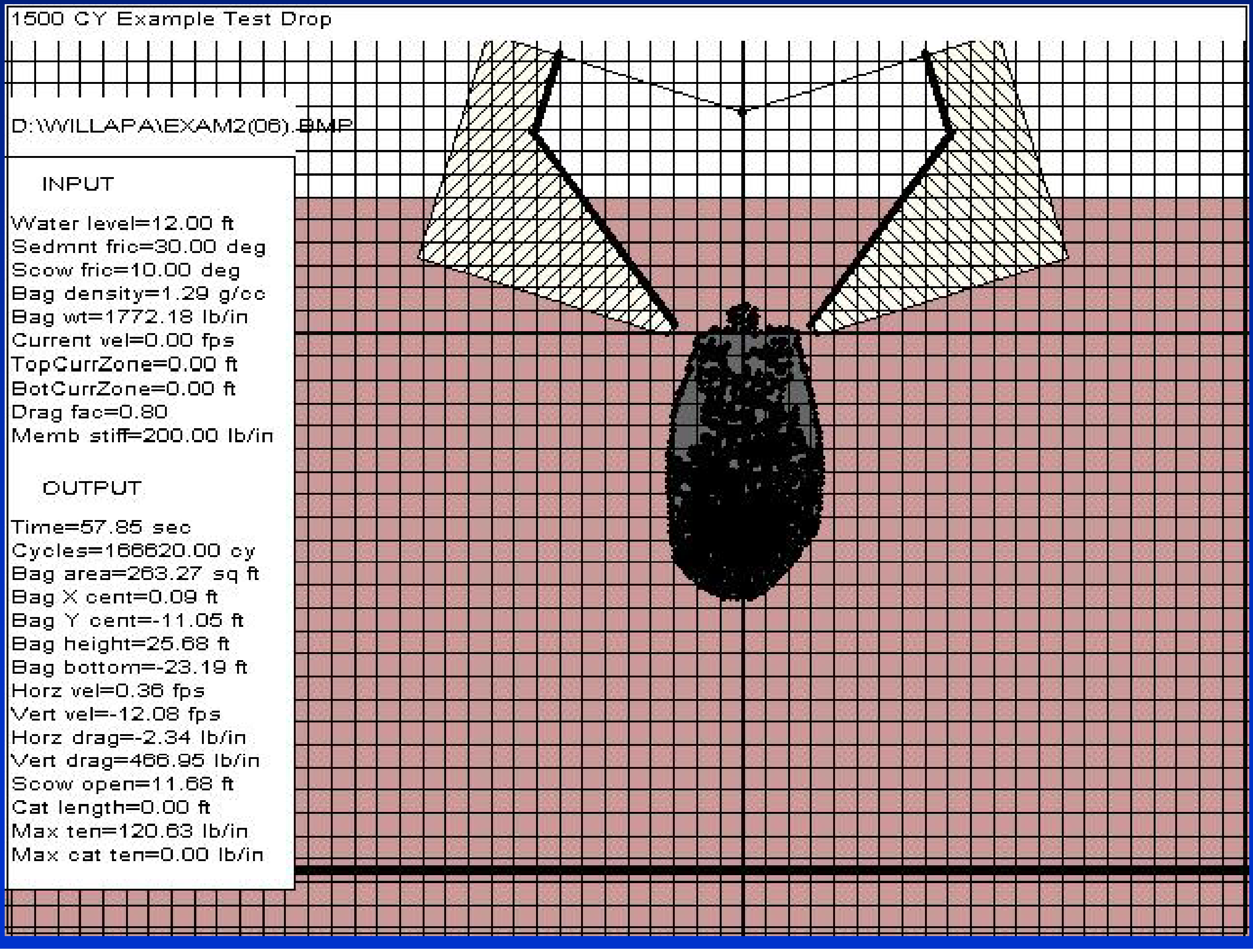
Split-Hull Scow Container Drop Simulations



