U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT

2016 LEVEE SAFETY MEETING

"SHARED RISKS, SHARED SOLUTIONS"

Sheraton Louisville Riverside Hotel,
Jeffersonville, IN

9-10 February 2016

AGENDA

Tuesday 9 February 2016

9:00 to 9:15	Opening Remarks - Day 1	Colonel Christopher Beck, P.E., Commander, Louisville District
9:15 to 10:15	Overview of the Levee Safety Program	Eric Halpin, P.E., HQ Assistant to Dam and Levee Safety
10:30 to 11:00	Presentation by Risk Cadre - Levee Risk Assessments	Greg Werncke, P.E., Senior Technical Advisor, Risk Management Center (RMC)
11:00 to 11:45	Understanding the Preservation of Large Diameter Gravity Pipes with Structural Epoxy - Spray-In-Place-Pipe Liner (SIPP)	Danny Warren, Warren Environmental Inc., A&W Maintenance Inc.
11:45 to 12:15	Interim Policy on Inspection	Matthew Whelan, P.E. - Levee Safety Area Representative (LSAR) Upper Wabash
1:15 to 1:45	Abandoning/Sealing/Removing Obsolete Project Components	Ross Wright, P.E. Levee Safety Area Representative (LSAR) Lower Ohio and Green Rivers
1:45 to 2:15	Controlling Water with Water - Dam-It Dams	Brian Francis, Dam-It Dams Product Specialist
2:15 to 2:45	Public Alerts and Warnings: What really matters?	Will Lehman, Economist at Hydrologic Engineering Center (HEC)
3:00 to 3:30	Installation and Inspection of Reinforced Concrete Pipes (RCP)	Trygve Hoff, American Concrete Pipe Association (ACPA) Region Engineer that serves KY, OH, & IN
3:30 to 4:30	Levee Safety Areas (LSA) - Levee sponsors will provide short discussions on lessons learned on their projects. For example - issues with gate replacements; rebuild of pumps, mowing techniques, etc.	Levee Safety Area Representatives (LSARs) - Alvey, Inspector; Bryan, PE; Lasoski, PE; Wright, PE; Whelan, PE.
7:30 to 8:00	**Presentation: Silver Jackets Overview**	Brandon Brummett, P.E., PMP - Louisville District Outreach Coordinator

"Life Safety is Paramount"

v 4.0

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Wednesday 10 February 2016

8:30 to 8:45	Opening Remarks - Day 2	John Bock, P.E., Chief, Engineering Division and Levee Safety Officer (LSO)
8:45 to 9:15	Painting and Repainting Waterfront Steel Structures	Mark Jelinek, Sherwin Williams
9:15 to 9:45	Programs and Project Management Studies	Amy Babey, PMP, Chief of Plan Formulation Section
9:45 to 10:15	Discuss Silver Jackets Study for Metro Louisville Emergency Preparedness Plan (EPP)	Nathan Bryan, P.E., Levee Safety, Geotechnical Engineer
10:30 to 11:00	Cannelton Relief Well Project	Rick Hockett, PG, Risk Cadre, Geologist
11:00 to 11:30	Overtopping Leading to Levee Breaches	Terry Sullivan, P.E., Geotechnical/Geology Branch Chief, Eastern Division, Risk Management Center, Institute of Water Resources
11:30 to 12:30	USACE Assistance During Emergency Operations	Don Walker, Emergency Operations Manager, Emergency Operations Center (EOC) Louisville District
1:30 to 2:00	Western Excelsior - Current Work on New Orleans Levee Systems	Lee Pierce, Western Excelsior
2:00 to 2:30	Mechanical Solutions to Pump Station & Levee Components	Mark Robertson, P.E., Regional Technical Specialist (RTS) Mechanical Engineer LRL
2:30 to 3:00	H&H Presentation on Revised Wabash River Discharges and Potential Impacts to Levee Sponsors Maintaining Levees Along the Wabash River; & Potential Update Study to Ohio River Discharges - Study.	Richard Pruitt, P.E., Chief of Hydrology & Hydraulics Section

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Introduction To Woven Environmental Armoring Turf Reinforcement Technology

USACE Application Projects

- Levee Overtopping/Overwash
- Channels
- Ponds / Storage Lagoons Bank Stabilization
- Dike Repair Slope Stability
- Canal / River Bank Stabilization
- Dam Overflow Structure Project
- Shallow Plane Slope Stability

Anchor Reinforced Vegetation System (ARVS)
High Performance Turf Reinforcement Mat (HPTRM)

Presentation Outline
Storm Water Management
Applications Using Permanent Vegetated Armoring Materials

- **Introduction Western Excelsior Corporation**

- **National Discharge Elimination System (NPDES)**
  - Best Management Practices (BMPS) EPA Fact Sheets: Vegetated Swales & Turf Reinforcement Mats

- **Types & Performance Criteria Permanent Erosion Control Products**
  - 2nd Next Generation (High Performance Turf Reinforcement Mats HPTRM)
  - Anchored Reinforced Vegetation System (ARVS) -

- **Design Consideration for Durability & Applications**
  - Hydraulic Stress Criteria
  - Non-Hydraulic Stress Criteria
  - High Loading / High Survivability Considerations
  - Steep Slopes, Canal/River Bank Stabilization, Channels (Vegetated Waterways) Levee Overtop Armoring and Shallow Plan Slope Failures

- **US Army Corp. of Engineers (ARVS Wave Testing & SpecsIntact Specs**

- **Questions / Discussion**

About The Presenter

- **R. Lee Pierce**
  - Director Public Agency & USACE Specification Development, North America/South America
  - Western Excelsior Corporation (WEC), Chattanooga, TN
- **Experience**
  - 34 years in the Development of Technical Products & Specifications for the Construction/Civil Engineering Markets in the US & International Market Place
  - Responsible for WEC Market Development, North/South America
  - Responsible for USACE Levee Armoring Development Nationally
  - Washington DC Legislative Development & State of LA (Coastal Protection Restoration Authority (CPRA) Member
  - Member International Erosion Control Association
  - Member Erosion Control Technical Council
    - Past Executive board member

LP1

Regulation

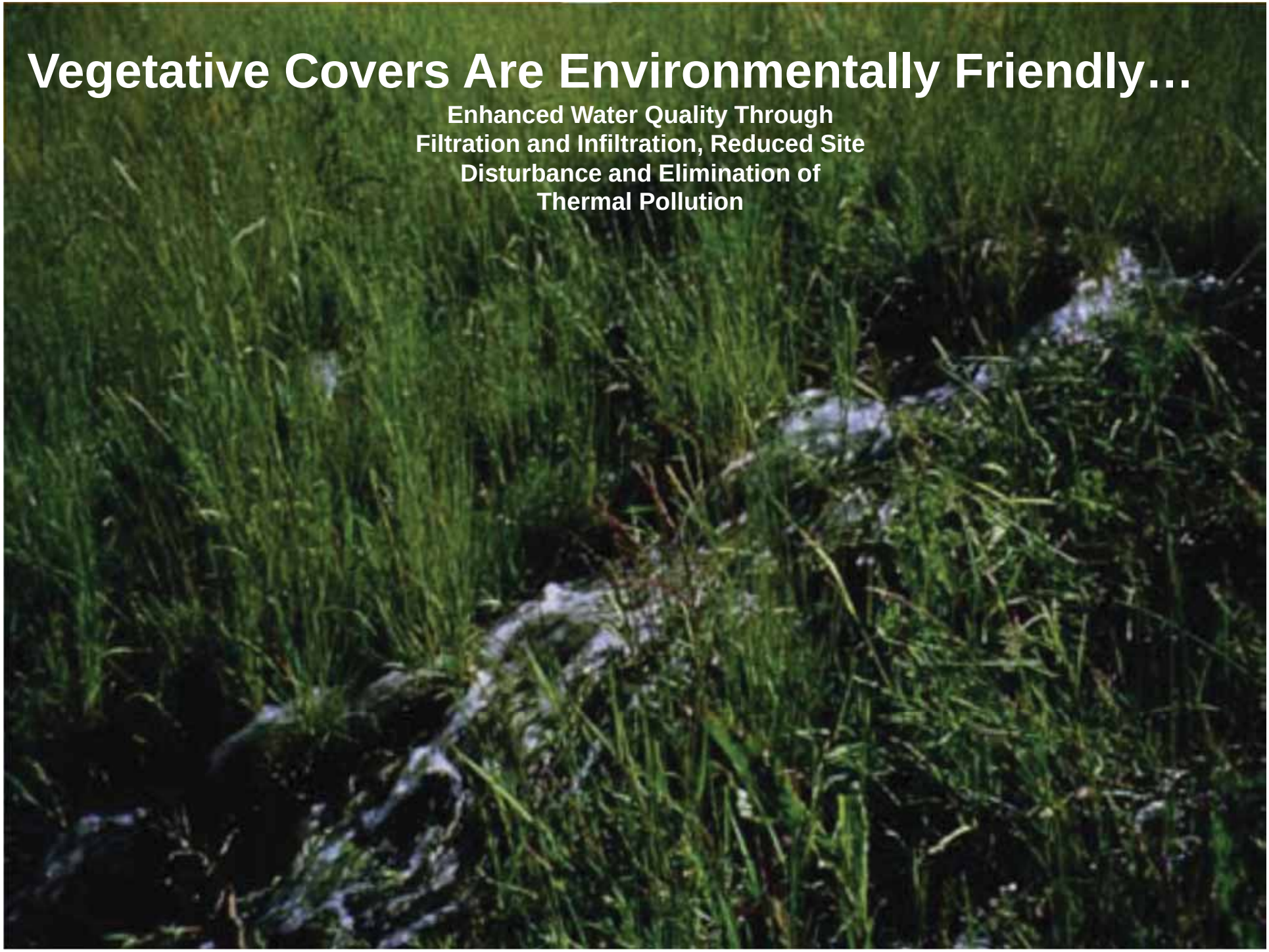
- Erosion-related pollutants cost the United States up to US$13 billion annually.
- United States spends over US $1 billion removing sediment from harbors and waterways Annually.
- EPA estimates that sediment deposition in reservoirs from storm water runoff costs up US $500 million annually.
- Annual water storage replacement costs from sediment range from US$2 to US$6 billion.

- The Driving Forces:
  - EPA – Environmental Protection Agency – Via Clean Water Act (CWA)
  - NPDES – National Pollutant Discharge Elimination System
    - ***Use of Best Management Practices for NPDES Compliance (EPA TRM Fact Sheet)***

Slide 4

LP1 Actual Cost documented in the Clean Water Act of 1990

Lee Pierce, 6/20/2014



Vegetative Covers Are Environmentally Friendly…

Enhanced Water Quality Through Filtration and Infiltration, Reduced Site Disturbance and Elimination of Thermal Pollution

EPA Fact Sheets
Best Management Practice

United States Environmental Protection Agency | Office of Water Washington, D.C. | 832-F-99-006 September 1999

EPA

Storm Water Technology Fact Sheet
Vegetated Swales

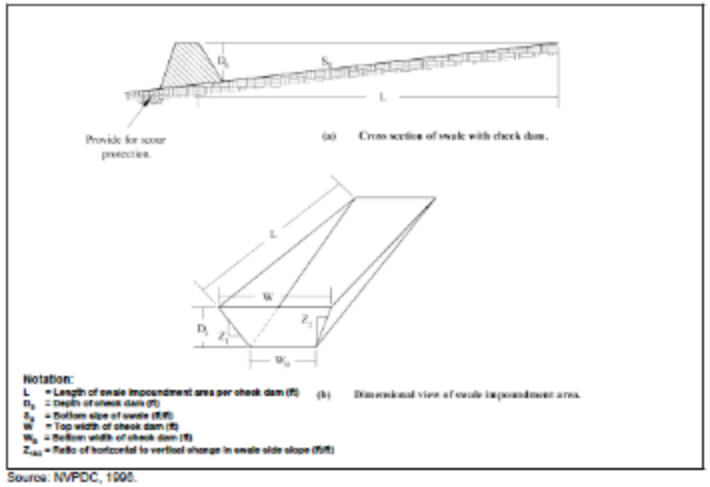
DESCRIPTION

A vegetated swale is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom. Swales can be natural or manmade, and are designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of storm water runoff. A typical design is shown in Figure 1.

Vegetated swales can serve as part of a storm water drainage system and can replace curbs, gutters and storm sewer systems. Therefore, swales are best suited for residential, industrial, and commercial areas with low flow and smaller populations.

APPLICABILITY

Vegetated swales can be used wherever the local climate and soils permit the establishment and maintenance of a dense vegetative cover. The feasibility of installing a vegetated swale at a



Source: NVPDC, 1996.

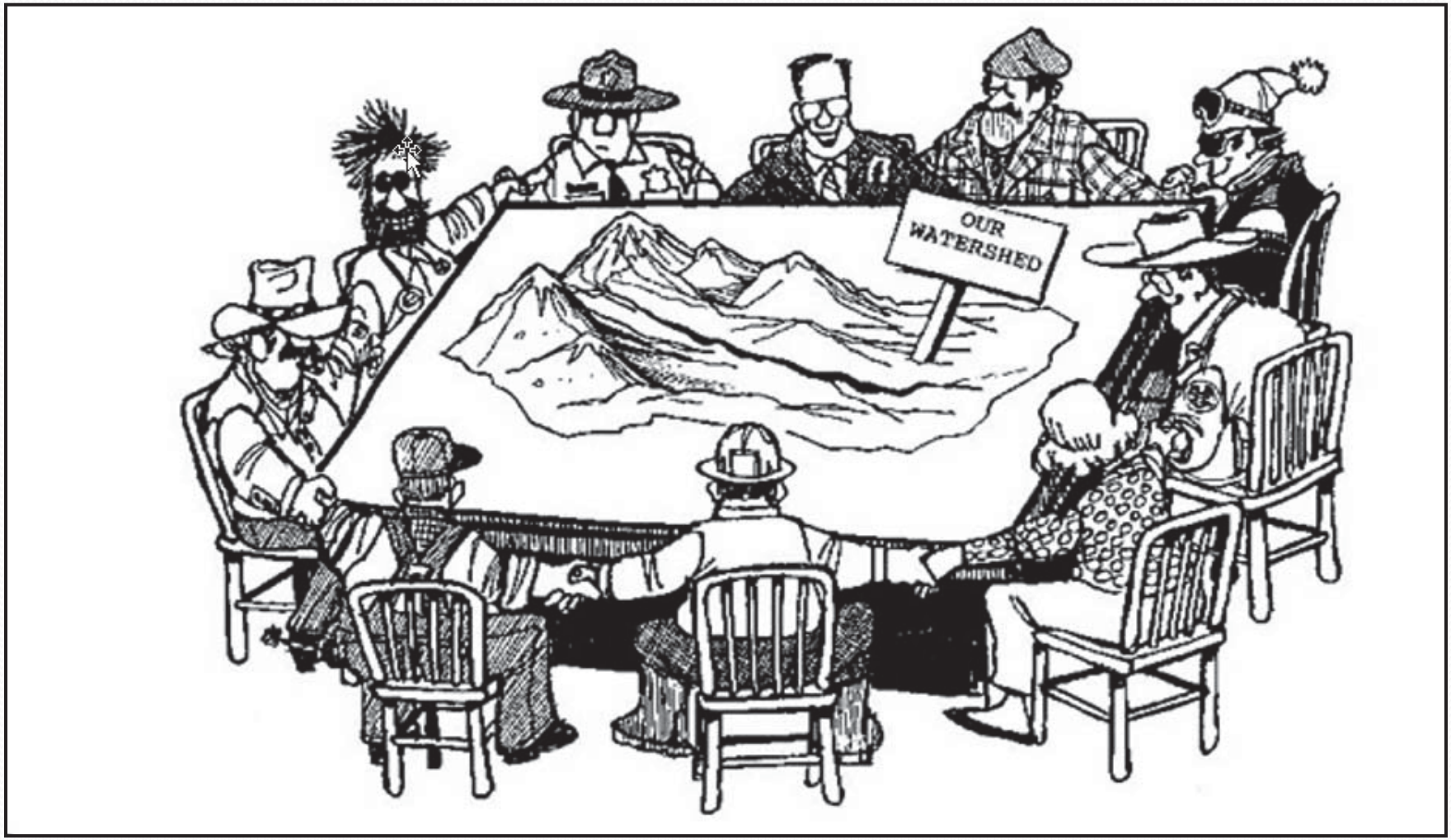
FIGURE 1 EXAMPLE OF A VEGETATED SWALE

ADVANTAGES AND DISADVANTAGES

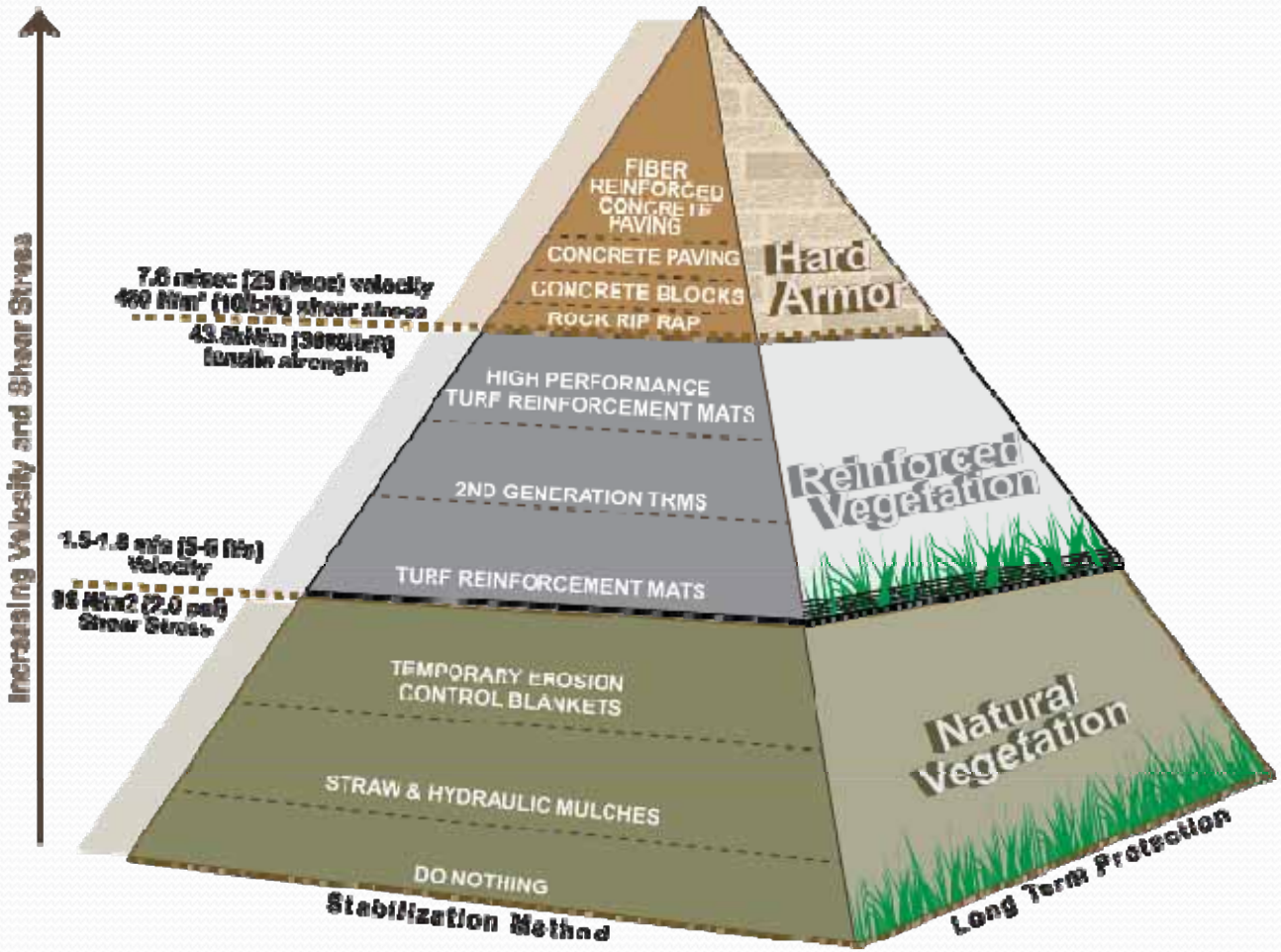
Swales typically have several advantages over conventional storm water management practice, such as storm sewer systems, including the reduction of peak flows; the removal of pollutants, the promotion of runoff infiltration, and lower capital costs. However, vegetated swales are typically ineffective in, and vulnerable to, large storms, because high-velocity flows can erode the vegetated cover.

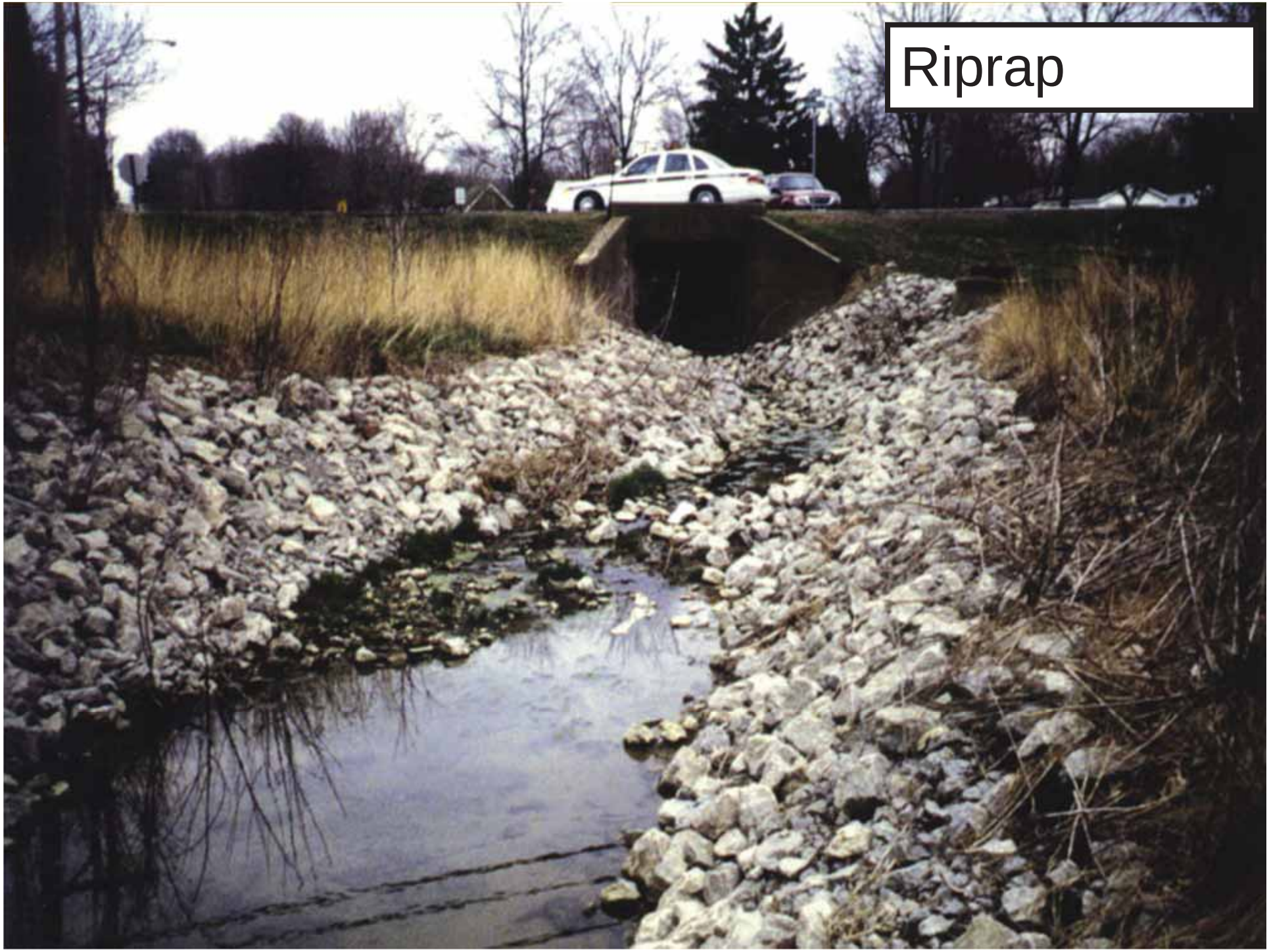
TABLE 1 EFFECTIVENESS OF DESIGN SWALES

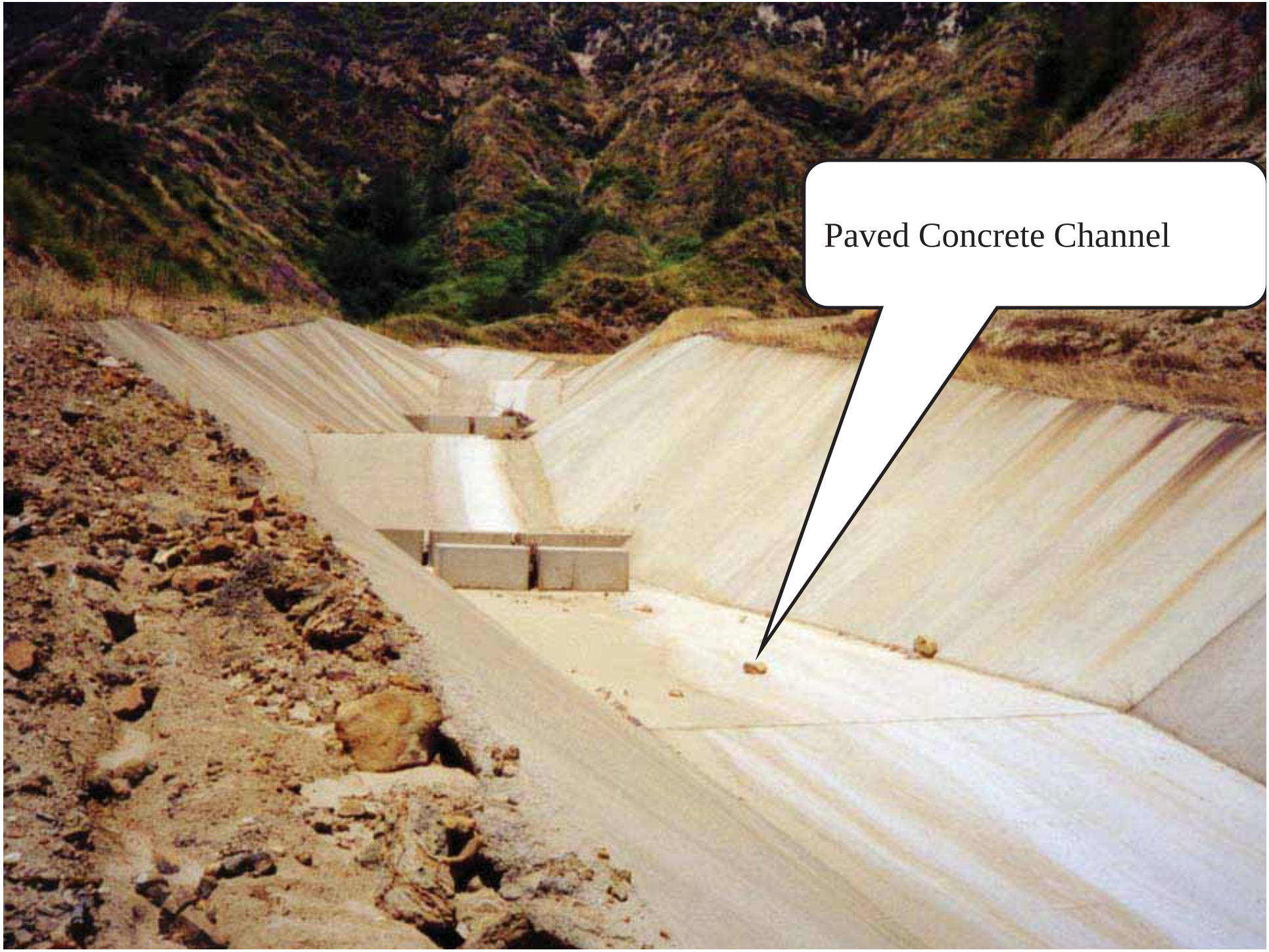
Pollutant	Median % Removal
Total Suspended Solids	81
Oxygen Demanding Substances	67
Nitrate	38
Total Phosphorus	9
Hydrocarbons	62
Cadmium	42
Copper	51
Lead	67
Zinc	71