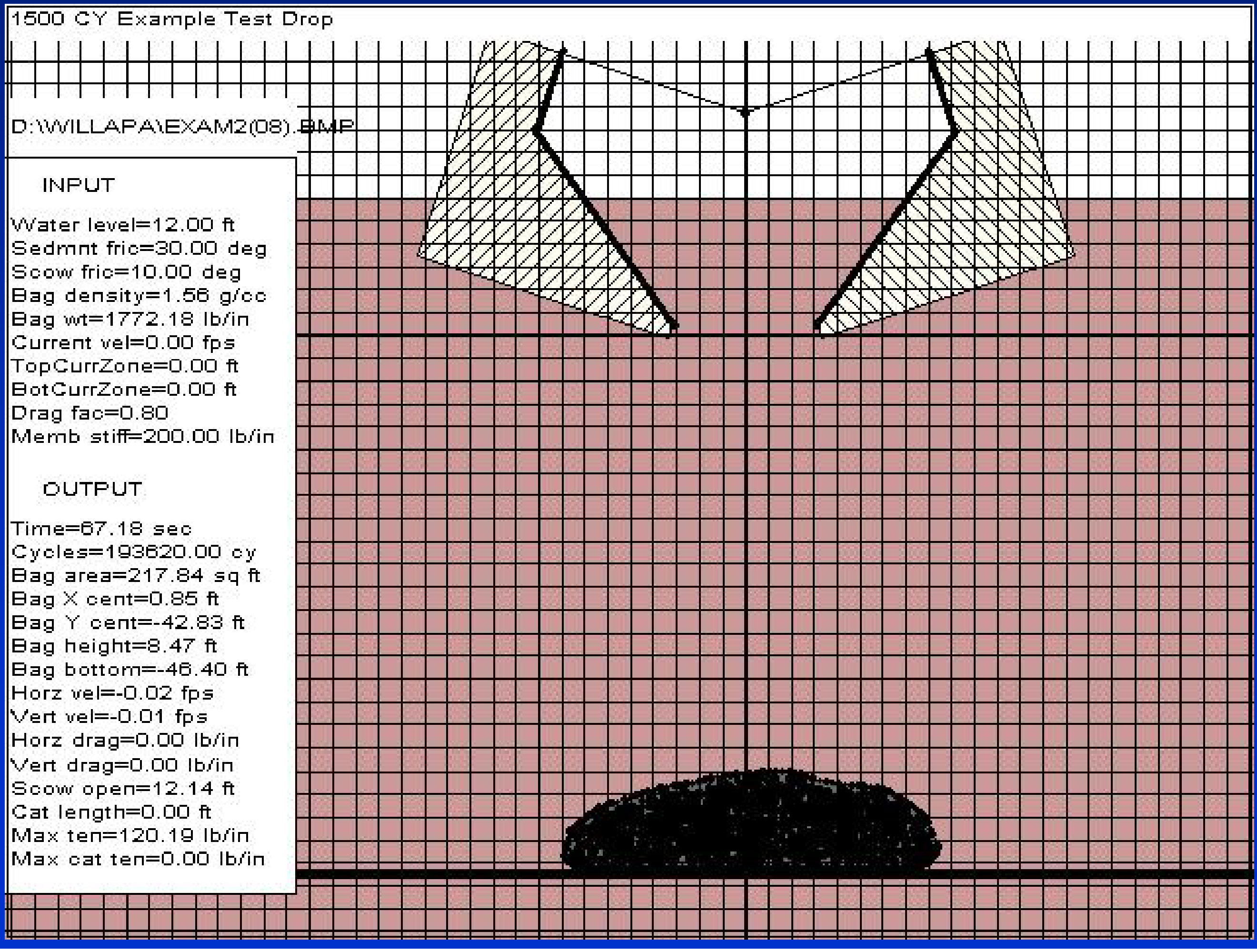
Split-Hull Scow Container Drop Simulations