OUR
WATERSHED

Erosion Control Performance Levels




Riprap


Paved Concrete Channel

LP2

EPA Storm Water Fact Sheet

Qualifies As:
Best Management Practice

United States Environmental Protection Agency
Office of Water Washington, D.C.
EPA 832-F-99-002 September 1999

EPA

Storm Water Technology Fact Sheet
Turf Reinforcement Mats

DESCRIPTION

This fact sheet describes the use of turf reinforcement mats (TRMs). TRMs combine vegetative growth and synthetic materials to form a high-strength mat that helps to prevent soil erosion in drainage areas and on steep slopes. TRMs are classified as a "soft engineering practice," in contrast to concrete and riprap, which they may replace in certain erosion control situations.

High-volume and high-velocity storm water runoff can erode soil within open channels, drainage ditches, and swales, and on steep exposed slopes, increasing the transport of sediments into receiving waters. Water quality impacts of increased sediment load include the conveyance of nutrient and pesticide pollutants, disruption of fish spawning, and impairment of aquatic habitat.

Traditionally, hard-armor erosion control techniques such as concrete blocks, rock riprap, and reinforced paving systems have been employed to prevent soil erosion in these highly erosive areas. Although these permanent measures can withstand great hydraulic forces, they are costly, and they do not provide the pollutant removal capabilities of vegetative systems.

TRMs enhance the natural ability of vegetation to permanently protect soil from erosion. TRMs are composed of interwoven layers of non-degradable geosynthetic materials such as polypropylene, nylon and polyvinyl chloride (PVC) netting, stitched together to form a three-dimensional matrix. They are thick and porous enough to allow for soil filling and retention. In addition to providing scour protection, the mesh netting of TRMs is designed to enhance vegetative root and stem development. By protecting the soil from scouring forces and enhancing vegetative growth, TRMs can raise the threshold of natural vegetation to withstand higher hydraulic forces on stabilization slopes, streambanks, and channels. In addition to reducing flow velocities, the use of natural vegetation provides particulate contaminant removal through sedimentation and soil infiltration, and improves the aesthetics of a site.

TRMs offer high shear strength, resistance to ultraviolet (UV) degradation, and inertness to chemicals found in soils. Figure 1 illustrates the applicability of TRMs within the spectrum of available erosion control techniques. Temporary erosion control blankets and mats, also shown in Figure 1, eventually leave vegetation unprotected and unreinforced, and should only be used to establish vegetation under mild hydraulic situations.

TRMs, unlike temporary erosion control products, are designed to stay in place permanently to protect seeds and soils and to improve germination. TRMs can incorporate natural fiber materials to assist in establishing vegetation. However, the permanent reinforcement structure of TRMs is composed of entirely non-degradable synthetic materials. The structure of a typical TRM is illustrated in Figure 2. A variety of ground-anchoring devices can be used to secure TRMs, including: u-shaped wire staples, metal pins, and wood or plastic stakes. Appropriate ground anchoring devices are chosen based on site-specific soil and slope conditions.

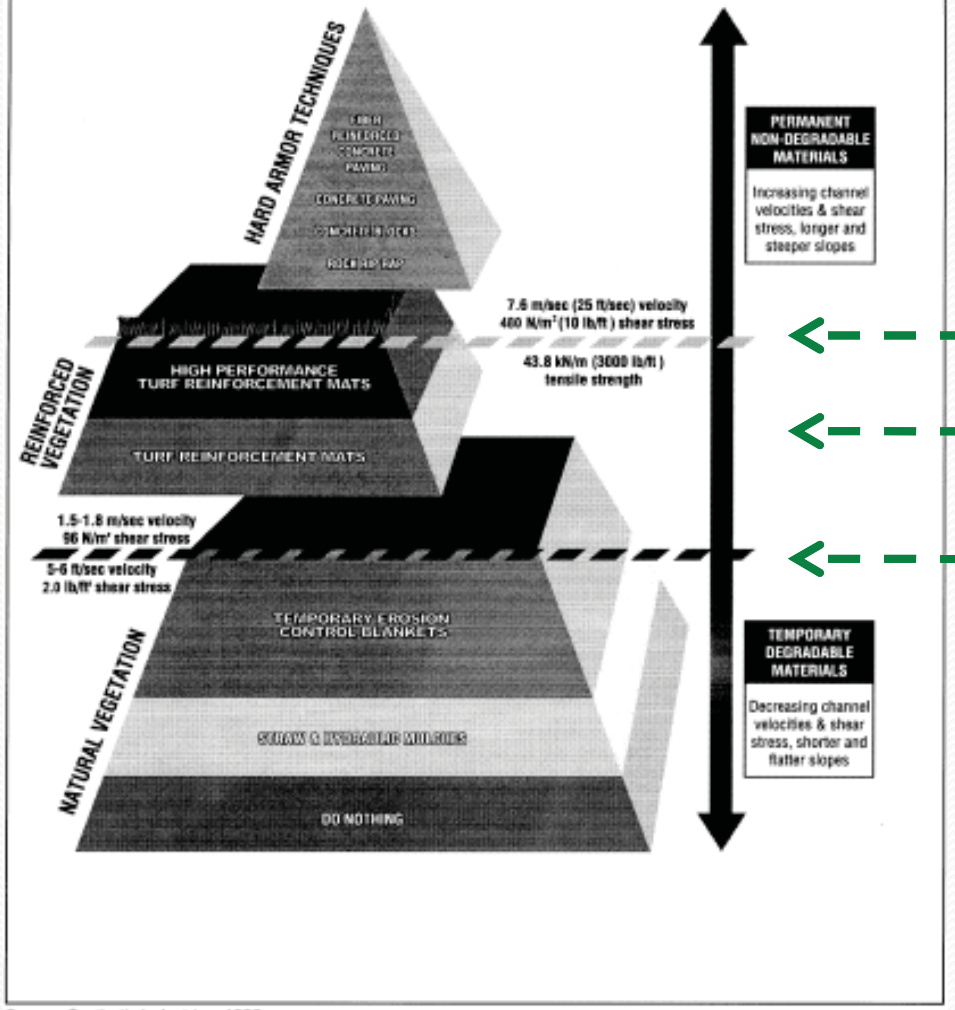
Vegetative seed selection is based on the geographic region of the project and site specific concerns. Sources of information on seed selection

Slide 11

LP2 Qualaifies TRMs as a Best Management Practice for NPDES Compliance.

Lee Pierce, 6/20/2014

EPA STORM WATER FACT SHEET
Turf Reinforcement Mats



Source: Synthetic Industries, 1998.

FIGURE 1 EROSION CONTROL TECHNIQUES

PERFORMANCE CRITERIA

High Performance Turf Reinforcement Mats (HPTRM)
Shear Stresses ≥ 10 lbs/ft, Tensile Strength ≥ 3000 lbs/ft

Std Turf Reinforcement Mats (TRM)
Shear Stresses ≤ 8 lbs/ft, Tensile Strength < 3000 lbs/ft

Natural Vegetation Hydraulic Limits (Shear Stress)
Vegetated Cover Only ≤ 2 lbs/ft

Key Learning's
TRM Proven Performance Criteria

- **Primary Consideration Must Be Given to Performance Properties**
  - **Mechanical Performance Properties**
    - **Tensile Strength**
    - Higher Tensile Strength @ Low Strain (High Modulus)
    - Initial Tangent Modulus
    - **UV Stability**
    - Flexibility
  - **Hydraulic Properties**
    - **Shear Stress**
    - **Velocity**
- **Structural (Performance) Properties Aid in the Products Long-Term Functionality**
  - **Function Longevity**
    - **Design Life Up to: 50 years**
  - **Durability**
    - **Non-Hydraulic Stress Conditions**
    - ***Temperate, Arid and/or Semi/Arid Climate Conditions***
  - **Quality Control and Assurance**

- **Lead to the Focus On Woven Homogenous Three Dimensional Construction**

LP3

Tensile Strength Important for 3 Reasons

1. **Non – Hydraulic Stress Resistance**
   - Resist Wheel Loadings
   - Heavy Mowing Activity
   - Construction Traffic
   - General Maintenance Activity
   - Debris Loading
   - Ice Flows
   - Animal Loading
   - Higher Factor of Safety

2. **Design Life up to 25 or 50 Years**
   - Higher strength based on UV degradation time allows for longer design life

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Slide 14

LP3 You need to design not just for the Hydraulic Condtions but also look at these non-hydraulic condtions. If the exist, a HPTRM is warranted.

Lee Pierce, 6/20/2014

LP4

2nd Generation Woven Homogenous Three Dimensional Structure TRMs

- **Woven Construction**
  - Homogenous structure assures dimensional stability
  - Provides for long-term durability
  - Loft and Structural Integrity Formed by Weaving Process
  - No Laminated, Fused, Stitched Layers or composite structures

Slide 15

LP4 !st Generation TRM Failurs led to the development & usage of Woven TRM_HPTRM Technolgy.

Lee Pierce, 6/20/2014

Yarn Extrusion Equipment
Extrusion From Resin Pellet Form to Finished Material

LP5

Yarn Beaming Equipment

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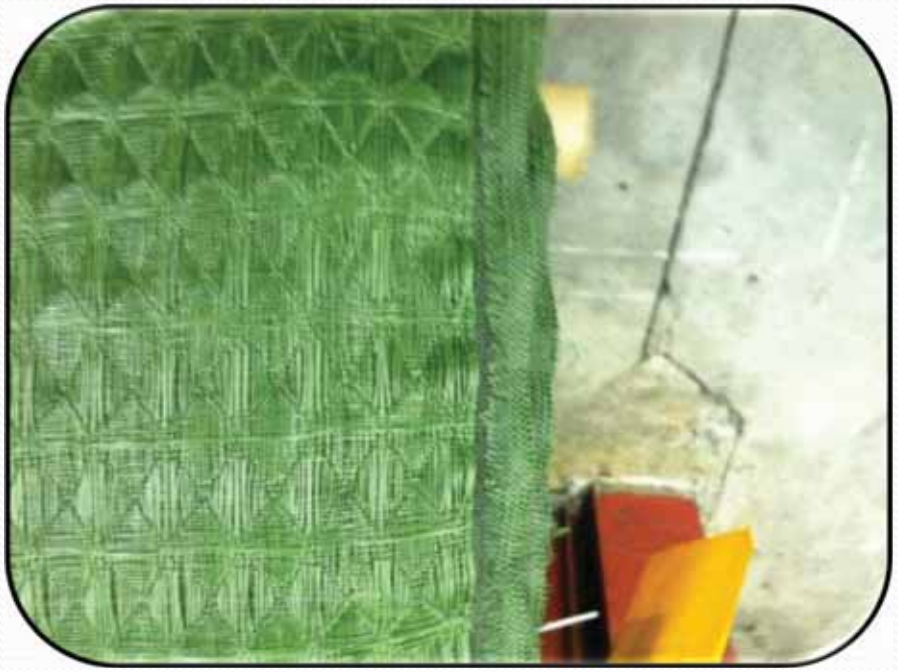
Slide 17

LP5 After the yarns are extruded, the are spooled and then the hard is threaded on to a beamer. The beam is then installed on the weaving look to produce the woven fabric.

Lee Pierce, 6/20/2014

Weaving Equipment & Edge Rollup Salvage



HPTRM Weaving Dobbie Head Looms

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Salvage Rollup

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15 Foot Wide Loom Capability
Maximize Installation width to minimize overlaps & waste
Increase production rates & reduced cost

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Next Generation High Performance (HPTRM)

High Loading / High Survivability

- **Mechanical Performance Properties**
  - Tensile Strength 4000 x 3000 lbs/ft **(59 kN/m x 44kN/m)**
  - Tensile Strength 3000 lbs/ft (44 kN/m) @ 15% Strain
  - Initial Tangent Modulus = MD 10.8 kips/ft x TD 27.8 kips/ft
  - **Initial Tangent Modulus = MD 14.5 / TD 37.7 Kilo N/m** Stability 90% @ 6000 hours
  - Flexibility 0.524 in-lbs (Ave)
  - Seedling Emergence (21 days) ≥ 423%
- **Hydraulic Properties**
  - Shear Stress 17 lbs/ft **(814 N/m^2)**
  - Velocity 25 fps **(7.6 m/s)**
- **Application**
  - Channels, Slopes, Ponds, Canal/River Banks
  - Up to 50 year design life
- **Non-Hydraulic Stress Activity**
  - Regular mowing/maintenance activity, heavy mowers/construction traffic/debris loading, wild life and/or where greater factors of safety are required

LP7

US Army Corps of Engineers
Mississippi Valley Division

Corps Hurricane Response

Task Force Hope Status Report Newsletter *December 15, 2011*

Corps completes successful levee armoring test

Twofold test indicates grass/HPTRM combo will provide HSDRRS levees with extra resilience to storm surge overtopping

by Susan Spaht

Two months ago, the Corps of Engineers, its non-Federal sponsors, the LSU AgCenter, and Evans-Graves Engineers prepared a selected section of levee in St. Charles Parish for a special armoring test.* The test team laid out High Performance Turf Reinforced Mattresses (HPTRM) plus two types of grass, and waited 60 days for the grass to grow. The test was twofold:

Test 1. Turf Establishment - this test would evaluate the ability of the grass to take root through the HPTRM and form a sturdy bond that would anchor the HPTRM and "armor" the levee. Armoring of levees is the last step in the completion

Continued on page 2

Also in this issue:
MG John W. Peabody letter.....Page 5

Above: Todd Grantier, the Corps' test team leader, checks the levee grass before mowing operations begin. *Below:* a tractor-mower drives along the St. Charles Parish levee test site mowing the grass/HPTRM combo.

Corps' armoring test called success by test team

Levee board tractors mow the grass at the levee test site in St. Charles Parish as test team members closely observe the work and take notes.

Continued from page 1

of the Hurricane and Storm Damage Risk Reduction System (HSDRRS). Armoring provides the extra resilience a levee would need to withstand the possibility of overtopping from a storm surge greater than a 100-year storm.

Test 2. Operations and Maintenance – this test would determine the ability of the new grass/HPTRM unit to withstand normal grass-mowing operations. This test was performed using the Pontchartrain Levee District and East Jefferson Levee District's own tractor-mower equipment, i.e., the equipment they own and use regularly to cut the grass on their levees.

The grass-cutting test was witnessed by representatives of levee districts, the State's Office of Coastal Protection and Restoration, the LSU AgCenter and the Corps of Engineers.

Tough Conditions

The armoring test was started this fall and was purposefully planned for this portion of the levee system to make the test as tough as possible. The test team wanted to prove a point.

The test grass was given a mere 60 days to grow and take root through the HPTRM. "It would have been much better to have given the grass 120 days to grow," said Mike Park, Chief of Task Force Hope. "And October is not the best time to plant grass, but that was way our timing worked out.

"We selected one of the most severe bends in the entire levee system," Park added, "and the most severe loading environment (tractor-mowers) we could come up with. And the ground was wet when the mowing was performed." These are all less than favorable conditions for growing grass and for mowing operations. The test team's point was that if the grass could take root through the HPTRM and anchor it to the levee in these less-than-ideal conditions, and if the mowing operations would go smoothly on the sharp levee bend, then certainly the grass will grow and the maintenance work will go well when performed in more favorable conditions.

Continued on page 3

Slide 23

LP7 USACE has fullly tested the HPTRM for Non-Hydraulic Stresses (Mowing) different tractors and different tire configuations. UACSE has not fully approve the PP5 Xtreme Armor System.

Lee Pierce, 6/21/2014

Continued from page 2

"Our team was confident that we could get the grass to grow through the HPTRMs," said Todd Grantier, the Corps' test leader. "There was more concern about the mowing operations." Would the tractor-mower blades get caught in the HPTRM? Would the mower blades tear the HPTRM in the process of cutting the grass, or pull up the HPTRM? Would the mowers slip when passing over the HPTRM on the severe bend in the levee? "There were no extraordinary problems," said Grantier, "everything went smoothly."

Mike Park

"This is going to work," said Park. "This was a very successful test, and we learned some important lessons from it."

Lessons Learned

1. One obvious lesson learned, or at least confirmed, is that it is best to plant levee grass in the spring, in the proper growing season, and allow it longer growing time before mowing it. "Although it wasn't ideal to plant grass late in the season," said Grantier, "we learned that by using sod we can get turf well-established before the winter dormant season."

2. The grass used in the levee test was typical, commercially-available Bermuda sod. This is the grass that the Corps will use, along with HPTRMs, to armor the HSDRRS levees. This grass is designed and bred to grow at a slow rate. At the time of the test mowing operations, the grass was only about two inches high after two months of growing. The advantage here is that the levee boards will not have to mow the levees as often as they presently do. That is expected to result in lower maintenance costs.

Mowing grass on severe levee bend

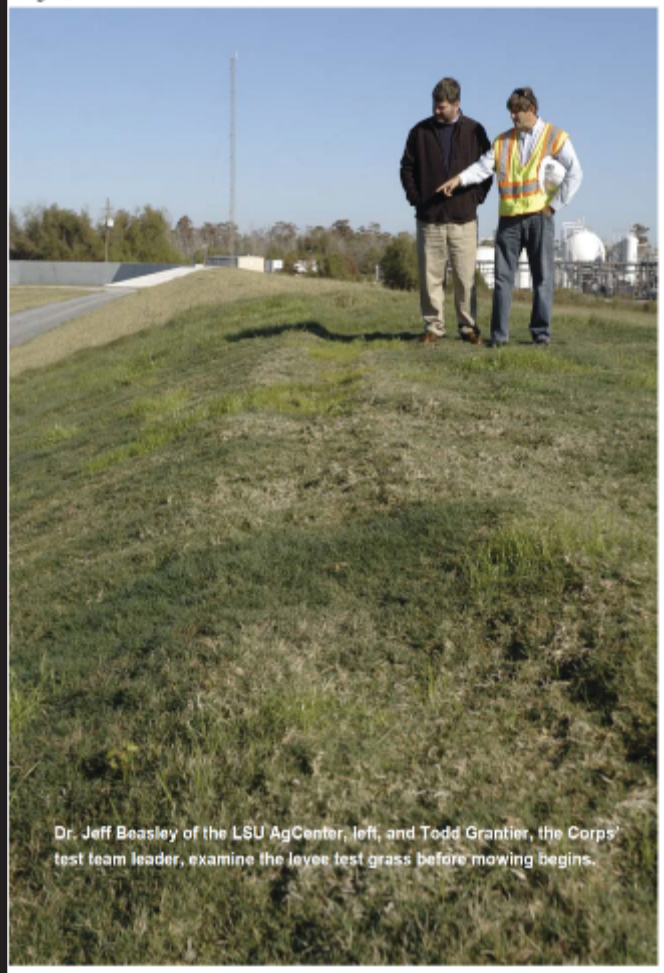
"This was a very successful test, and we learned some important lessons from it." - Mike Park, Chief, Task Force Hope

Turf Flotation Tire

Ribbed Agriculture Tire

3. Another interesting lesson learned from the HPTRM test had to do with the tractor tires. The large Bush Hog tractor used in the mowing operations had *ribbed agriculture tires* which have very deep treads (see photo). "After several passes on the severe levee bend," explained Grantier, "those tire treads cut the

Continued on page 4



Dr. Jeff Beasley of the LSU AgCenter, left, and Todd Grantier, the Corps' test team leader, examine the levee test grass before mowing begins.

Continued from page 3

young grass down to the HPTRM. The HPTRM was not damaged, nor was the levee. This cutting could be avoided if the tractor was fitted with *turf flotation tires*. "That will be one of the considerations we will offer to the levee boards."

4. When the tractors passed over a test section with no HPTRM, i.e., just grass, the tires left deep impressions in the grass. When the tractors passed over a grass/HPTRM combo section, there were no tire impressions made. "This tells to us that the HPTRM reduces reaction to wheel loading, and protects the levee during maintenance operations by reducing wheel slippage and rutting," said Grantier. "A valuable lesson learned."

*see Oct. 5, 2011 Newsletter. http://www.mvn.usace.army.mil/hps2/_pdf/October_5_2011.pdf

"This tells us that the HPTRM reduces reaction to the wheel loading and protects the levee during maintenance operations by reducing slippage and rutting"

Contact Information

U.S. Army Corps of Engineers

Task Force Hope
(504) 862-1836

New Orleans District
(504) 862-2201

Hurricane Protection Office
(504) 862-1708

The *Status Report Newsletter* supports the information program for Task Force Hope and its stakeholders. It also serves as the primary tool for accurately transmitting the Corps' hurricane risk reduction efforts to stakeholders.

This is an online publication that is open to public distribution.