Split-Hull Scow Container Drop Simulations



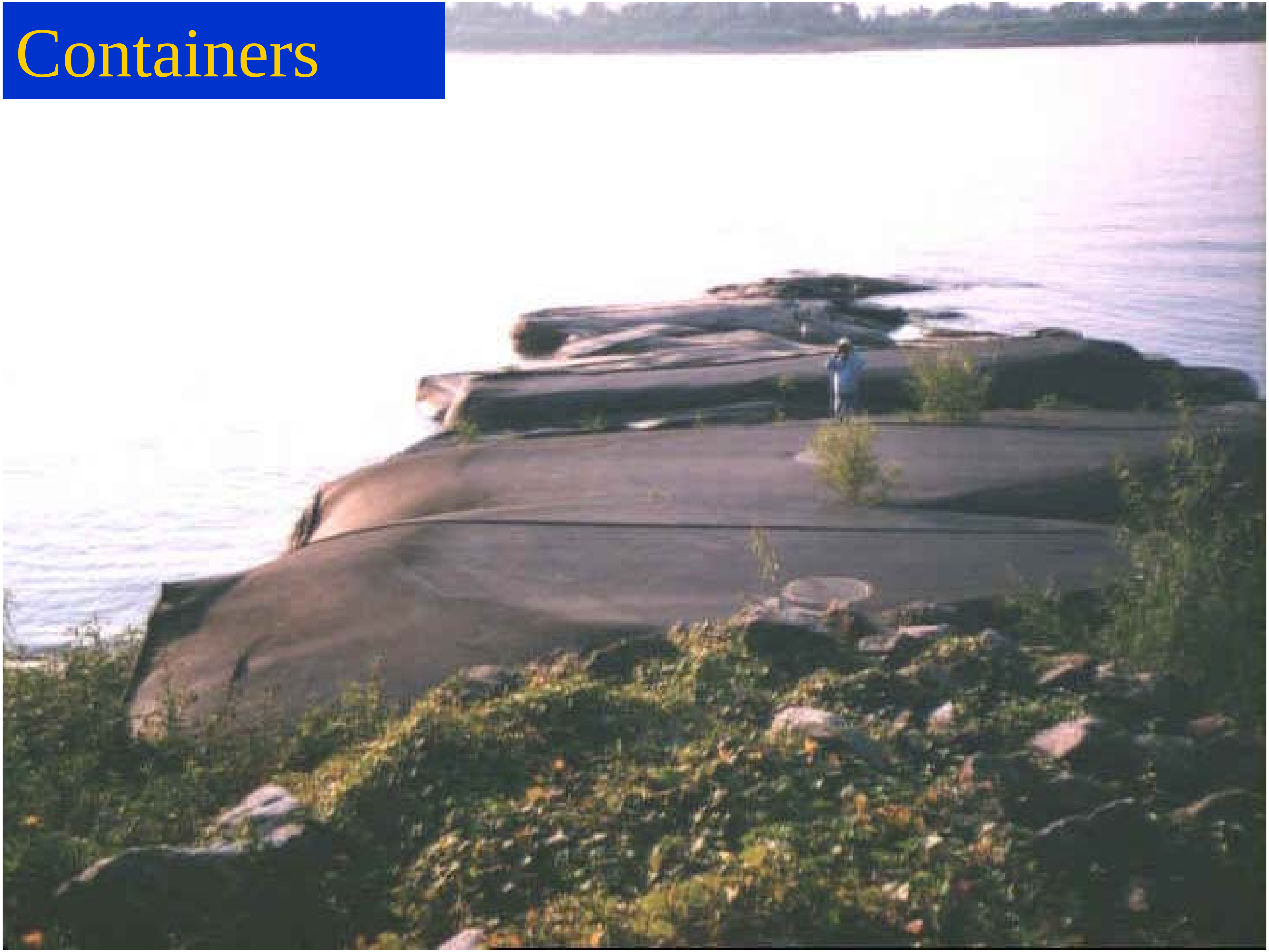
Split-Hull Scow Container Drop Simulations



Bags and Containers After 6 years

Red Eye Crossing
Baton Rouge, LA
October 1999

Containers



Bags

Note influence of Bags and Containers

Naviduct
Isjlmer, The Netherlands

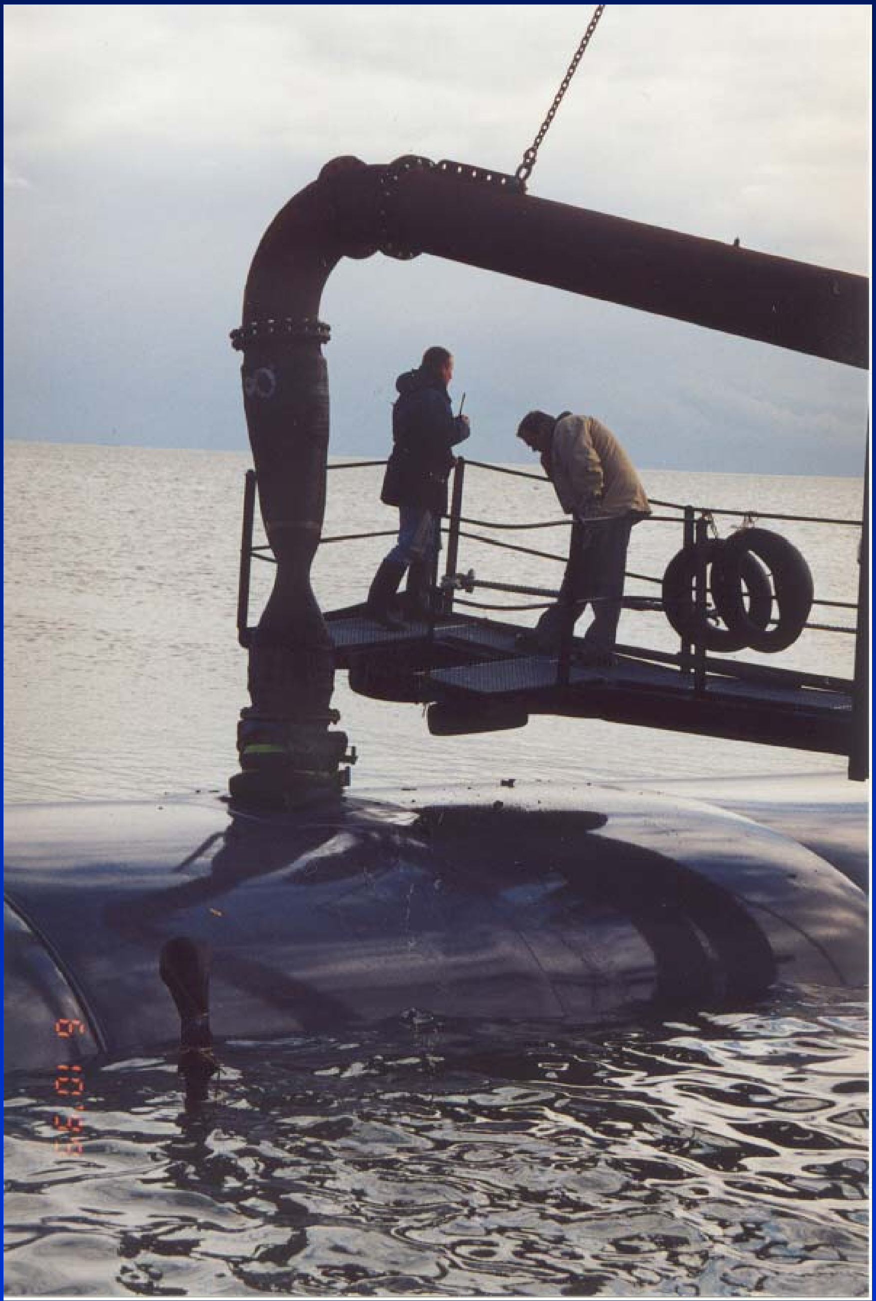
Geotextile Tubes

Used As A Dike Core For
Land Reclamation

Dredged Material Disposal Area

The Naviduct Project

Detail of 0.5 meter diameter fill-pipe



The Naviduct Project

The fill operation

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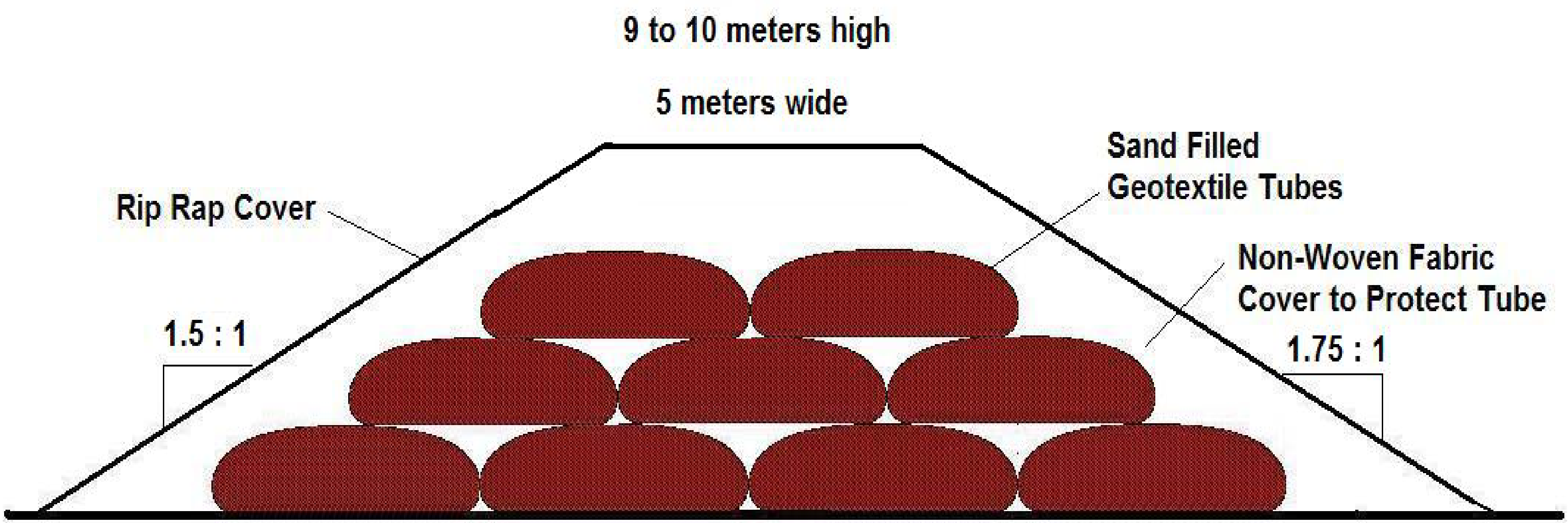
The Naviduct Project