This issue and past issues can be found at: http://www.mvn.usace.army.mil/hps

Comments and questions may be sent to the Status Report Newsletter editor at: b2fwdpao@usace.army.mil

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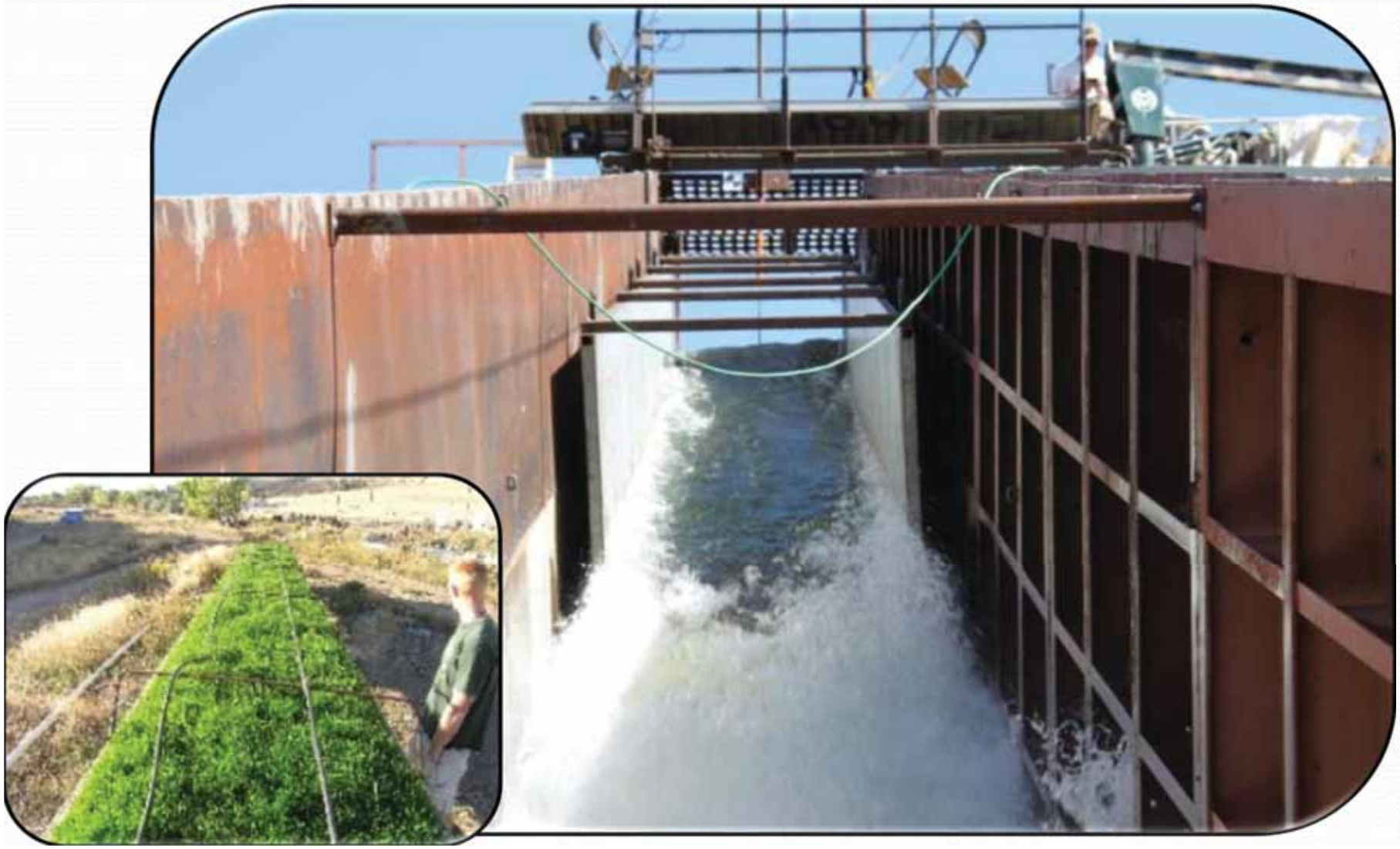
Colorado State University

Engineering Research Center

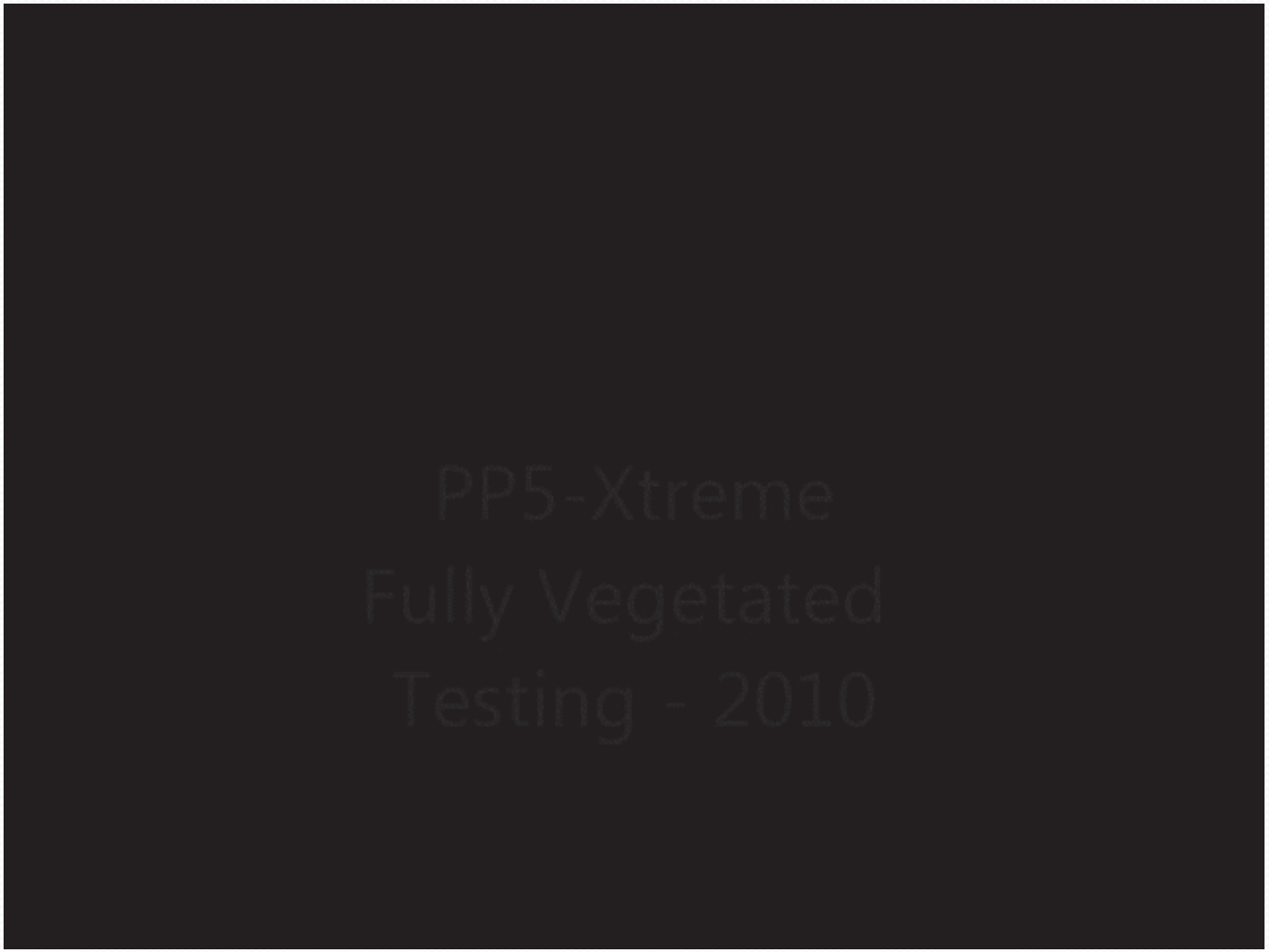
Colorado State University Hydraulic Testing Laboratory Channelized Performance Testing

- Product Installed on a Soil Plot, Identical to Field Installation
- Product Exposed to a Series of Increasing Flows, Systematically Increasing Shear Stress
- Soil Loss Measured After Each Flow
- Threshold of Performance Determined as Shear Stress Associated with 0.5 Inches of Soil Loss (Average of All Measurements)

HPTRM Vegetated Performance Testing



HPTRM Flume Testing Colorado State University



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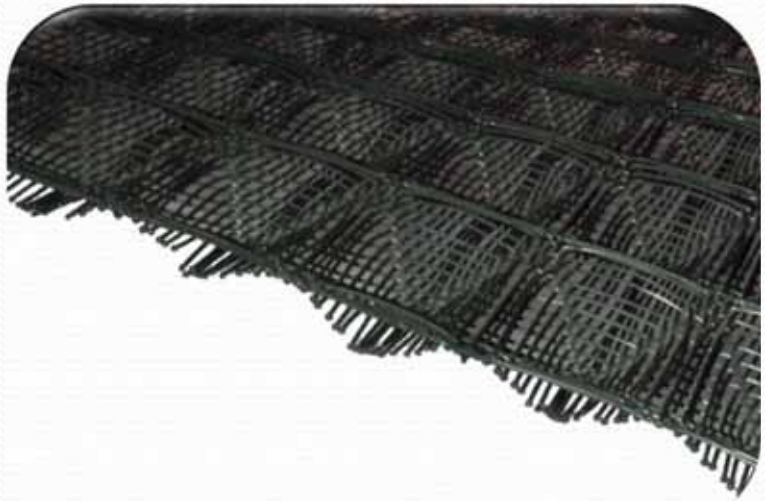
Anchored Reinforced Vegetation System (ARVS)

High Loading / High Survivability

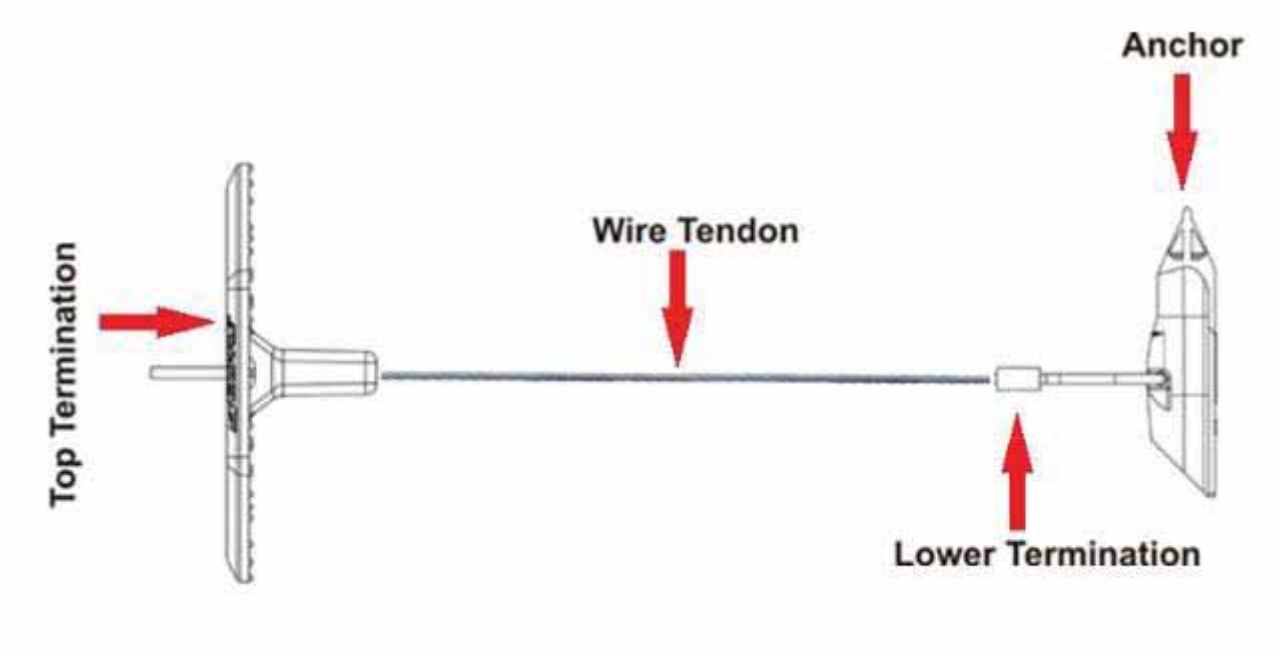
- **Woven HPTRM Mechanical Performance Properties**
  - Tensile Strength 4000 x 3000 lbs/ft
  - Tensile Strength 3000 lbs/ft @ 15% Strain
  - Initial Tangent Modulus = MD 10.8 / CD 17.8 kips/ft
  - UV Stability 90% @ 6000 hours / 85% @ 10,000 hours
  - Flexibility 0.524 in-lbs (Ave)
  - Seedling Emergence (21 days) ≥ 423%
- **Percussion Driven Earth Percussion Anchors (PDEAs)**
  - Tie Down /Add Factor of Safety
- **Hydraulic Properties**
  - Shear Stress 17 lbs/ft
  - Velocity 25 fps
- **Application**
  - Channels, Steepen Slopes, Ponds/Reservoir, Canal/River Banks ***Levee Overtop/Overwash Armoring & Shallow Plane Slope Failures***
  - Up to 50 year design life
- **Non-Hydraulic Stress Activity**
  - Regular mowing/maintenance activity, heavy tractor mowers/construction traffic, animals, debris/ice loadings and/or where greater factors of safety are required

High Performance Turf Reinforcement Mat (HPTRM)



Percussion Driven Anchor Components

There are four components that make up our anchor system:



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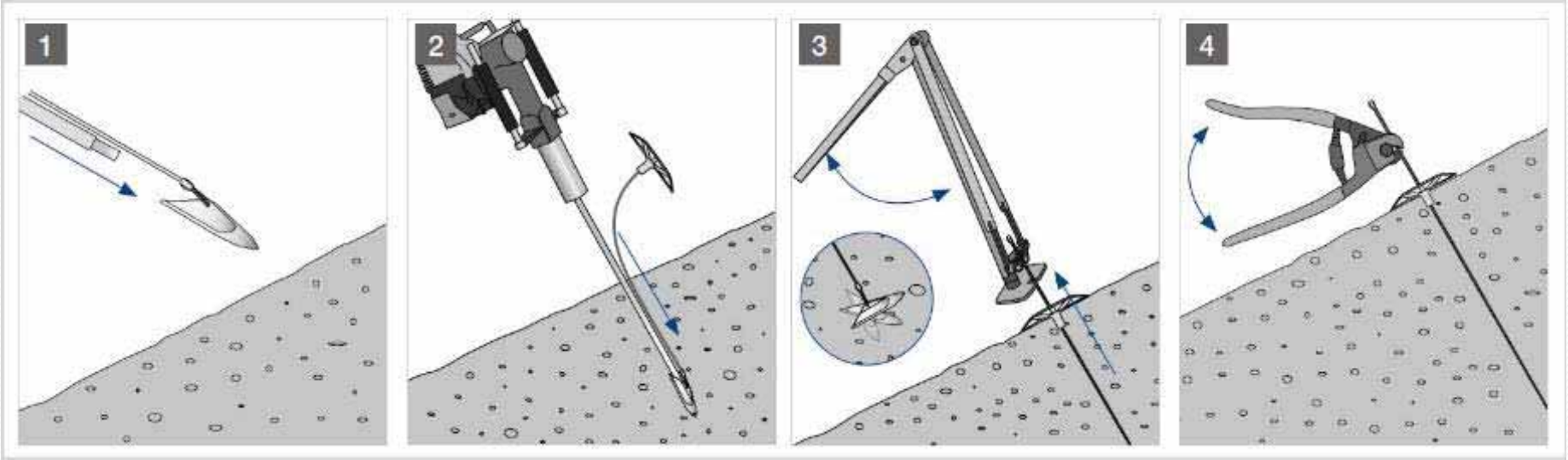
(ARVS) Anchor Installation Sequence

INSTALLATION



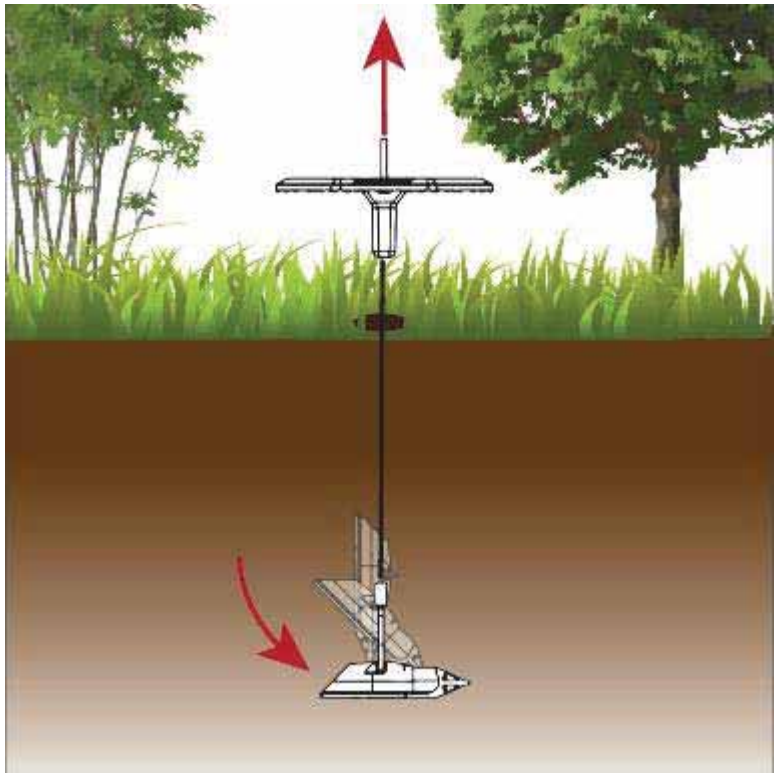
Rhino Gas Anchor Driver

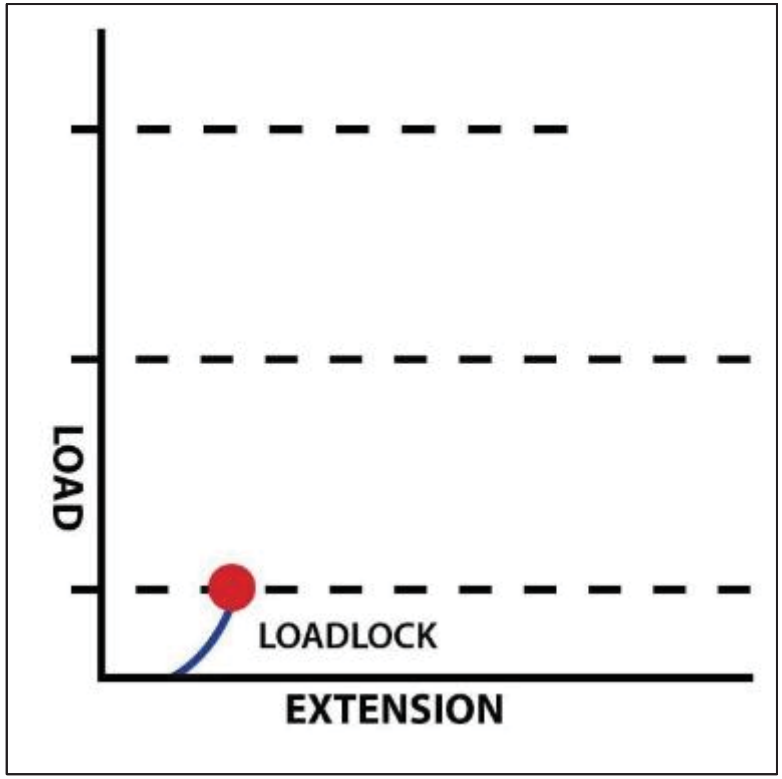
- **4 Stroke Gas Engine**
- **No generators, compressors, air hoses or extension cords required**
- **Drives anchor drive rods with ease**
- **Lightweight and portable at only 35 lbs**
- **Inclinable to operate at any angle**
- **Drive up to 1,000 anchors on 1 gallon of gas**
- **Powerful as a pneumatic driver**
- **Saves time, money, and energy**

JackJaw® Anchor Jack

- Jaw and lever mechanism makes easy work of extraction, removing drive rods from tough soil in seconds
- Load-Lock Gripple Anchor Assemblies
- Pulls straight up and extracts without bending
- Eliminates side loading and resulting strain on operator's back
- Saves labor by making it a one-person job
- Constructed entirely of heavy duty steel
- Adaptable base plate for soft soils
- Lightweight and portable

Typical Anchor Behavior





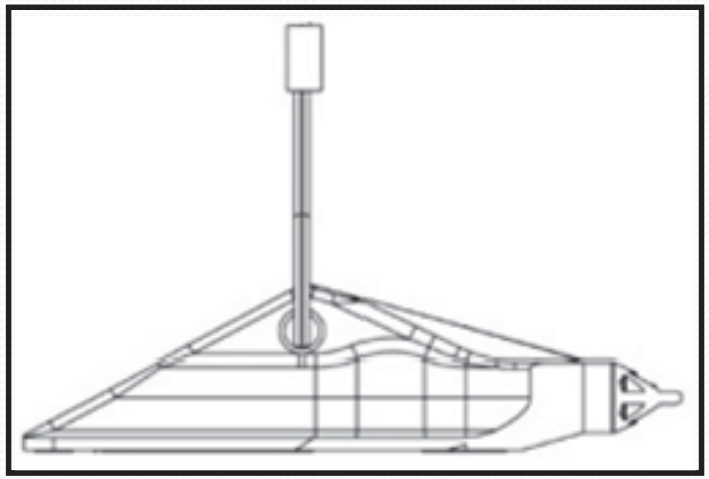
The first stage is where the load is applied to the anchor and it is resisted by the soil. As the load increases, the soil begins to fail and the capacity of the soil to resist the load increases slowly with increasing extension. The capacity of the soil takes a jump when the soil fails and the anchor pulls out.

Anchor Installation Video

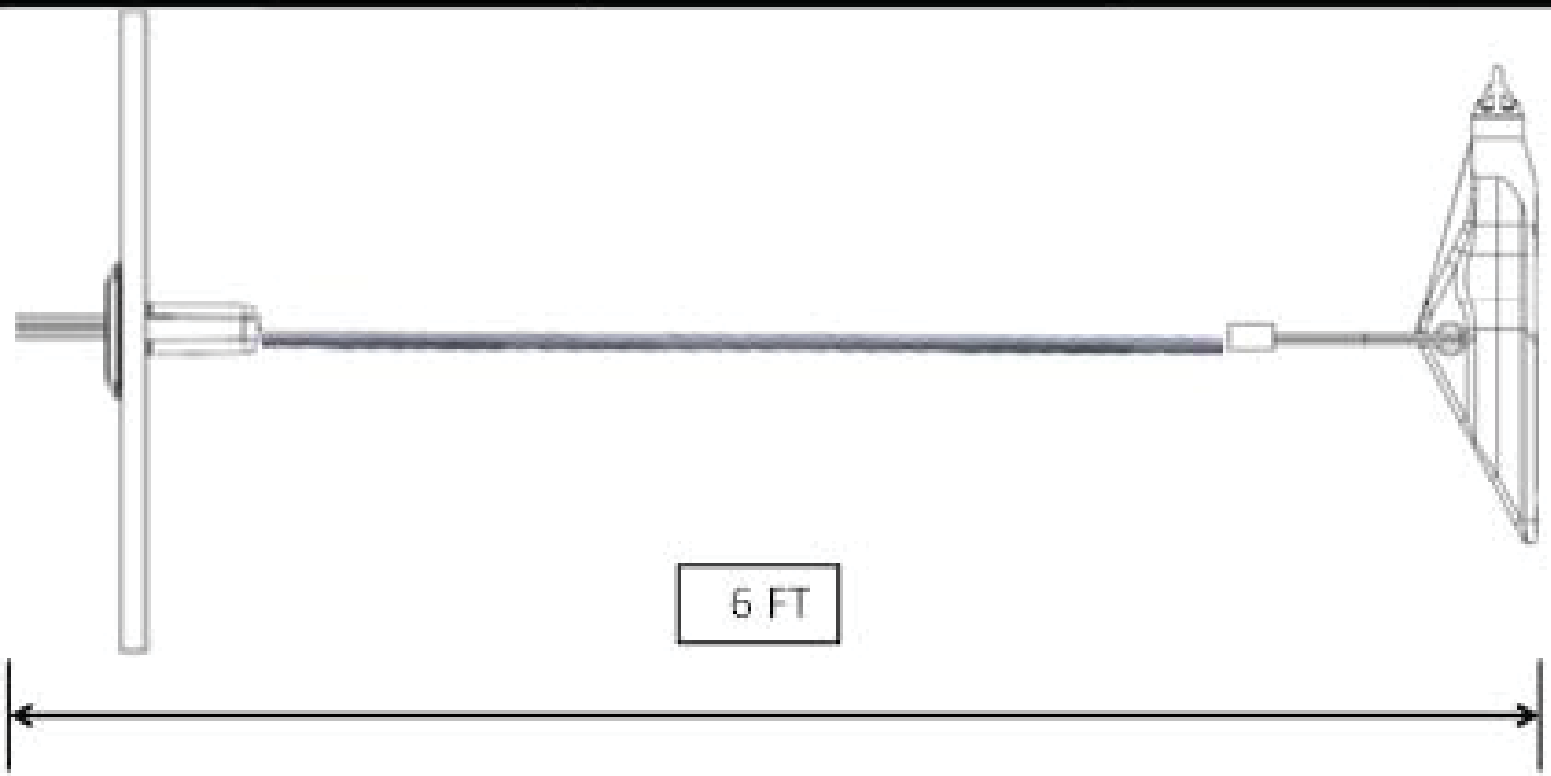
WEC400-6-XA3-6FT-4MM-Z
Anchor Physical Properties

Component	Material	Physical Properties	WEC400-6-XA3-6FT-4MM-Z Percussion Driven Earth Anchor
Anchor Head	Zinc Alloy (ZA 2) ASTM B-240-10	5.0 in. x 1.62 in. x 1.23 in. (L x W x H)	Corrosion resistant pressure die cast zinc alloy.
Lower Termination	Aluminum ferrule MS51844	Length: 15.875mm (5/8") Wall Thickness: 4.8mm(3/16")	N/A
Cable Tendon	Zinc-Aluminum Coated Carbon Steel ASTM A-1023	3mm (1/8") diameter 1x19 strand Zinc-Aluminum Wire Tendon 3FT	Corrosion resistant zinc-aluminum coated cable.
Top Accessory Bearing Plate	Zinc-Aluminum Alloy ZL2 ASTM B-240-10	Diameter: 108mm (4.25in) Thickness: 2.5mm (0.1in)	Corrosion resistant pressure die cast zinc alloy. Coated with ClearClad Anodic.
Top Termination	Zinc Alloy ZA 2 ASTM B-240-10	Diameter: 108mm (4.25in) Thickness: 2.5mm (0.1in)	Corrosion resistant pressure die cast zinc alloy. Coated with ClearClad Anodic. Utilizing a ceramic roller & directional locking device.

Performance Properties	Value	WEC400-6-XA3-6FT-4MM-Z Percussion Driven Earth Anchor
Anchor & Cable Assembly Ultimate Strength	kips	2.6 kips
Anchor Weight	Kg	182 Kg
Anchor Head Bearing Area*	in^2	6 sq in



XTREME ARMOR SYSTEM	PRODUCT CODE	DATE	12/18/2013
	WEC400-6-XA3-6FT-4MM-Z	CREATED BY	JUSTIN WILLIAMSON

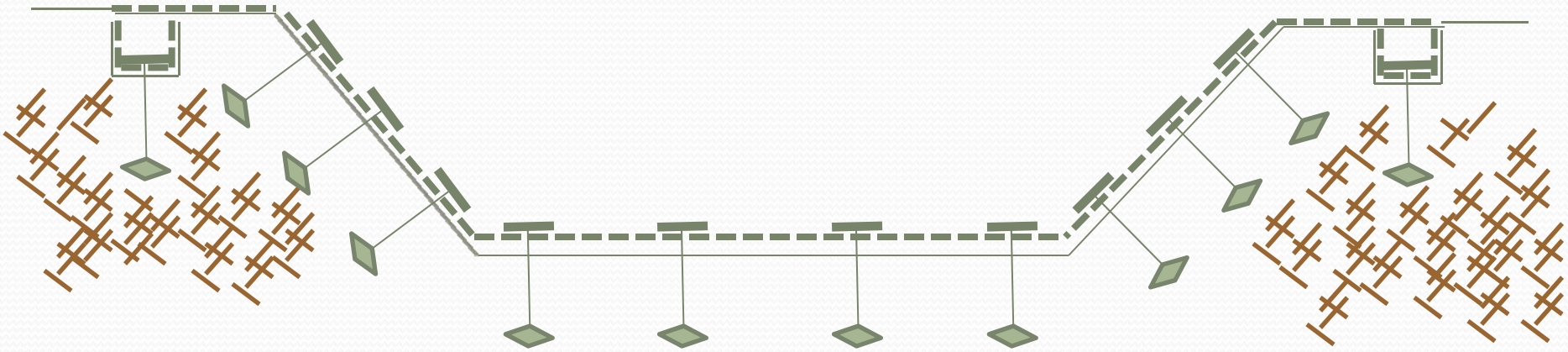


ANCHOR		TERRA-LOCK		CABLE SIZE		CABLE STRAND		SPECIFICATION REQUIREMENTS	
A2	☐	WEC100	☐	1/8" (3MM)	☐	1X19	☒	MINIMUM LOAD RATING	1,000 LBS
A3	☒	WEC300	☐	5/32"(4MM)	☒	7X7	☐	ULTIMATE LOAD RATING	2,600 LBS
A4	☐	WEC400	☒	1/4" (6MM)	☐	7X19	☐	XTREME ARMOR SYSTEM	
CABLE TYPE		ZINC ALUMINUM	☒	STAINLESS STEEL	☐				

Typical ARVS Details

"An Anchored Reinforced Vegetation System (ARVS)"

Non-Structural Channel Tie – Down Application



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Panel 1

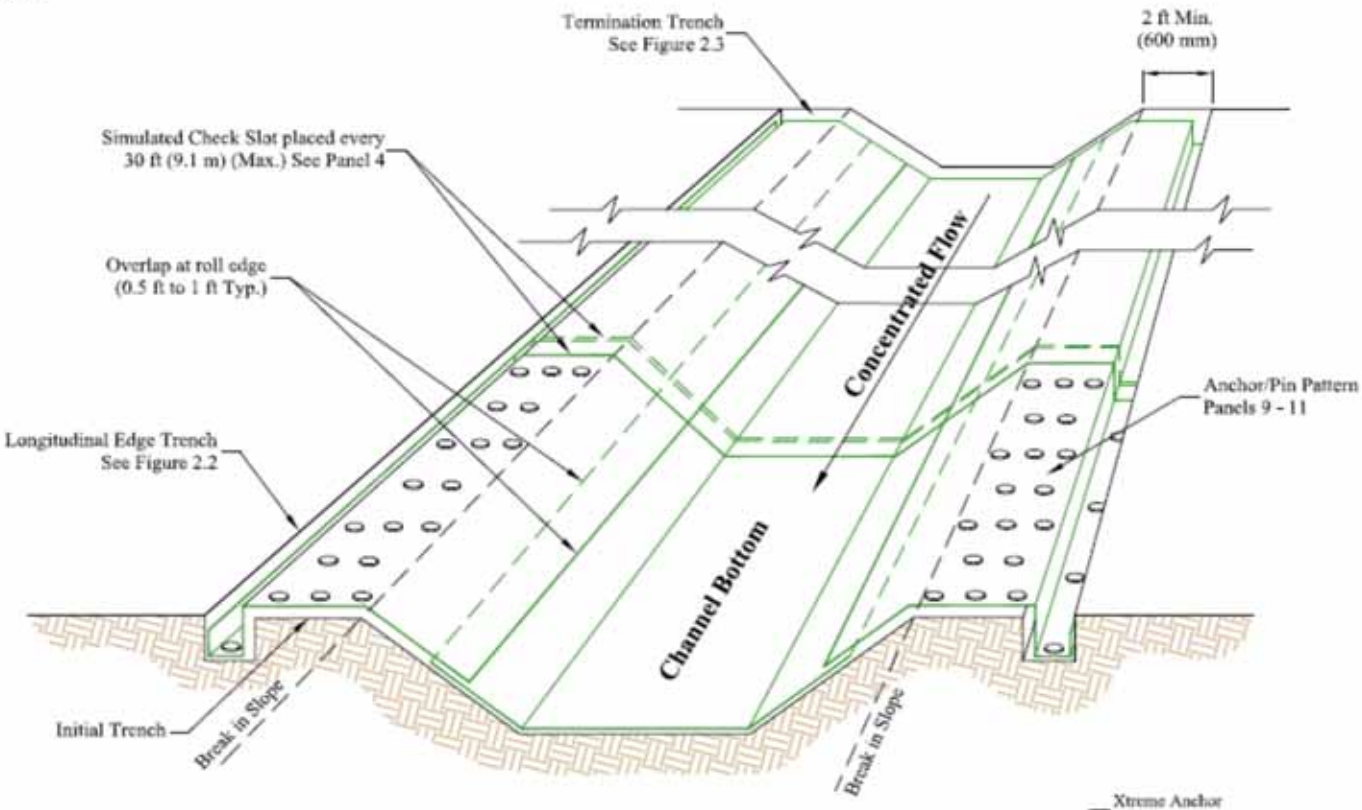


Figure 1.1: Non-Structural Channel Installation Prespective View

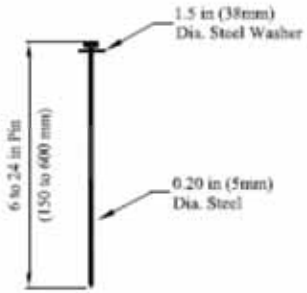


Figure 1.2: Steel Pin Fastener

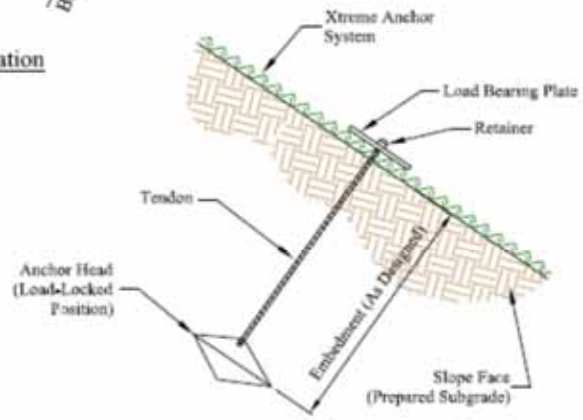


Figure 1.3: Earth Percussion Anchor Detail

Step 1 - Site Preparation

Prepare site to design profile and grade. Remove debris, rocks, clods, etc.. Ground surface should be smooth prior to installation to ensure HP-TRM remains in contact with slope.

Step 2 - Seeding

Seeding of site should be conducted to design requirements or to follow local or state seeding requirements as necessary. Seed prior to application of HP-TRM and include necessary soil amendments and fertilizer.

Step 3 - Pin Selection

At a minimum, 12 in. long steel, round pins with a1.5 in head washer are to be used to secure the HP-TRM to the ground surface. Installation in rocky, sandy or other loose soil may require alternate fasteners. Judgment should be applied by field personnel to ensure the pins provide sufficient pullout resistance and the HP-TRM is in intimate contact with the soil over the entirety of the installation.

Step 4 - Selection of Anchors

Anchor selection is determined by geotechnical conditions and consideration of exposure to the elements. Anchor type and size installed shall be in conformance with requirements supplied within the project specifications.

Step 5 - Excavate Anchor Trench and Secure HP-TRM

Excavate a trench along the top of the channel side slopes and the upstream terminal end of the channel to secure the edges of the HP-TRM. The trench should run along the length and width of the installation, be 2 ft. wide and 2 ft. deep. Anchor and pin HP-TRM along bottom of trench, fill with compacted soil, overlap HP-TRM towards toe of slope and secure with row of staples (shown in Figures 2.3 and 3.1).

Step 6 - Secure Body of HP-TRM

Roll HP-TRM down slope from anchor trench. Pin and anchor body of HP-TRM following the pattern shown in appropriate figures (specified by roll width and anchor density pattern). The appropriate anchor density pattern is determined by geotechnical conditions and is presented in the project specifications. Leave end of HP-TRM unsecured to allow for overlap shown in Figure 4.1 and 4.2. Place downstream HP-TRM underneath upstream HP-TRM to form shingle pattern. Secure seam as shown in Figure 4.1 and 4.2. Continue downstream by securing downstream HP-TRM identical to previous rolls.

Step 7 - Edge Treatments - Complete Installation

Secure downstream terminal edge as shown in Figure 2.1 and 3.1. Secure edges of installation with longitudinal anchor trench shown in Figure 2.2. Optionally, at the discretion of the engineer, the product may be seeded on top and soil filled by placing and smoothing top soil in the voids of the HP-TRM.

XTREME ARMOR SYSTEM

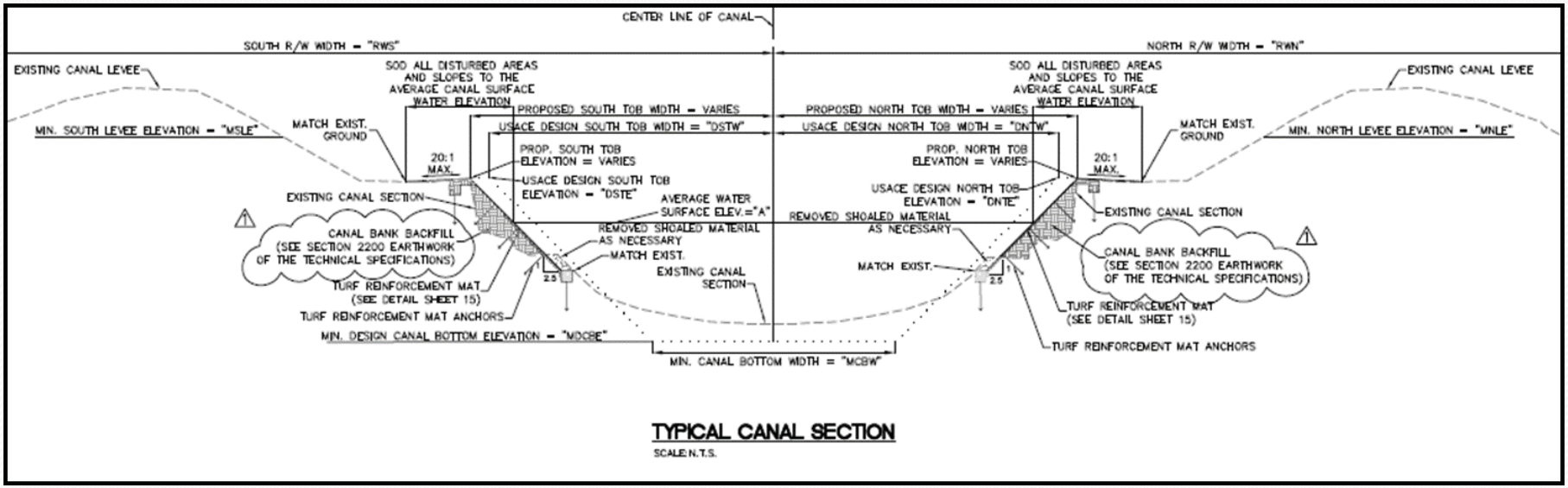
Non-Structural Channel Application
Standard Drawing, Perspective View
Provided by Western Excelsior

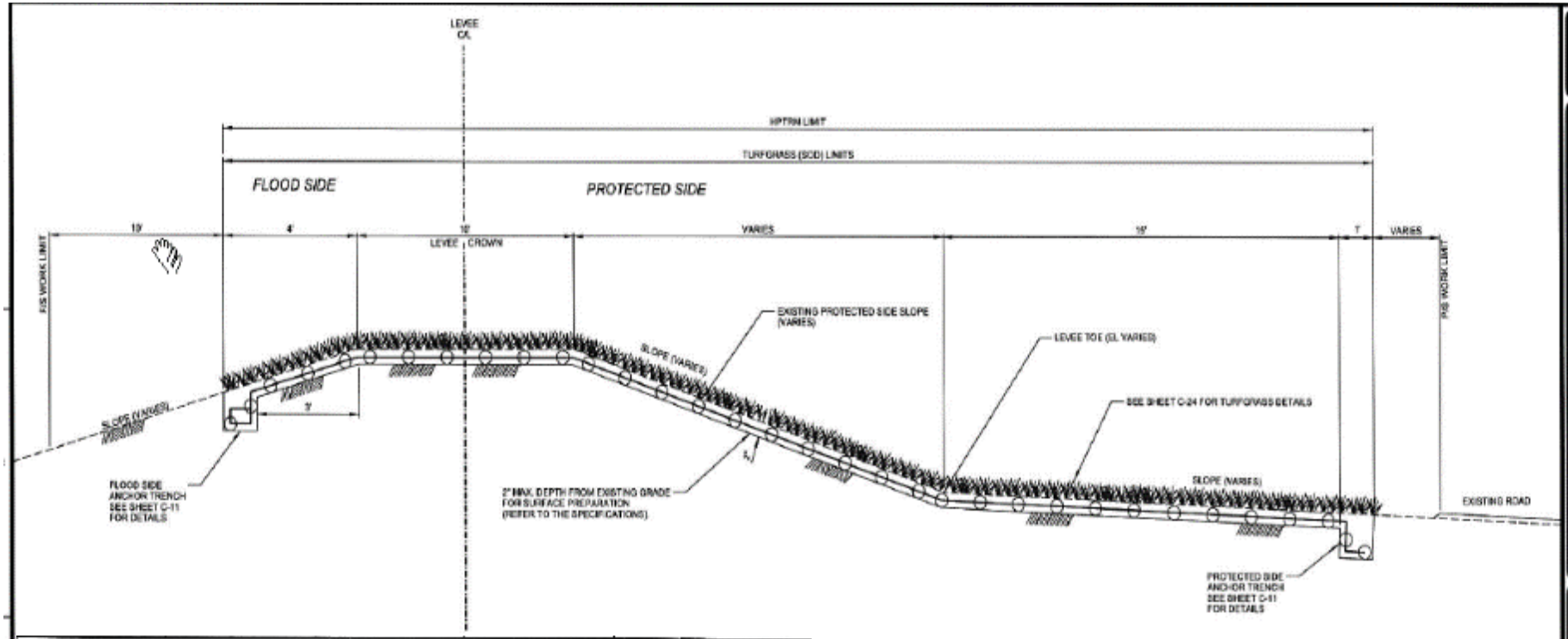
Project:

Drawing #
Page __ of __
Updated: 2/28/12

WESTERN EXCELSIOR

River / Canal Bank Stabilization Typical Detail Section





US Army Corps of Engineers
New Orleans District

HURRICANE STORM DAMAGE RISK REDUCTION SYSTEM (HSDRRS)

LAKE PONTCHARTRAIN AND VICINITY (LPV), ARM-01 LEVEE HPTRM ARMORING, REACHES 2A AND 2B,

ST. CHARLES PARISH, LA

SOLICITATION NO.: W912P8-14-R-0013
CONTRACT NO.:

SEPT. 2014

NOTES:

1) SEE "TYPICAL LEVEE HPTRM SECTION" SHEETS FOR DIMENSIONS OF ALL EXISTING LEVEE SECTIONS WITHIN INDIVIDUAL LIMITS.

2) TYPICAL LEVEE HPTRM SECTION - 1 SHALL HAVE PROTECTED SIDE HPTRM LIMITS AS SHOWN IN ON SHEET C-09.

3) PDEA ANCHORS AND PINS OMITTED FOR CLARITY. REFER TO SPECIFICATIONS FOR PLACEMENT REQUIREMENTS OF PDEAS AND PINS.

4) REFER TO SPECIFICATIONS FOR HPTRM, PDEA, PIN, AND TURFGRASS SOD REQUIREMENTS.

US Army Corps of Engineers
NEW ORLEANS DISTRICT

U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

HURRICANE STORM DAMAGE RISK REDUCTION SYSTEM (HSDRRS)
LAKE PONTCHARTRAIN AND VICINITY
ARM-01 LEVEE HPTRM ARMORING
REACHES 2A AND 2B
ST. CHARLES PARISH, LA

HPTRM THEORETICAL SECTION

SHEET IDENTIFICATION
C-08

Panel 6 - Cross Section View and Detail of Anchor Trenches

Anchor trenches are installed to prohibit flow from running unimpeded under the HP-TRM. Upstream longitudinal edges of the installation shall be secured as shown in these drawings in Panel 6.

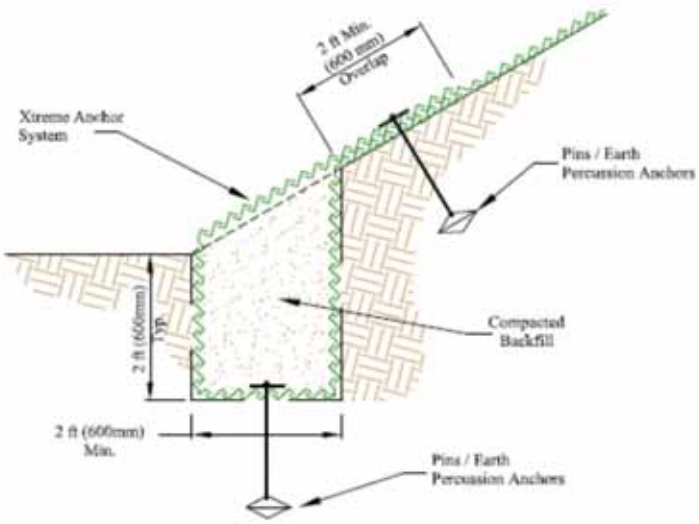


Figure 6.1: Initial Trench At Toe of Bank Detail

*Note: This detail is for applications where toe scour is not a concern.

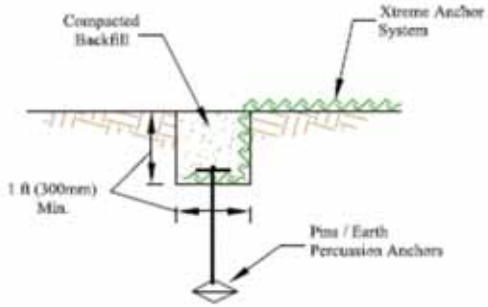


Figure 6.2: Longitudinal Edge Trench Detail

Panel 7 - Cross Section View and Detail of Special Anchor Trenches

Upstream and downstream anchor trenches shall be secured with anchors (PDEAs) and pins. Anchor type and size are provided in the project specifications. Drawings in Panel 7 provide staple and anchor frequency.