Tube left: filling complete; Tube right: being filled

The Naviduct Project

Large scale Rip Rap test covering Tubes

Rip Rap Covered Tubes in Ecuador

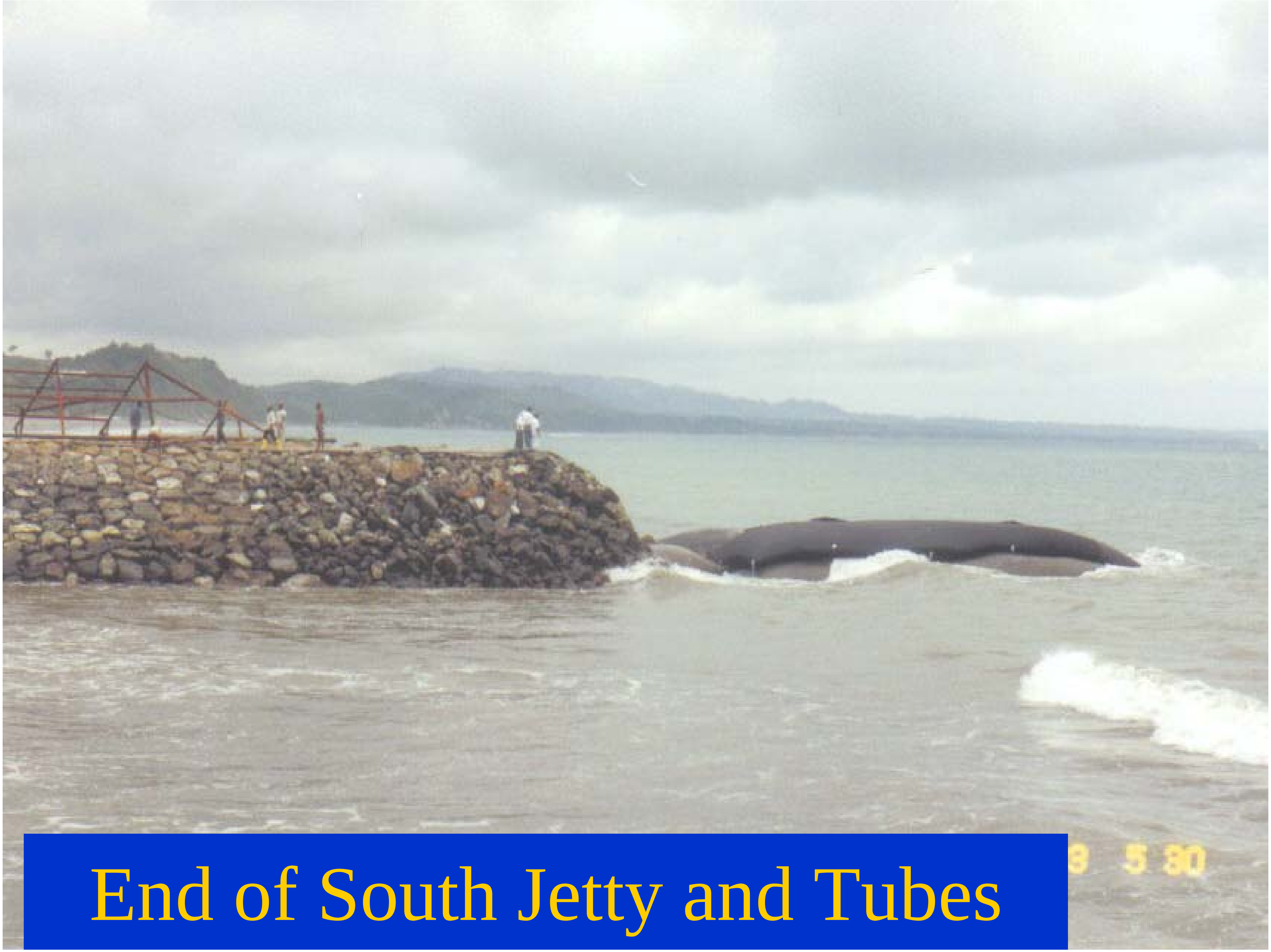


Rip Rap Covered Geotextile Tube Jetty

Esmeraldas, Ecuador

Rip Rap Covered Tubes

Stack of Three Sand Filled Tubes



End of South Jetty and Tubes

South Jetty Looking South

Placing Rip Rap on Tubes in North Jetty