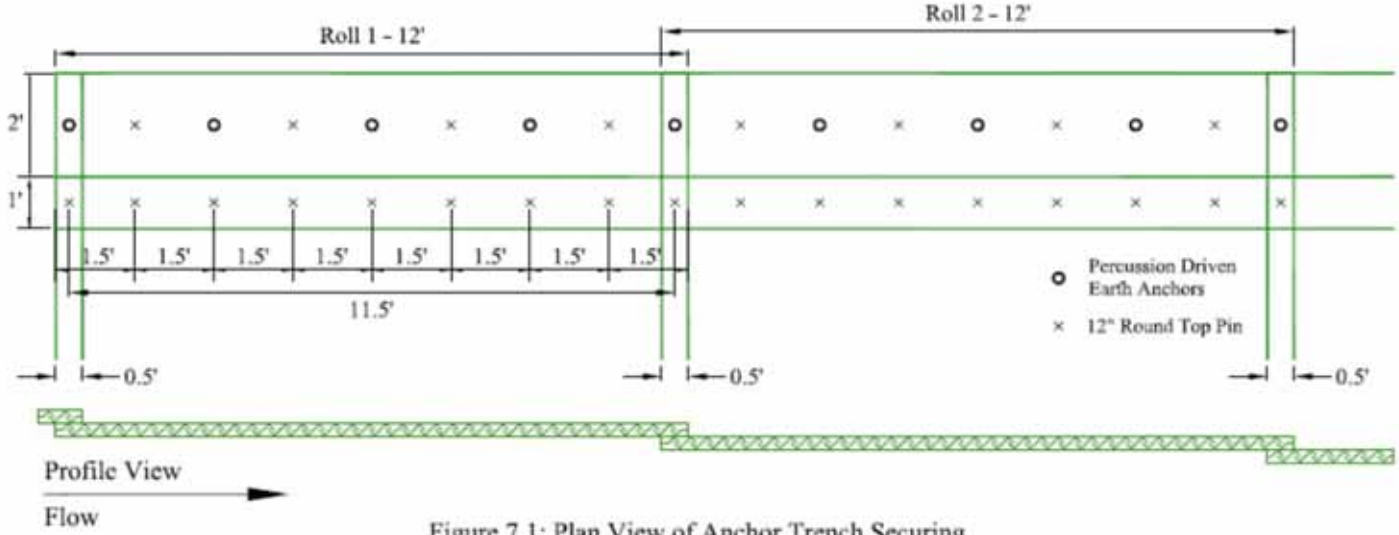
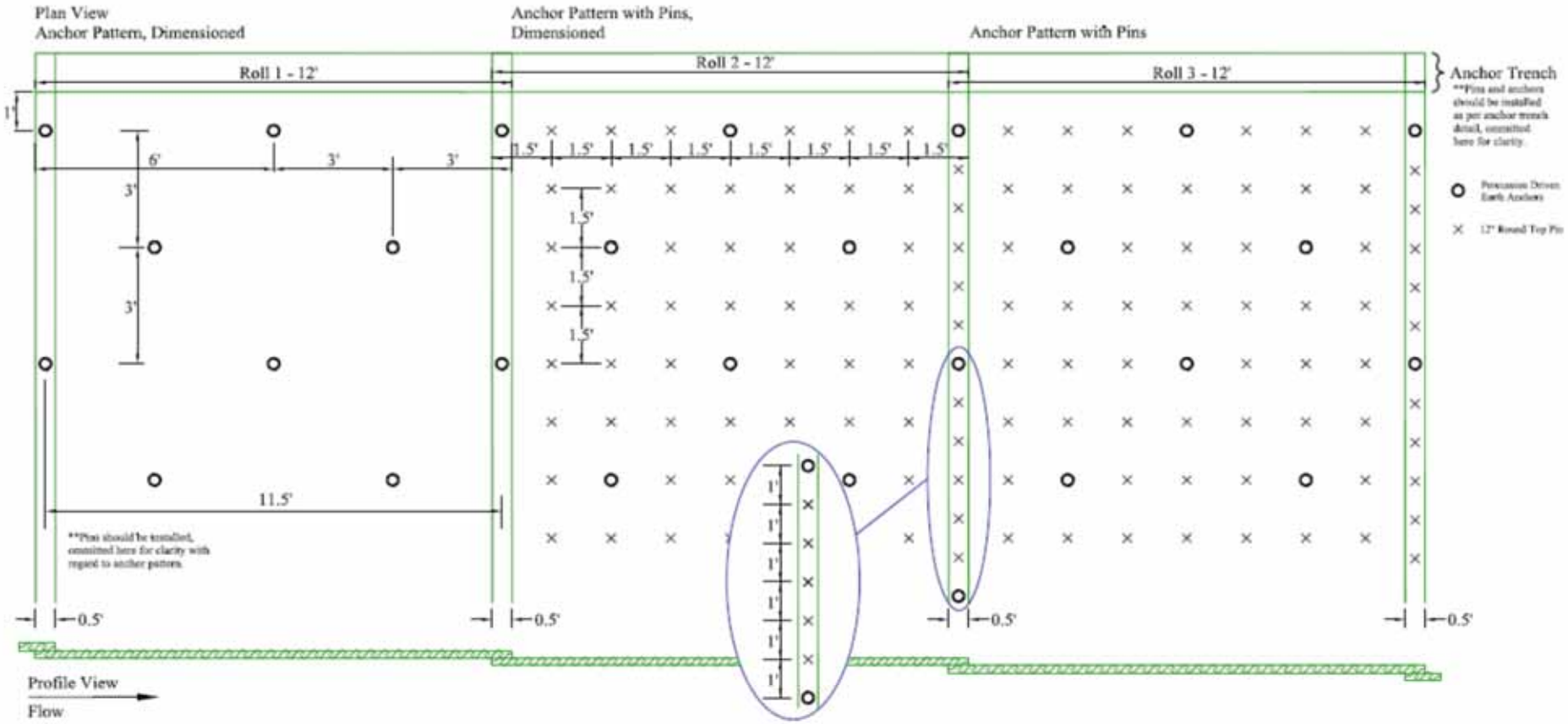


Figure 7.1: Plan View of Anchor Trench Securing

XTREME ARMOR SYSTEM	Non-Structural Channel Application Standard Drawing, Perspective View Provided by Western Excelsior	Project:	Drawing # Page __ of __ Updated: 2/28/12

Panel 9 - Xtreme Anchor System Anchor and Staple Pattern
12' Materail width, 1/2 Anchor per Square Yard Configuration



XTREME ARMOR SYSTEM	Non-Structural Channel Application Standard Drawing, Perspective View Provided by Western Excelsior	Project:	Drawing # Page __ of __ Updated: 2/28/12

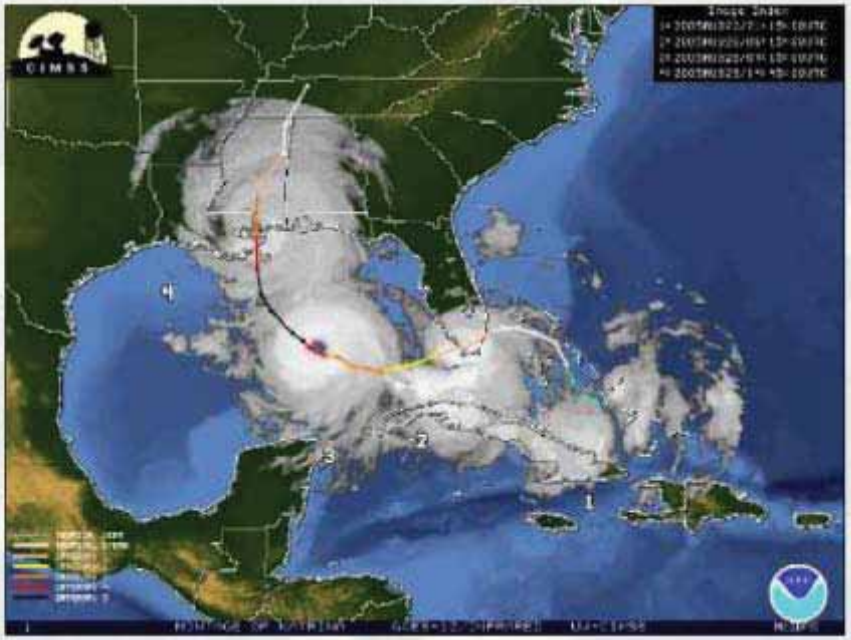
HURRICANE KATRINA

August 29,2005

Demonstrated the Vulnerability of our Nation's Levee System

Hurricane Katrina

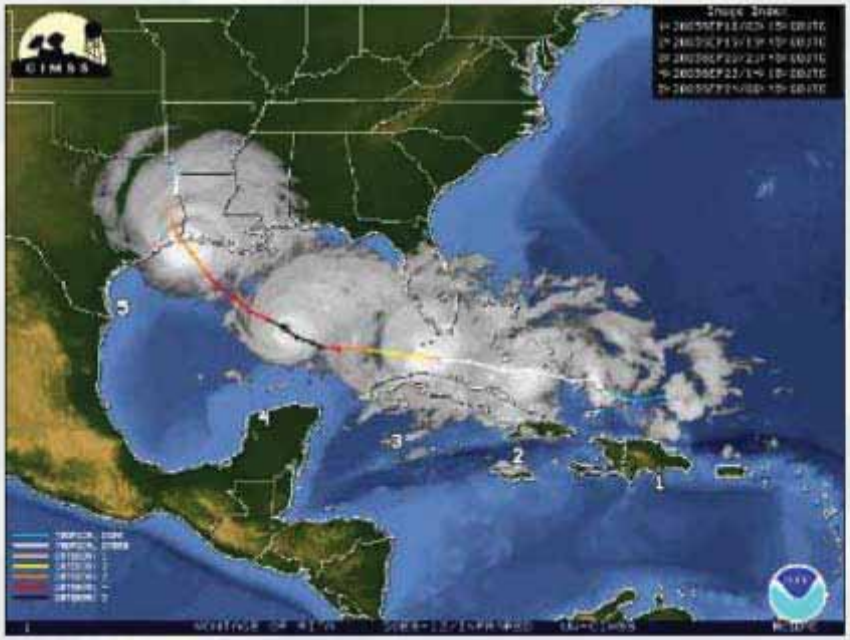
Aug 29, 2005



- One of America's largest natural disasters
- Cat 5 less than 12 hrs before landfall
- 127 MPH wind at Louisiana landfall
- Maximum surge of 28 to 30 feet along Mississippi coast
- 80 percent of the city of New Orleans flooded

Hurricane Rita

Sep 24, 2005



- Cat 4 less than 12 hrs before landfall
- 175 MPH max sustained winds in Gulf of Mexico
- 120 MPH max sustained winds at landfall
- Cat 3 strength at landfall

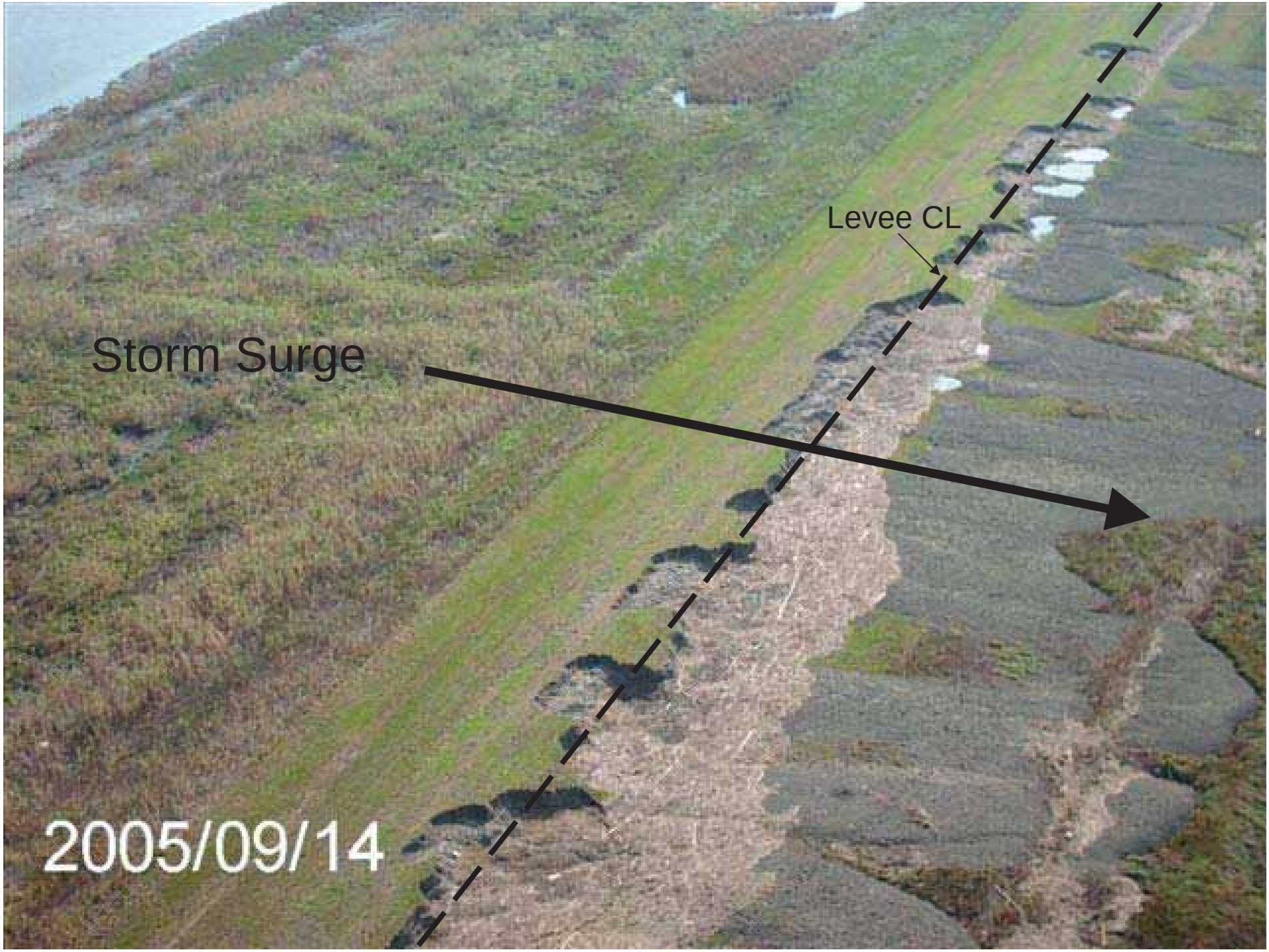
Mississippi River Gulf Outlet Levee
2.5ft Over Top of Levee
Katrina – August 2005

Wave Overtopping Effects

Effects of Hurricane Katrina

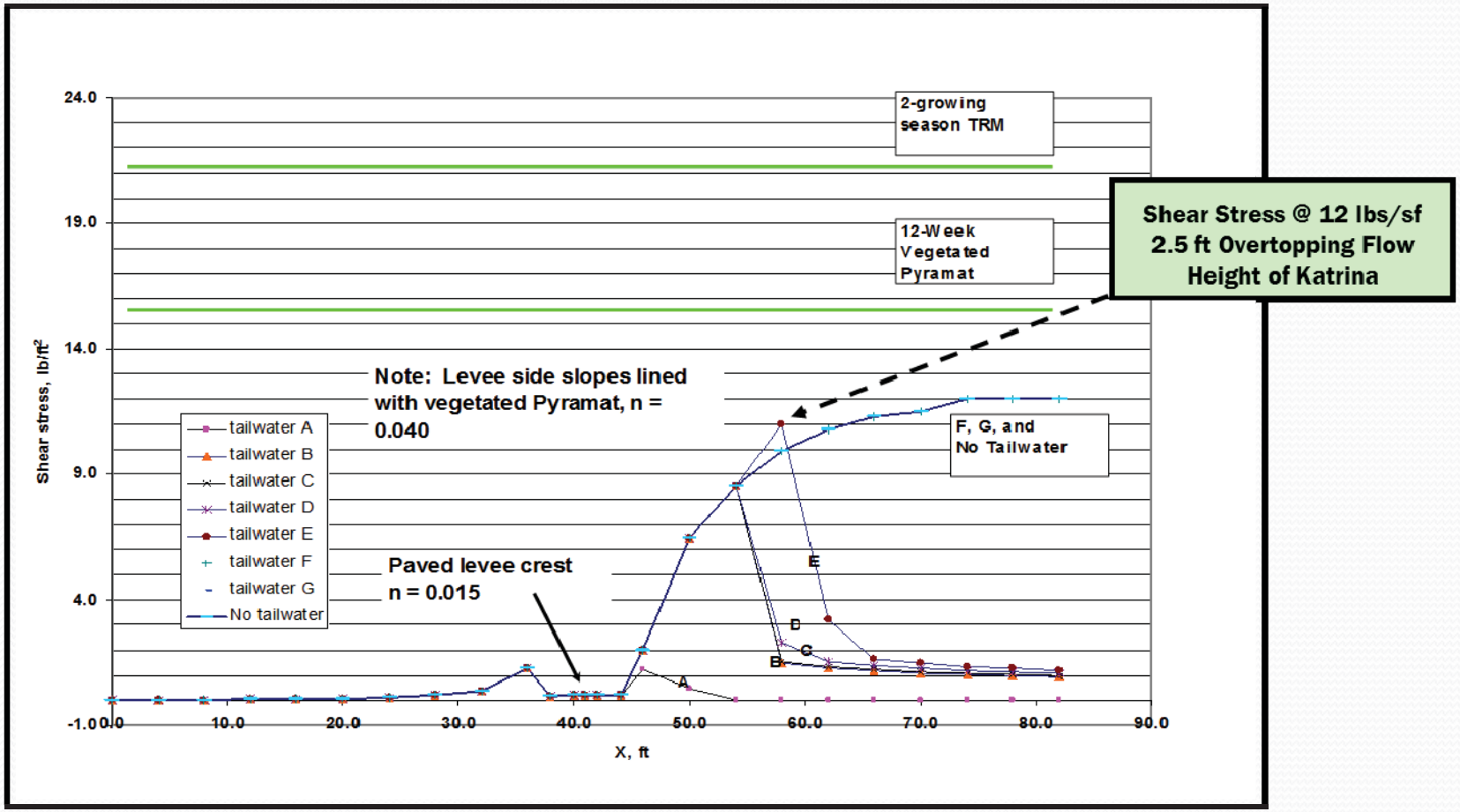
Transition Erosion

Levee Erosion


Levee CL
Storm Surge
2005/09/14

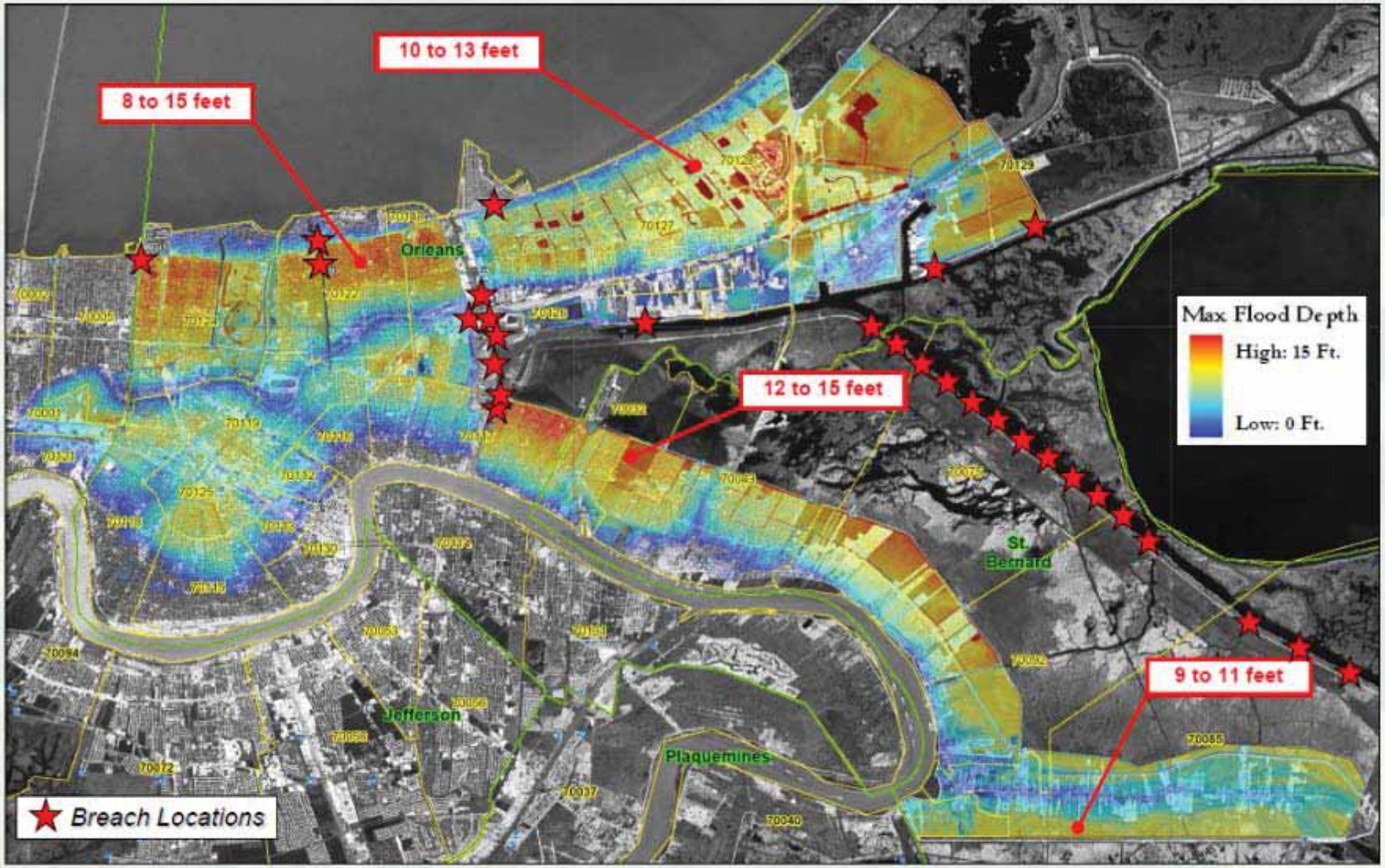
ARVS Testing

ARVS CSU Testing Vs Modeled MRGO Levee Overtopping Condition



New Orleans

Levee and Floodwall Breaches



IPET Findings / Lessons Learned

Findings

- **The majority of the 50 levee and floodwall breaches resulted from overtopping and subsequent breaching from scour or scour induced instability.**
- For levee breaches, the degree of erosion and breaching was directly related to the character of the in place levee materials
- **No levee breaches occurred without overtopping**.

Lessons Learned

- Design criteria should routinely provide **resilience** of the structure to re[illegible] vulnerability to breaching.
- While levee resilience is di[illegible] quality of levee materials and [illegible] emplacement, armoring can augm[illegible] existing levee materials to provide additional **resilience**.
- Design methodologies for structures that are a single line of defense for life and safety need to systematically and conceptually consider:
  1. Adaptability for changing hazards (e.g., subsidence, wetland loss)
  2. Adaptability for future use/needs
  3. Redundancy
  4. **Resiliency**
- Losses for a storm that exceeds design criteria can be expected to be significant, but dramatically less if the HSDRRS is resilient to levee and floodwall breaching.

Armoring can augment existing levee materials to provide additional (RESILIENCE)

Authority:
4th Supplemental - P.L. 109-234

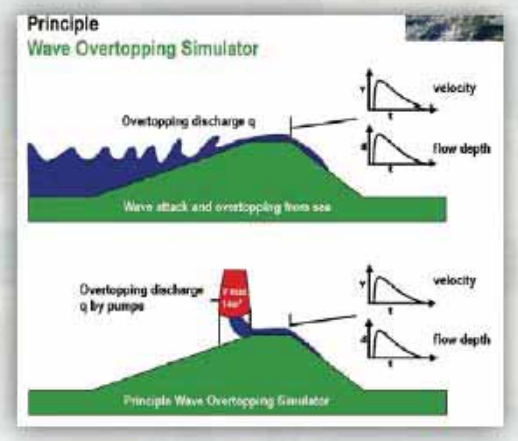
"…shall be used for armoring critical elements of the New Orleans hurricane and storm damage reduction system"

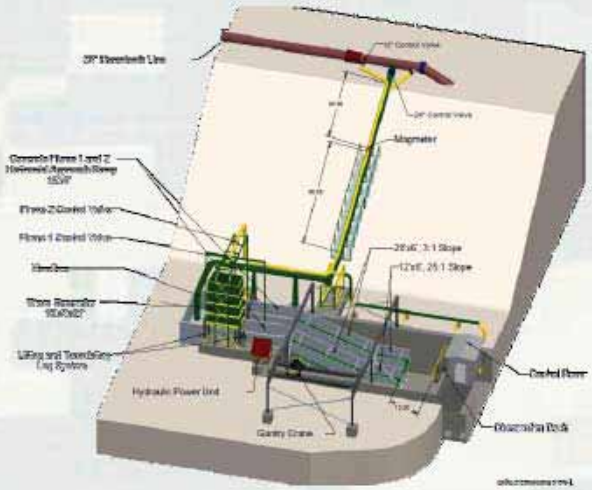
<u>Key point:</u> Authority for Armoring is unique to the HSDRRS. No USACE design standards existed to inform Armoring application.

Armoring R&D Program

Wave Overtopping Simulation

- Commissioned Colorado State University to erect a full scale wave overtopping simulator
  - Apparatus applied Dutch mobile wave overtopping simulator design to a full scale levee section
  - Designed to test erosion resistance of alternative Armoring materials for 500-yr HSDRRS overtopping conditions





USACE Wave Overtopping Testing at Colorado State

Full-Scale Wave Overtopping Testing of Western Excelsior PP5-Xtreme™ High-Strength Turf Reinforcement Mat

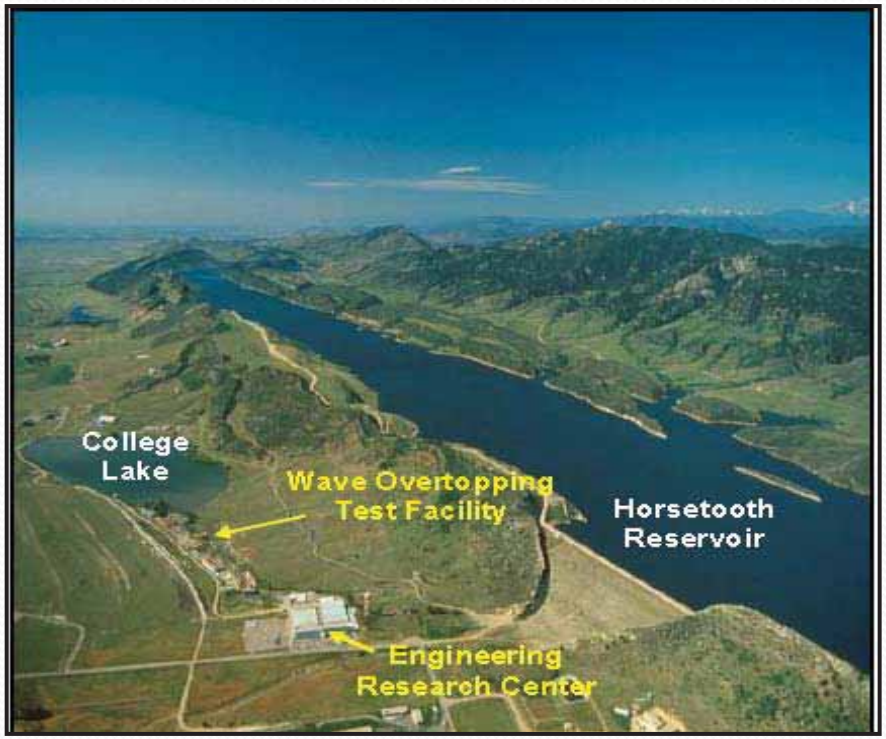


Figure 2.3. Location of Wave Overtopping Test Facility.

Test Simulates Wave Heights From 6 inch to 8 foot (Peak Spectral Wave period of 9.0 seconds)

Three Identical Test Sequences Equivalent to One Hour (Avg. Overtopping Discharge of 4.0 cfs/ft

Armoring R&D Program

Bermuda Grass Performance Observations

Fall 2010 Testing

- **Green Bermuda (unreinforced/reinforced)** – survived 4.0 cfs/ft for 3 simulated storm hours

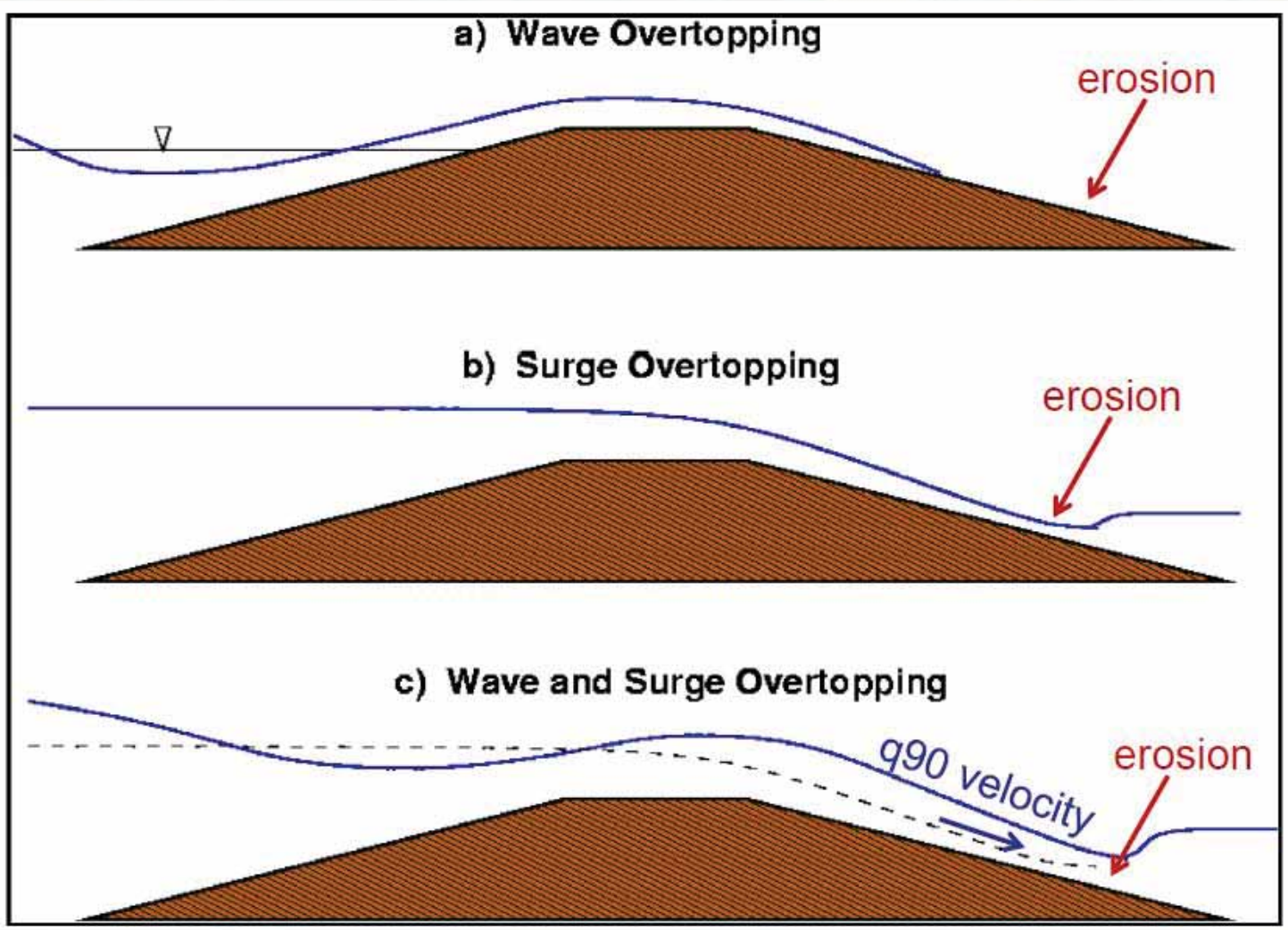
Spring 2011 Testing

- **Dormant Bermuda reinforced w/ HPTRM** – survived 4.0 cfs/ft for 3 simulated storm hours
- **Dormant Bermuda (unreinforced/reinforced w/TRM)** – failed at 2.0 cfs/ft

Overtopping rates were progressively raised to assess erosion resistance capabilities of tested materials

****Maximum capacity of the wave overtopping simulator = 4 cfs/ft***

Overtopping Erosion



Principle of Wave Overtopping Simulation

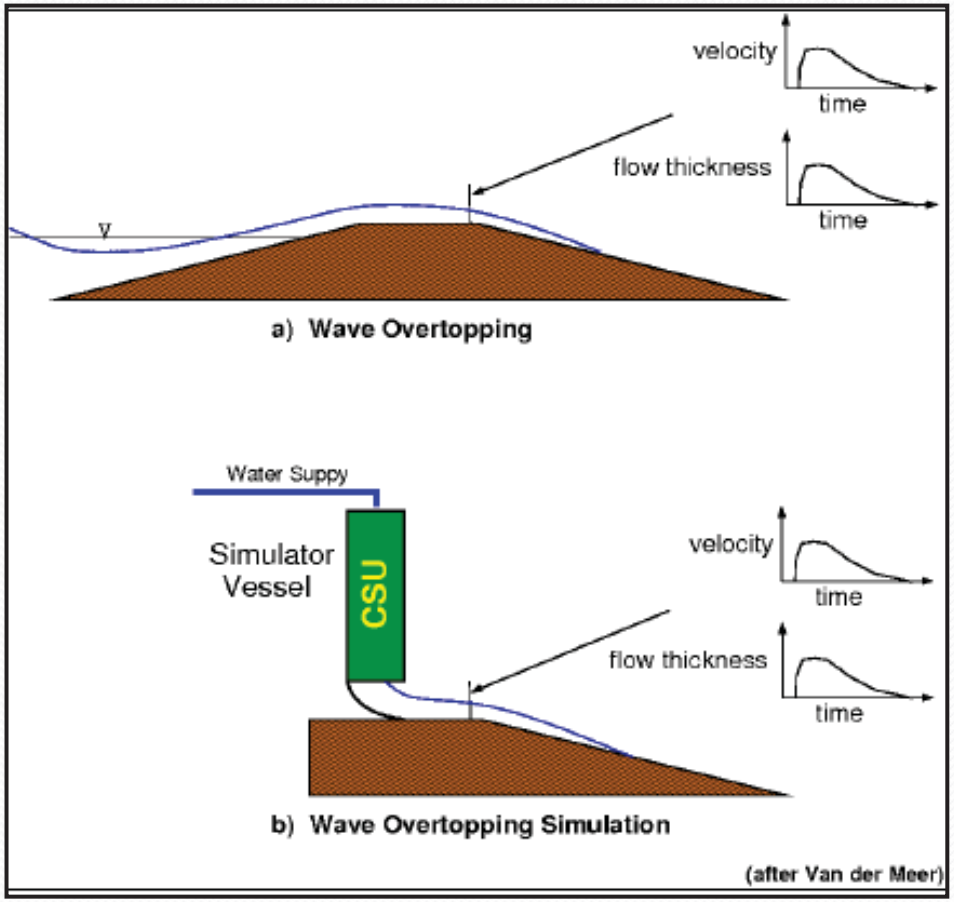


Table 3.1. Summary of Wave Overtopping Testing.

Run #	Equivalent Duration (hr)	Cumulative Duration (hr)	Average Discharge (cfs/ft)	Overtopping Volume per hour (ft³/ft)	Cumulative Overtopping Volume (ft³/ft)
1	1	1	4.0	14,400	14,400
2	1	2	4.0	14,400	28,800
3	1	3	4.0	14,400	43,200

Measurements Describe – Distribution of Overtopping Wave Volumes
(In Terms of Incident Wave Parameters, Levee Freeboard & Levee Geometry)
Each Overtopping Wave – Characterized by Flow Velocity, Flow Thickness at the leading Edge,
And by the Duration of Overtopping Flow.

Simulated Levee Slope Geometry

8ft length oriented on the 1 on 3 slope & 12ft oriented on the 1 on 25 slope

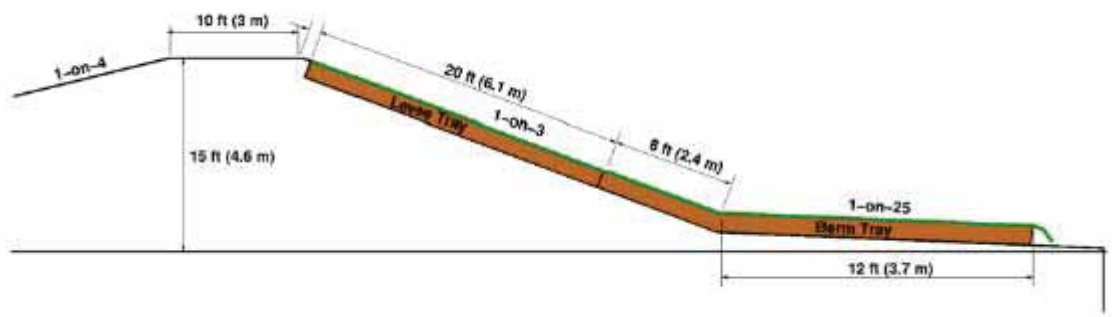


Figure 2.0 Dimensions and orientation of test trays.

Installation of Trays into the Wave Overtopping Simulator

Figure 3.2. Planter tray installation into the Wave Overtopping Test Facility.

Grass Growth & Wave Overtopping Testing at CSU

USACE Wave Overtop Testing

- The Corps plans to achieve 100-year level risk reduction for the Hurricane and Storm Damage Risk Reduction System (HSDRRS) by June 1, 2011. Armoring of levees will add an additional level of risk reduction known as "resiliency."
  - Armoring is one of the major components of resiliency," said Reuben Mabry, a Corps Armoring Team leader and a Senior Program Manager with Task Force Hope. "Resiliency is the ability for a structure to withstand forces greater than it was designed for; in the case of the HSDRRS, that could mean up to a 500-year event

USACE Wave Overtop Testing Time Lapse Photos

Colorado State University (CSU) designed, fabricated, calibrated, and successfully operates a unique Wave Overtopping Test Facility capable of simulating full-scale wave overtopping having maximum average overtopping discharges up to 4.0 ft^3/s per ft (4.0 cfs/ft) and higher depending on the incident wave conditions. The Facility simulates intermittent wave overtopping by controlled periodic releases of specified volumes of water held in a large vertical container.

Down & Upstream Tray Views Pre-Testing

Pre-Test

The Western Excelsior PP5-Xtreme™ HPTRM test tray set was installed in the flume and prepared for testing on 2 May 2014. Figures 4.3 – 4.6 contain photographs showing the installed trays.

Figure 4.3. Upstream end of installed PP5-Xtreme™ HPTRM tray prior to testing.

State University – Engineering Research Center Western Excelsior PP5-Xtreme

Figures 4.3 and 4.4 show the entire slope looking from upstream and downstream ends, respectively.

Figure 4.4. Downstream end of installed PP5-Xtreme™ HPTRM trays prior to testing.

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View of Trays HPTRM after 1 Equivalent Hour

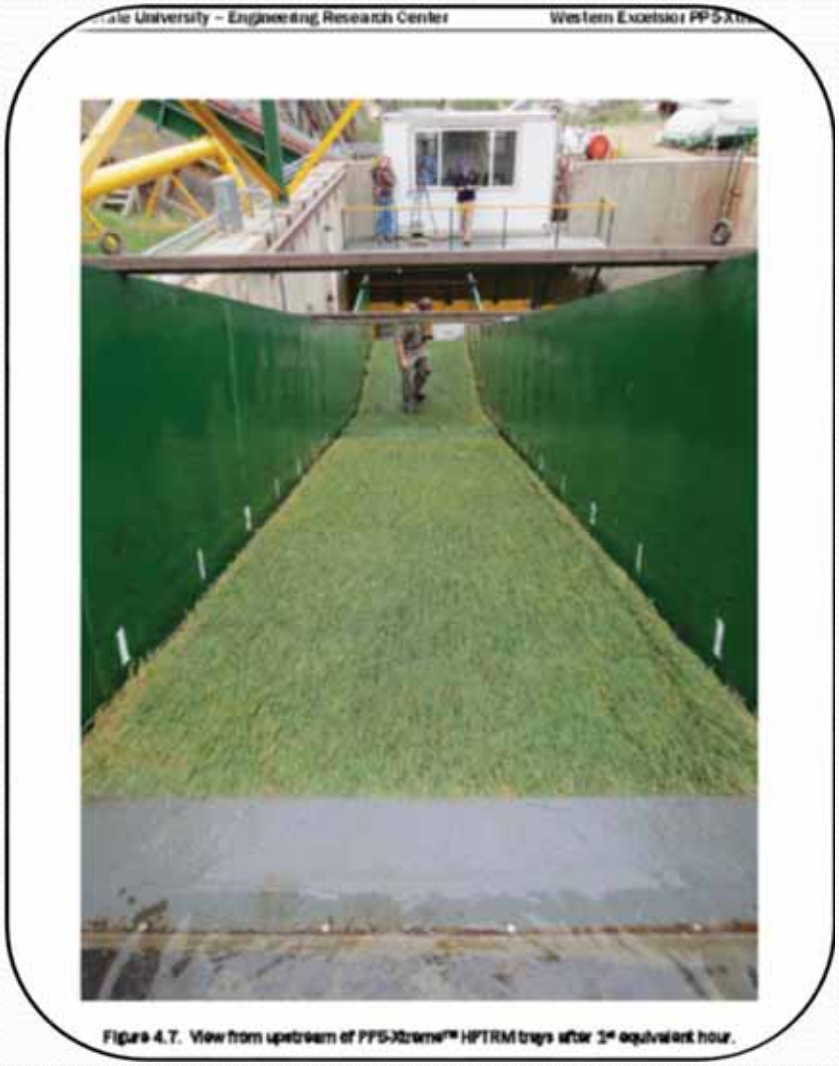

Figure 4.7. View from upstream of PP5-Xtreme™ HPTRM trays after 1st equivalent hour.

Figure 4.8. View from downstream of PP5-Xtreme™ HPTRM trays after 1st equivalent hr.

View of Trays HPTRM after 2 Equivalent Hour

Figure 4.14. Entire HPTRM slope looking downstream after 2nd equivalent test hour.

Figure 4.15. Entire HPTRM slope looking upstream after 2nd equivalent test hour.

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View of Trays HPTRM after 3 Equivalent Hour

Figure 4.21. Entire HPTRM slope looking downstream after 3rd equivalent test hour.

Figure 4.22. Entire HPTRM slope looking upstream after 3rd equivalent test hour.

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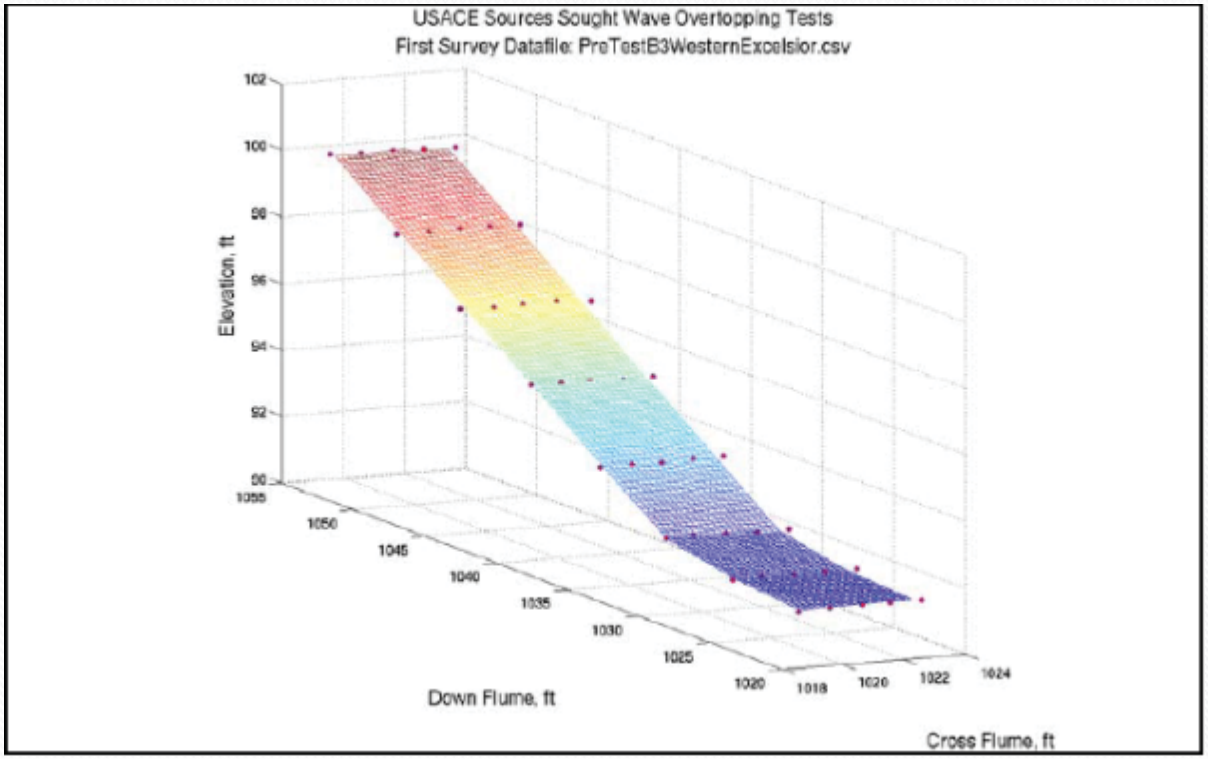
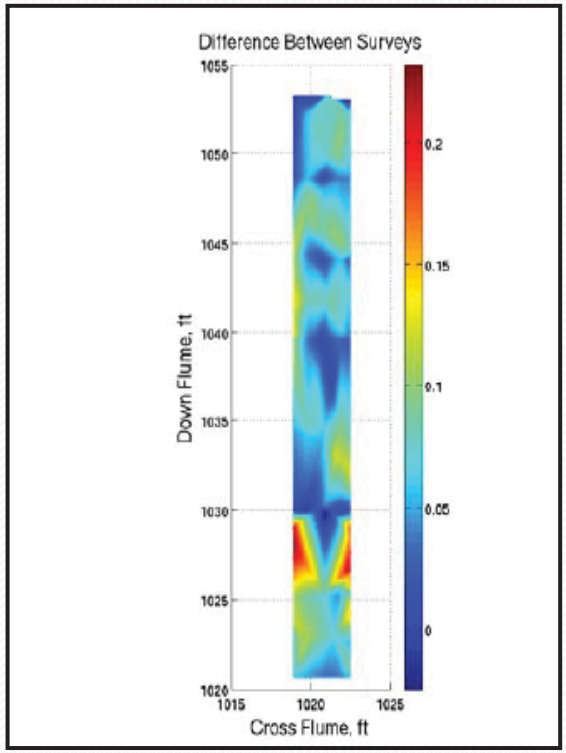
Soil Loss Estimated From Topographic Survey Data





Pre-Test Survey Points Fitted to Grid

Results

General Erosion was less than 1 Inch & less the 2 Inches at the Slope Transition

Anchor Reinforced Vegetation System Judged to be Very Good for the Xtreme Hydraulic Loading Conditions

The ARVS Armor System continued to function as effective slope protection & approved for use

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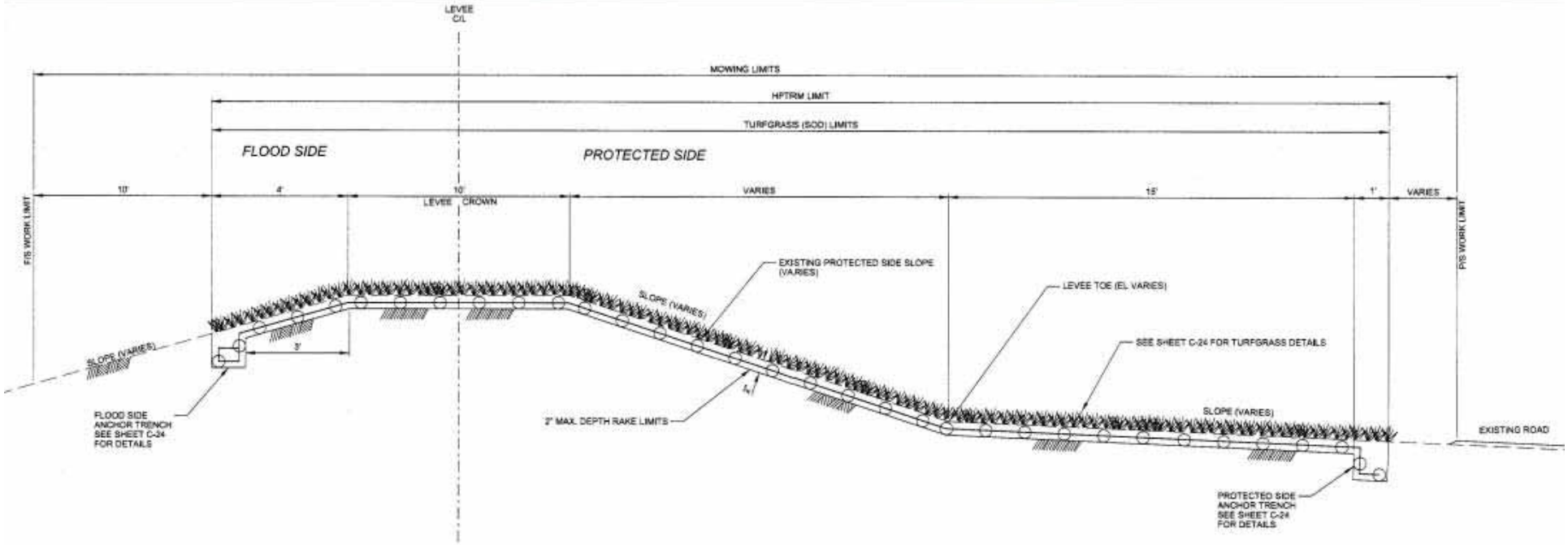
HPTRM Typical Design Section



EXISTING LEVEE GRADE
MAX 2" RAKE PROPOSED SURFACE
HPTRM
TURFGRASS (SOD) PLACEMENT

ARVS Armor System Benefits

1. System is Flexible with respect to Subsidence
2. Minor Erosion Areas can be Identified & simply Patched avoiding Catastrophic Failure
3. Does not Surcharge the Levee
4. Reduces Potential of Subsidence

NOTES:

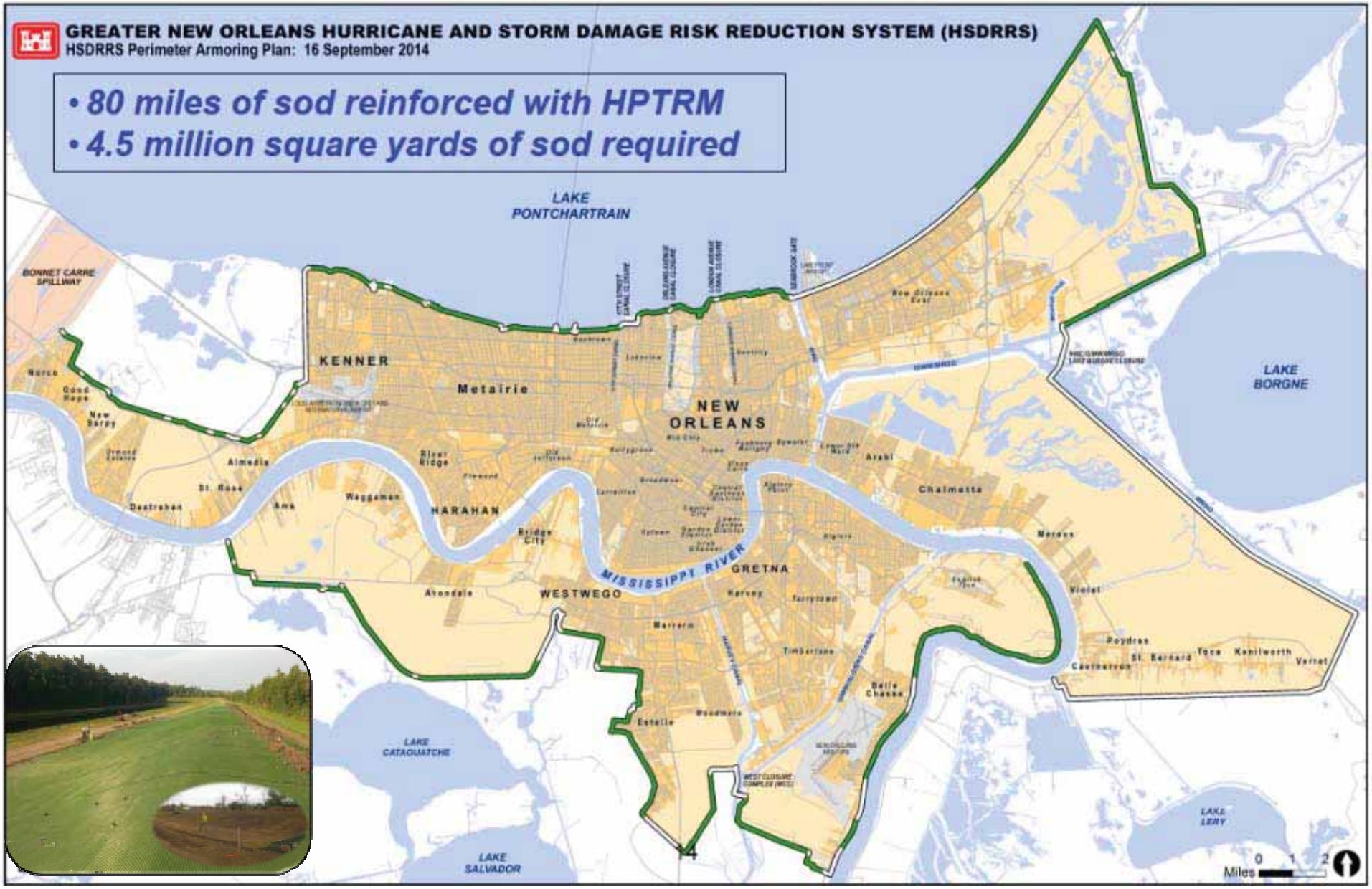
1). SEE "TYPICAL LEVEE HPTRM SECTION" SHEETS FOR DIMENSIONS OF ALL EXISTING LEVEE SECTIONS WITHIN REACH 1A, 1B, 2A, AND 2B.

2). TYPICAL LEVEE HPTRM SECTION - 1 SHALL HAVE PROTECTED SIDE HPTRM LIMITS AS SHOWN IN ON SHEET C-19.

3). REFER TO THE TYPICAL NEW ACCESS ROAD - DETAIL ON SHEET C-27 FOR THE P/S WORK LIMIT ALONG NEW ACCESS ROADS.

HPTRM THEORETICAL SECTION
N.T.S.

Armoring Plan



USACE Army Corp. of Engineers New Orleans District
WBV-14f.2a Louisiana Highway 45 Levee, Armoring Pilot, Jefferson Parish, LA

WBV-14f.2a Louisiana Highway 45 Levee, Armoring Pilot, Jefferson Parish, LA
ARVS HPTRM Installation

ARVS Armor System
Rolls are Flat to the slope for Intimate Contact
Seams are straight and not corrugated

ARVS Armor System (HPTRM)
Finished Installation – Ready for Seeding

Sod Laid On Pilot Levee Section

Finished Vegetated Levee Section

US Army Corp. of Engineers
WPV-ARM-01, W9112P8-15-D-002
HSDRRS, Westbank & Vicinity System Armoring
Plaquemines Parish, LA
(45,000 Square Yards)

ARVS Armor System Installation
$100 Million Pump Station

Finished ARVS Armor System Installation
Levee Ready for Sod

US Army Corp. of Engineers
LPV HSDRRS Leve Armoring
Lake Pontchartrian & Vicinity System Armoring
Plaquemines Parish, LA
(300,000 Square Yards)

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ARVS Armor System Installation

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Finished ARVS Armor System Installation
Levee Ready for Sod

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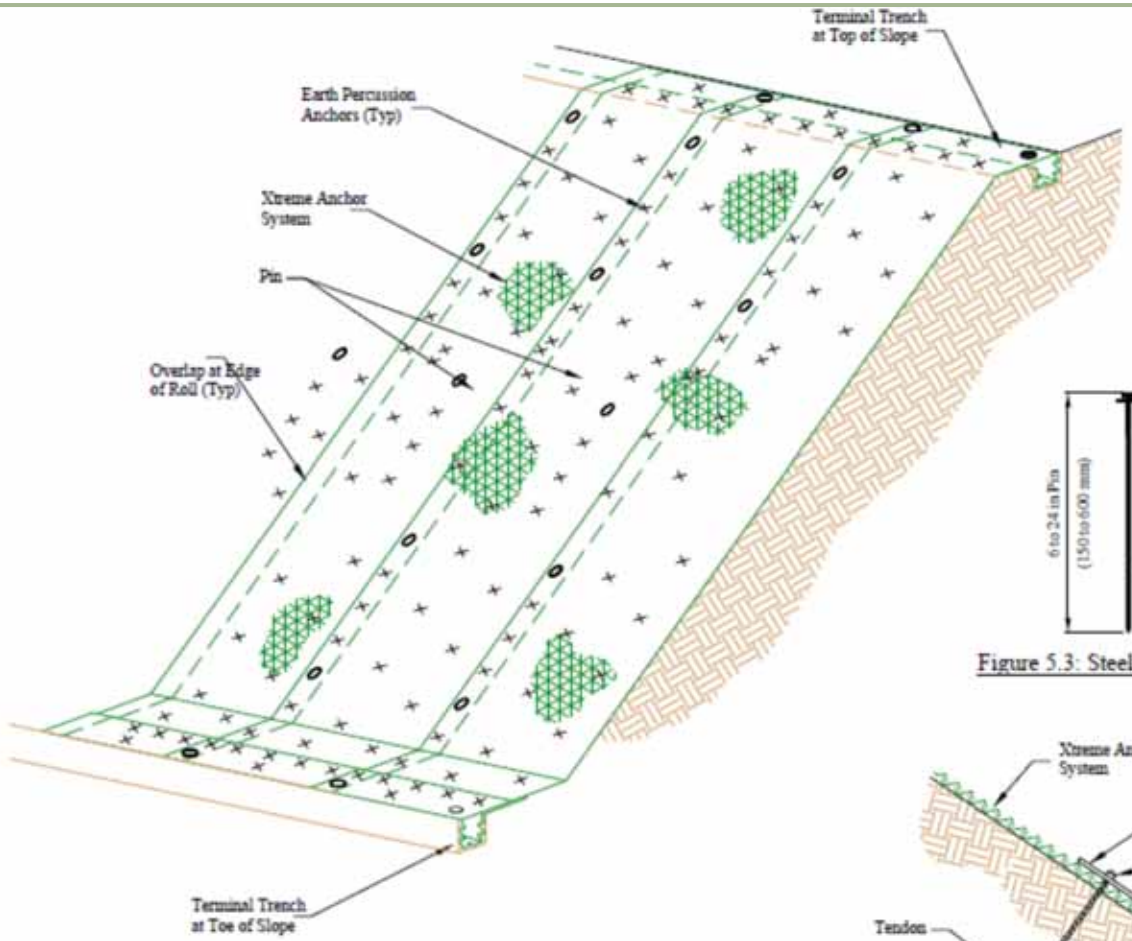
Finished ARVS Armor System Installation
Levee Ready for Sod

Finished ARVS Armor System Installation

Finished ARVS Armor System Installation

Structural Application – Shallow Plane Failures



PERSPECTIVE

Figure 5.1: Overview of Xtreme Armor System On A Slope

* Note: For Clarity, Perspective View Does Not Show All Pins And Anchors.

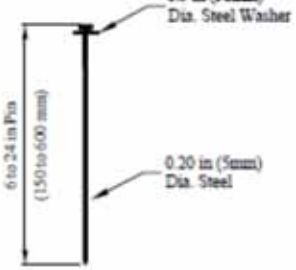


Figure 5.3: Steel Pin Fastener

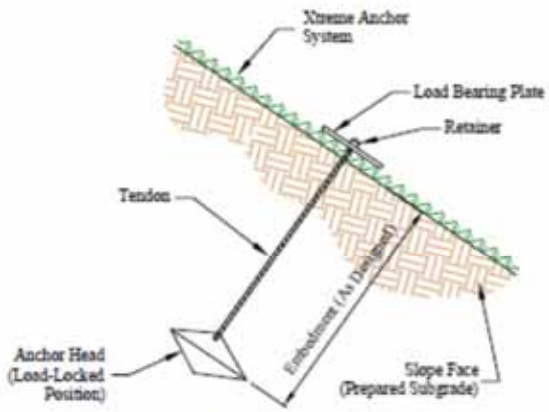


Figure 5.2: Earth Percussion Anchor Detail

Step 1 - Site Preparation

Prepare site to design profile and grade. Remove debris, rocks, clods, etc.. Ground surface should be smooth prior to installation to ensure HP-TRM remains in contact with slope.

Step 2 - Seeding

Seeding of site should be conducted to design requirements or to follow local or state seeding requirements as necessary. Seed prior to application of HP-TRM and include necessary soil amendments and fertilizer.

Step 3 - Pin Selection

At a minimum, 12 in. long steel, round pins with a1.5 in head washer are to be used to secure the HP-TRM to the ground surface. Installation in rocky, sandy or other loose soil may require alternate fasteners. Judgment should be applied by field personnel to ensure the pins provide sufficient pullout resistance and the HP-TRM is in intimate contact with the soil over the entirety of the installation.

Step 4 - Selection of Anchors

Anchor selection is determined by geotechnical conditions and consideration of exposure to the elements. Anchor type and size installed shall be in conformance with requirements supplied within the project specifications.

Step 5 - Excavate Anchor Trench and Secure HP-TRM

Excavate a trench along the top of the channel side slopes and the upstream terminal end of the channel to secure the edges of the HP-TRM. The trench should run along the length and width of the installation, be 2 ft. wide and 2 ft. deep. Anchor and pin HP-TRM along bottom of trench, fill with compacted soil, overlap HP-TRM towards toe of slope and secure with row of staples (shown in Figures 11.3 and 12.1).

Step 6 - Secure Body of HP-TRM

Roll HP-TRM down slope from anchor trench. Pin and anchor body of HP-TRM following the pattern shown in appropriate figures (specified by roll width and anchor density pattern). The appropriate anchor density pattern is determined by geotechnical conditions and is presented in the project specifications. Leave end of HP-TRM unsecured to allow for overlap shown in Figure 13.1 and 13.2. Place downstream HP-TRM underneath upstream HP-TRM to form shingle pattern. Secure seam as shown in Figure 13.1 and 13.2. Continue downstream by securing downstream HP-TRM identical to previous rolls.

Step 7 - Edge Treatments - Complete Installation

Secure downstream terminal edge as shown in Figure 11.3 and 12.1. Secure edges of installation with longitudinal anchor trench shown in Figure 11.2. Optionally, at the discretion of the engineer, the product may be seeded on top and soil filled by placing and smoothing top soil in the voids of the HP-TRM, in addition to seeding under the matting.

XTREME ARMOR SYSTEM

Non-Structural Channel Application
Standard Drawing, Perspective View
Provided by Western Excelsior

Project:

Drawing #
Page __ of __
Updated: 3/19/12

EXCELSIOR

New York Southold Dike Repair Project
Hurricane Sandy – USACE & NRCS

MATERIALS

- System shall be the ArmorMax System as manufactured by Propex (800-621-1273) or approved equal.
- All components of the stabilization system shall be furnished by a single manufacturer as a complete system.
- High Performance Turf Reinforcement Mat – (HPTRM)
- HPTRM shall be a lofty three dimensional woven polypropylene geosynthetic specially designed for erosion control applications on levees, slopes, canal/river bank stabilization and channels. Matrix shall be composed of monofilament yarns woven into uniform configuration of resilient pyramid-like projections. HPTRM should exhibit very high interlock and reinforcement capacity with both soil and root systems. It should also demonstrate the combination of high tensile strength, flexibility and UV resistance. Turf Reinforcement Mats manufactured from composite or discontinuous materials, loosely held together by stitched or glued netting, or composites of any type, shall not be allowed with this system.
- Should the contractor substitute this item, he shall submit a site specific slope stability analysis that verifies that it is in fact equivalent. The stability analysis shall include the following:
  - Overall Design Methodology
  - Input Parameters
  - Calculations / Model Output
  - Anchor Strength, Length and Spacing
  - Factor of Safety to support the slope reinforcement design based off a minimum of two conditions analyzed:
    - Drained Condition
    - Undrained Condition

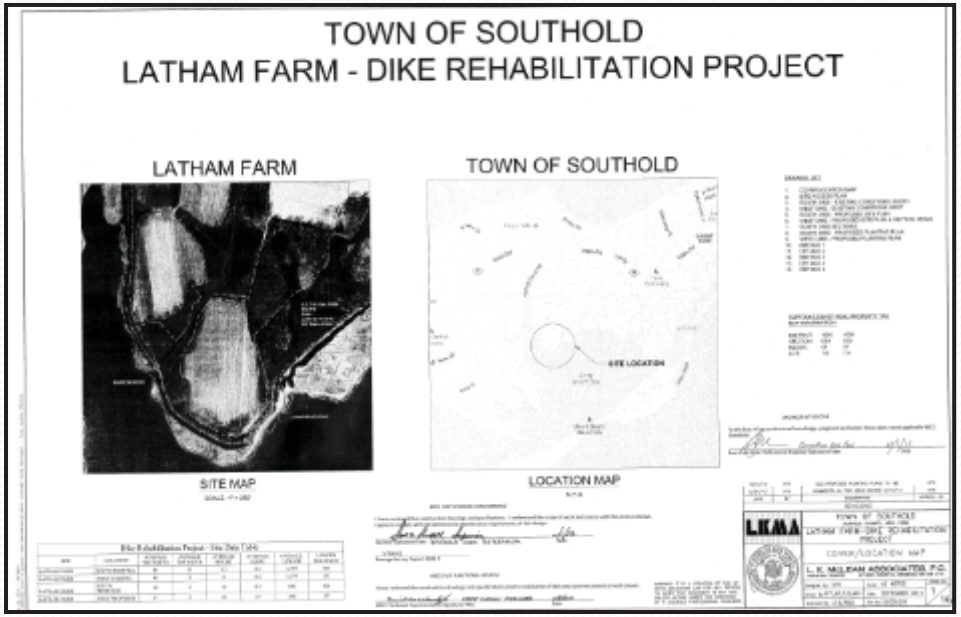
The HPTRM shall meet the following requirements:

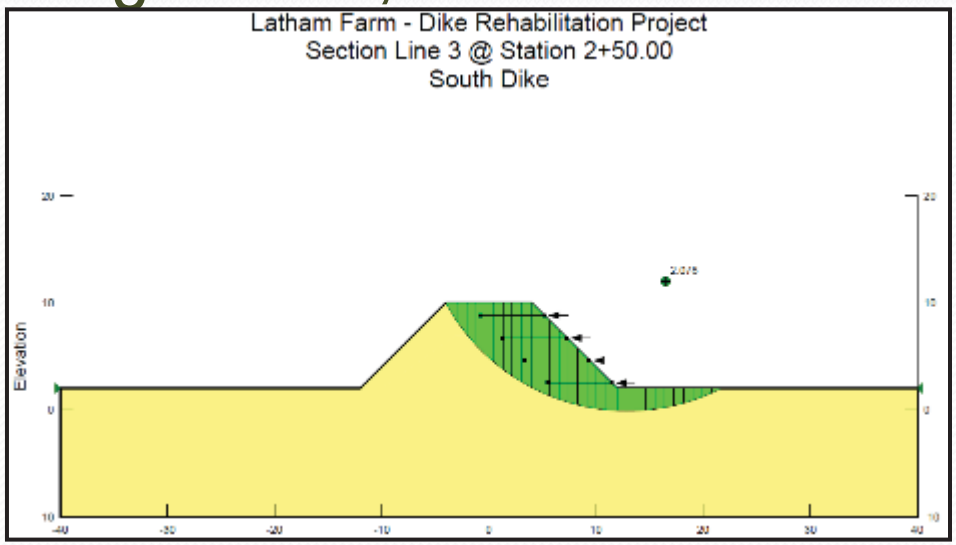
Property	Test Method	Units	Property Requirement1
Thickness	ASTM D-6525	in mm	0.4 10.2
Resiliency	ASTM D-6524	percent	80
Flexibility	ASTM D-6575	in-lb(avg) mg-cm (avg)	0.534 615000
Mass Per Unit Area	ASTM D-6566	oz/yd2 g/m2	13.5 455
Tensile Strength	ASTM D-6818	lbs/ft kn/m	4,000 x 3,000 58.4 x 43.8
Tensile Elongation	ASTM D-4595	percent	25
Light Penetration (% Passing)	ASTM D-6567	percent	15% Max
UV Resistance	ASTM D-4355	percent	90% @ 6,000 hrs

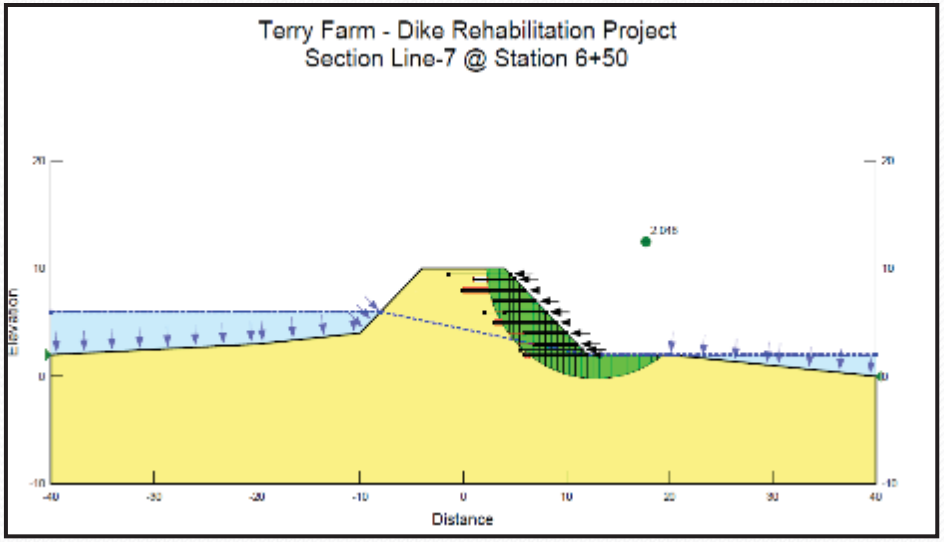
These materials shall conform to the following Minimum Average Roll Values (MARV) for physical properties, as derived from quality control testing performed by a Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP) accredited laboratory.

Manufacturing Quality Control

Hurricane Sandy Southold Dike Repair Project
USACE Project – Long Island, NY

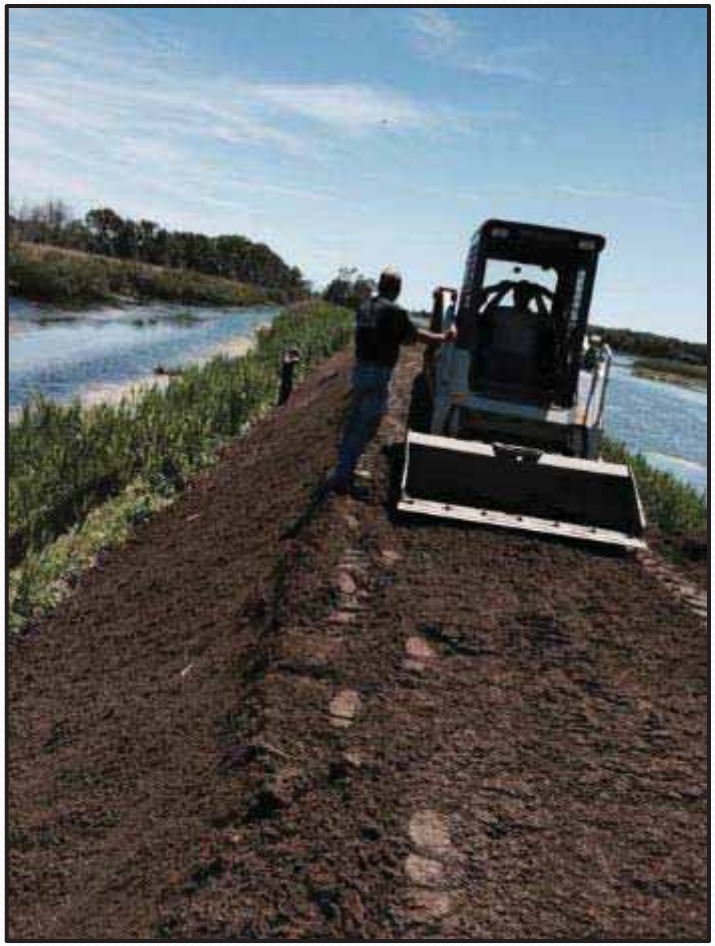






Project Totals 10,000 Square Yards
Slope Stability Analysis Required
Using Large Anchors – 6ft Depth

Hurricane Sandy Southold Dike Repair Project
USACE Project – Long Island, NY



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Large Anchor Installation Video

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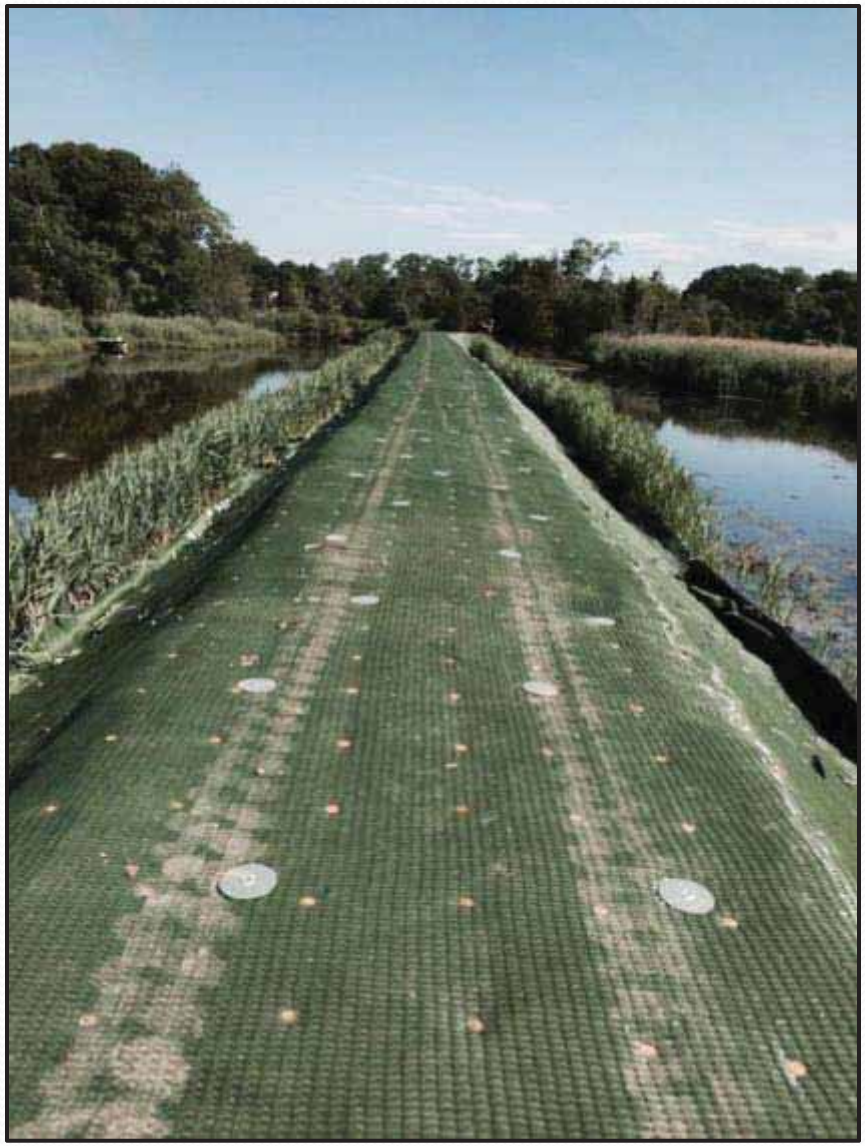
Installation of Xtreme Armor System



Finished Installation Xtreme Armor System Hydro-Seeded

Western Area Power Administration
Fort Randall-Sioux City 230kV Transmission Line
Sioux River Bank Stabilization Near Structure 103/4
Sioux City, Iowa

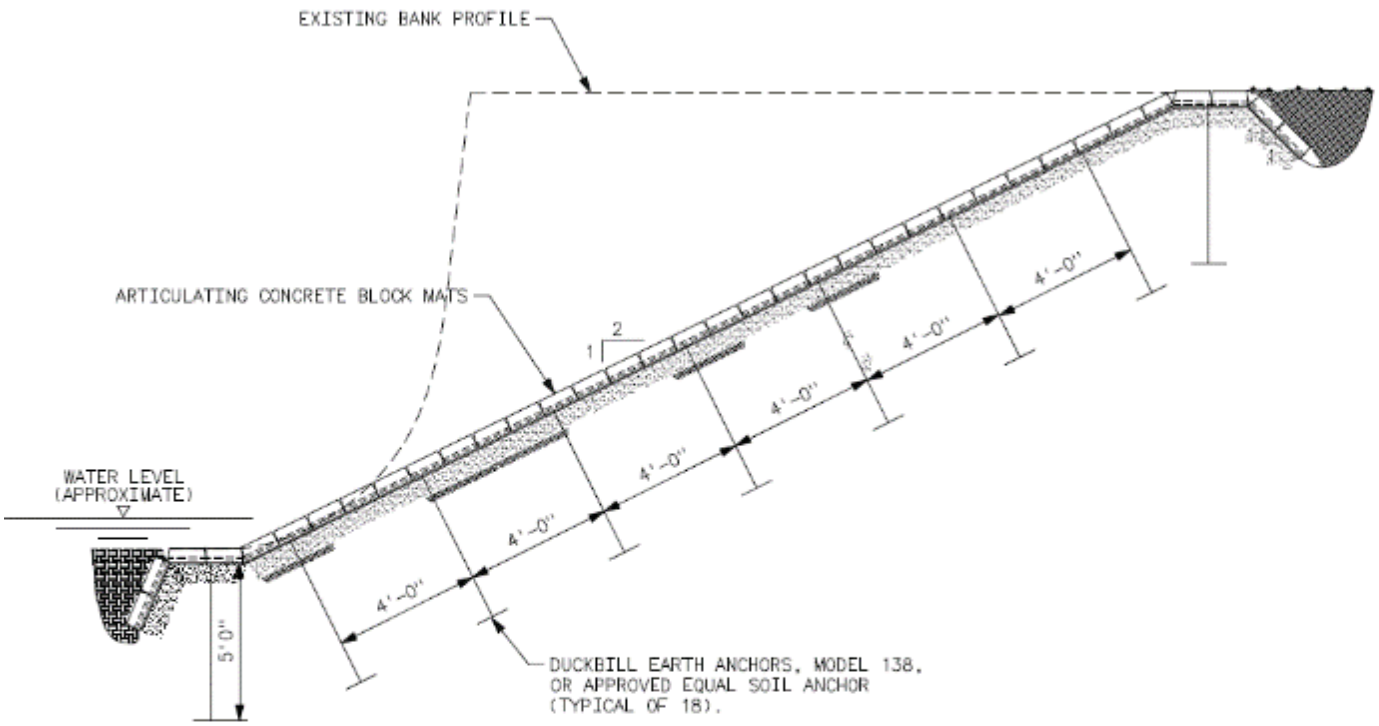
ARVS Armor System

Combination High Performance Turf Reinforcement Mat & Percussion Driven Earth Anchors

Typical Cross-Section Details – Conceptual Only

SOUTH DAKOTA
RIGHT-OF-WAY
FLOW
OUX RIVER
FR-SC 230KV
JUTE EROSION CONTROL MATTING (SEE NOTE 2)
62.5'
TRANSMISSION LINE CENTERLINE
CENTER OF STRUCTURE 103/4
103-4
26.0'
JUTE EROSION CONTROL MATTING (SEE NOTE 2)

Originally Designed Articulate Concrete Block



BANK CROSS-SECTION DETAIL
NOT TO SCALE

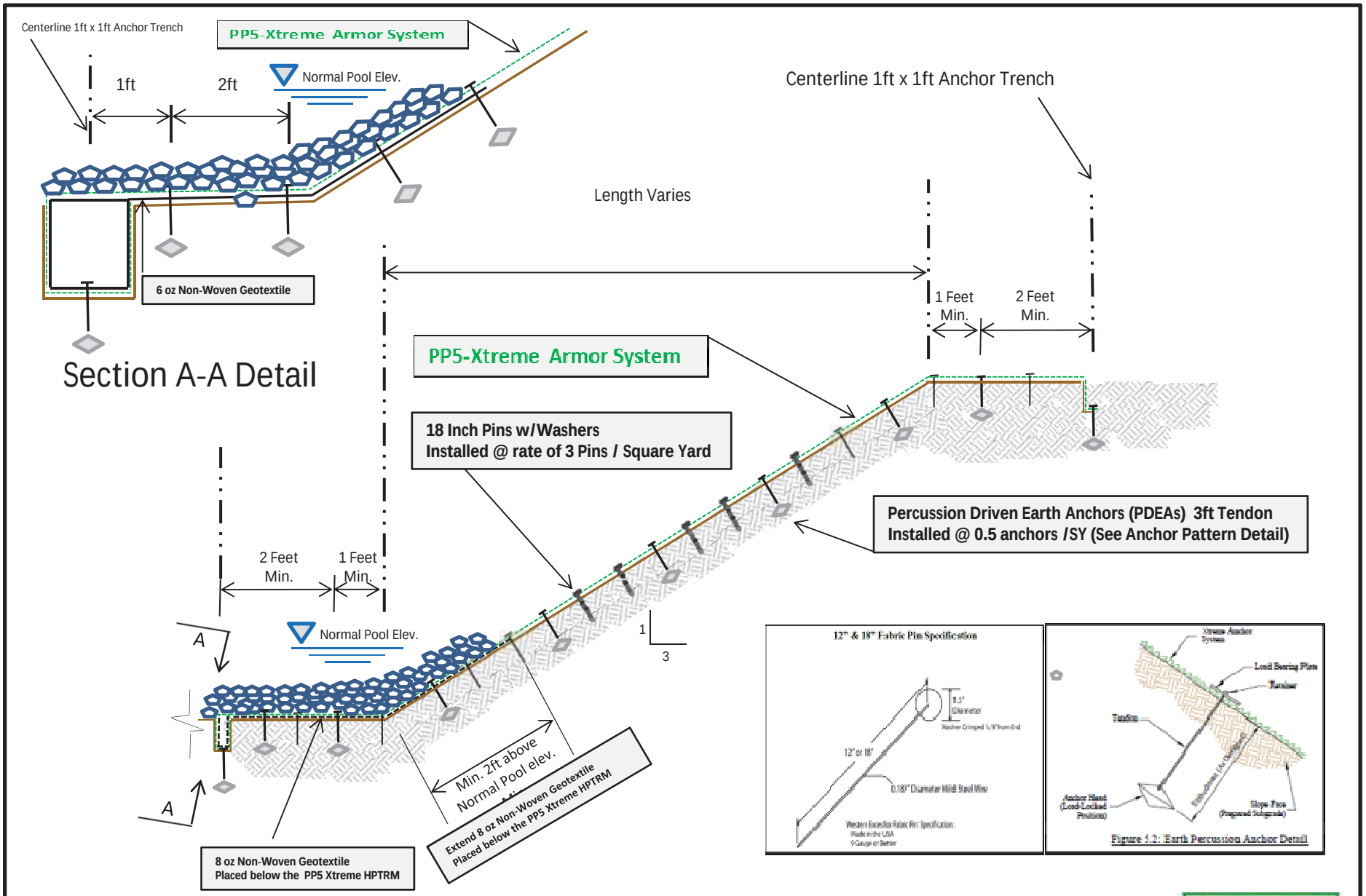
UNITED STATES DEPARTMENT OF ENERGY
WESTERN AREA POWER ADMINISTRATION
UPPER GREAT PLAINS CONSTRUCTION - HURON, SOUTH DAKOTA

FORT RANDALL-SIOUX CITY
IOWA

T-LINE STRUCTURE 103/4
UPSTREAM/DOWNSTREAM ANCHORS

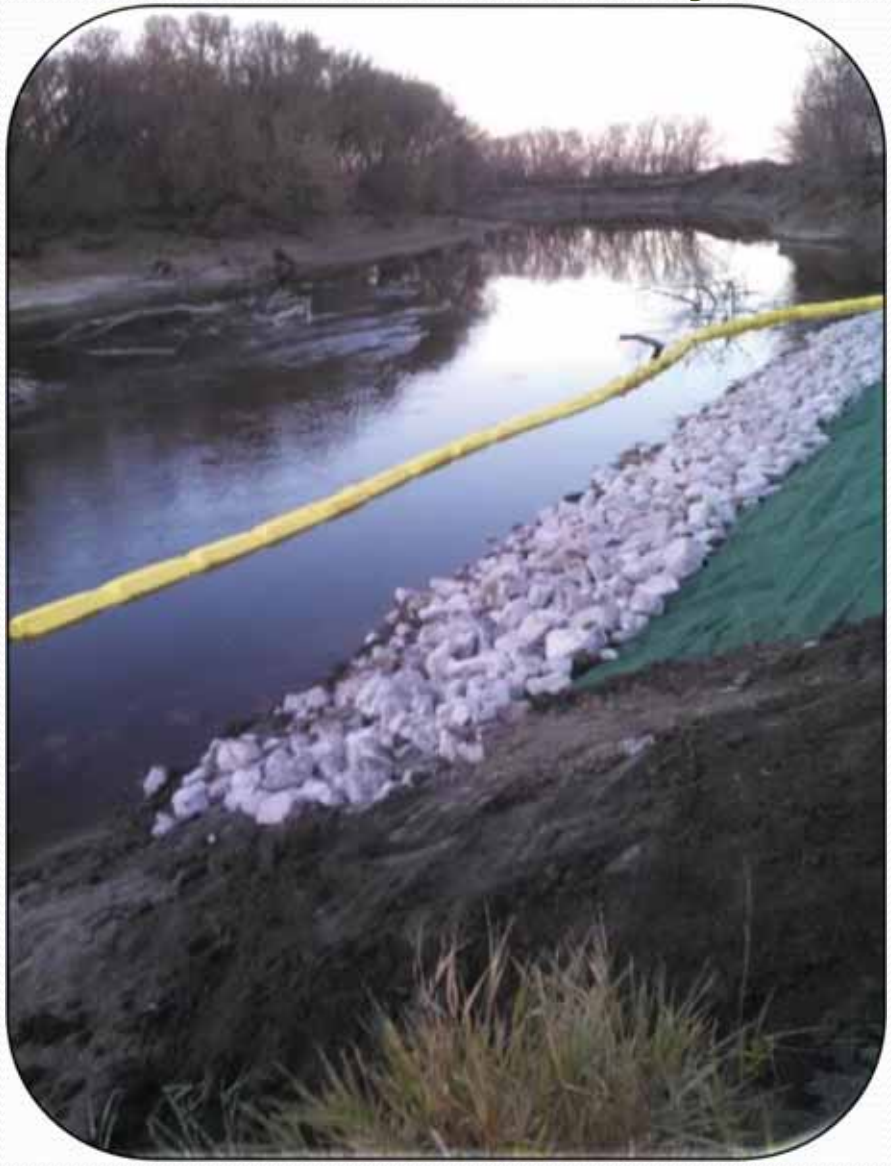
DESIGNED GAYLEEN LOWE APPROVED PAT DOAK
MANAGER, UPPER GREAT PLAINS CONSTRUCTION OFFICE

SCALE	DECEMBER 7, 2012	FR-SC-D	2032



Fort Randall –Sioux City 230kV Transmission Line
Bank Stabilization Near Structure 103/4
ARVS Armor System Combination High Performance Turf Reinforcement Mat (HPTRM) & PDEAs
Typical Cross-Section (No Scale) – Conceptual Only

Fort Randall-Sioux River Bank Stabilization Project



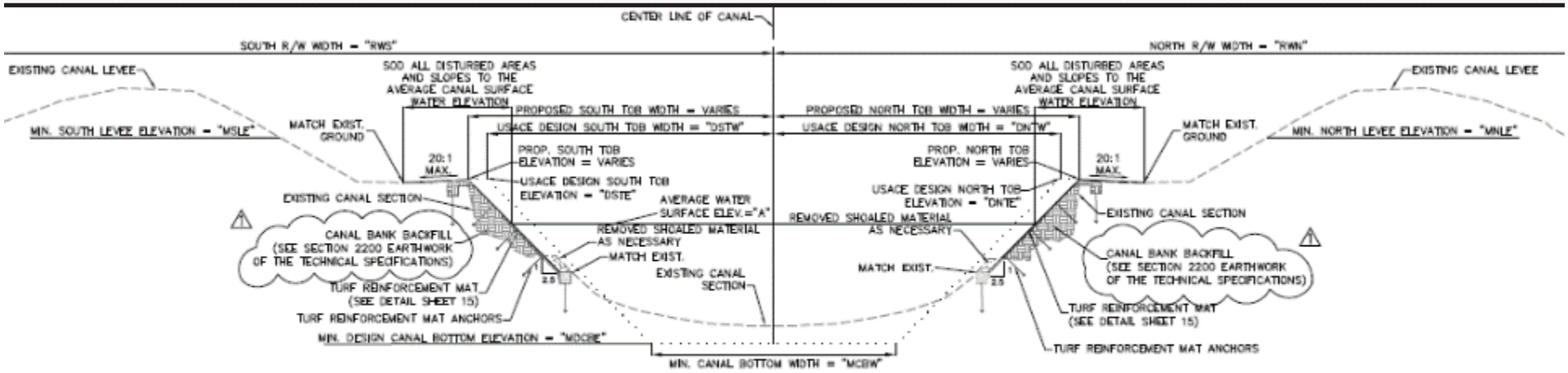
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Project Site Existing Conditions

sfwmd.gov

Erosive Conditions & Stability Issues Due To Seepage

South Florida Water Management
Typical Canal HPTRM Reinforced Section



TYPICAL CANAL SECTION

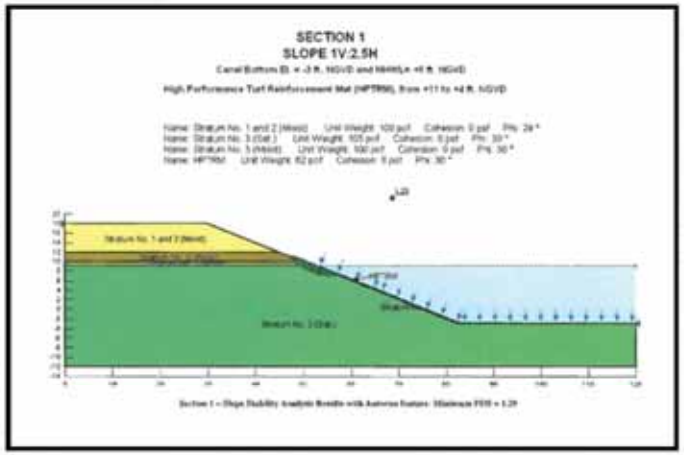
SCALE:N.T.S.

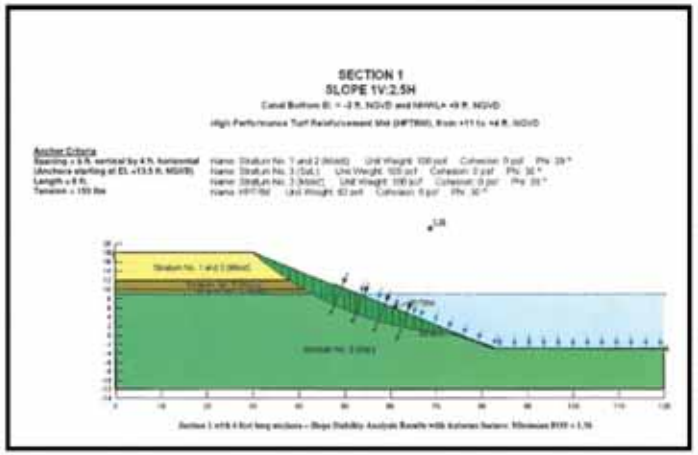
Hillsboro Canal Bank Stabilization Analysis

Atkins Engineering

Section 1 Slope Stability Results with HPTRM Anchor Consideration

HPTRM Anchor Criteria	Analysis Condition	Minimum FOS
Maximum Anchor Spacing = 5 feet vertical by 4 foot horizontal (top row @ Elev. +10.5 feet NGVD) Anchor Length = 6 feet Anchor Tension = 150 pounds	NHWL	1.36
	NLWL	1.35





RADISE'S Conclusions

It was RADISE's conclusion that an FOS of 1.3 is acceptable for this project and that the selected design alternative of a 2.5H:1V slope with HPTRM armoring, installed as described in the above table, is stable for Section 1 of the Hillsboro Canal. ***The other benefits in using HPTRM Armoring vs. Hard Armor (Rip/Rap, Reno Mattresses and/or Gabions) approaches is that these types of armoring systems will potentially add a surcharge load to the canal embankment reducing stability and they are twice as expense.*** We believe that the HPTRM Armoring Solution will provide for a High Factor of Safety and re

SFWMD Canal Project Quantities

C-41A Canal Projects

Segment # 1

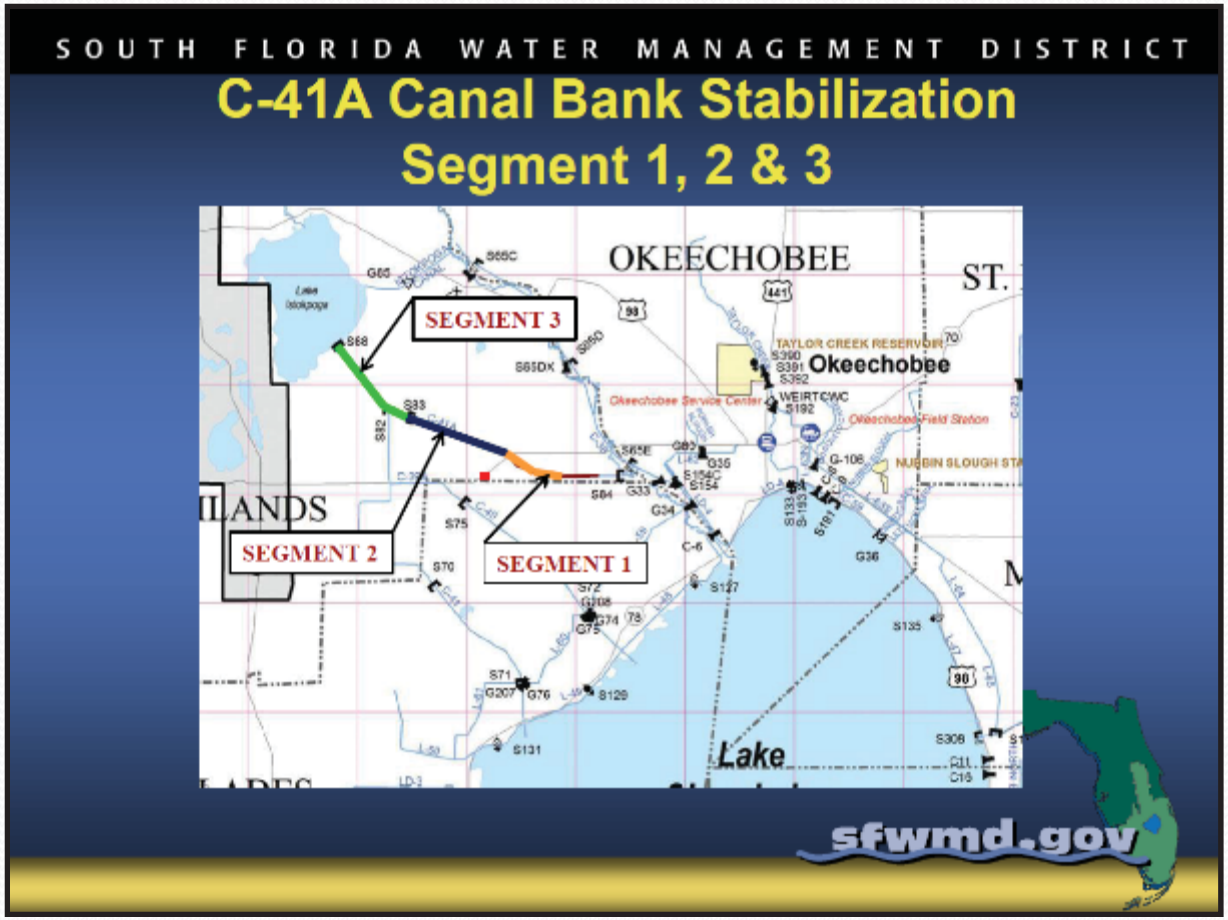
6.4 Miles – 150,000 Square Yards

Segment # 2

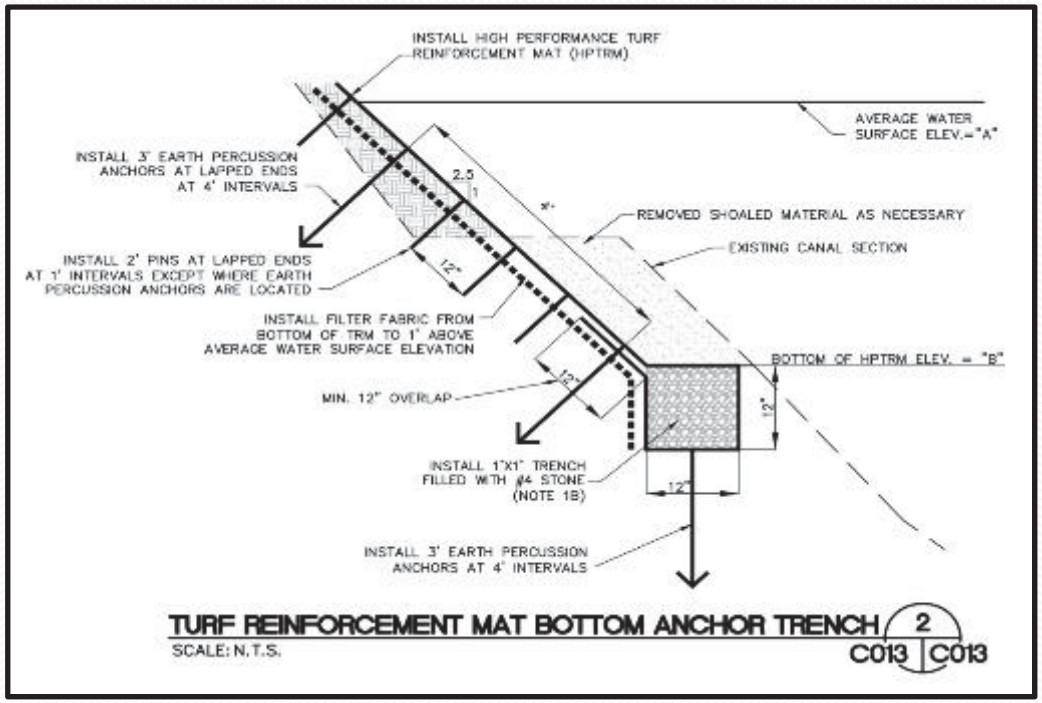
12.8 Miles – 300,000 Square Yards

Segment # 3

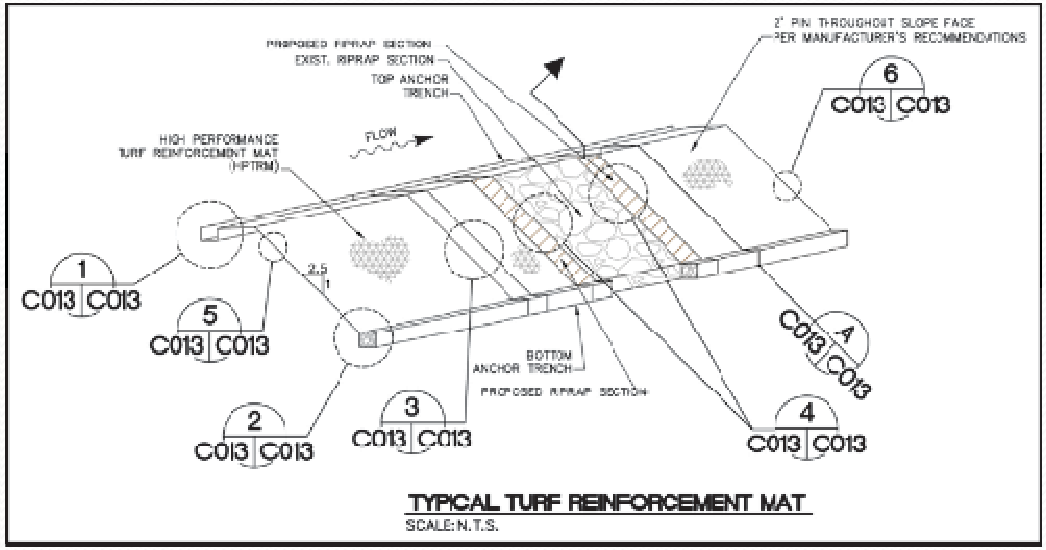
12.8 Miles – 300,00 Square Yards



SFWMD Canal HPTRM Stabilized Slope Toe Detail



Canal HPTRM Percussion Driven Earth Anchor Detail



GENERAL VIEW SEGMENT # 1

SFWMD Canal Project End Segment # 2
300,000 Square Yards October 3rd , 2011

ATL

Canal Bank Stabilization
HPTRM INSTALLATION W/ DIVERS
Turbidity Barrier

HPTRM Panel Construction

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AFL

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Percussion Driven Earth Anchor (PDEA) Being Drive at Seam Overlap

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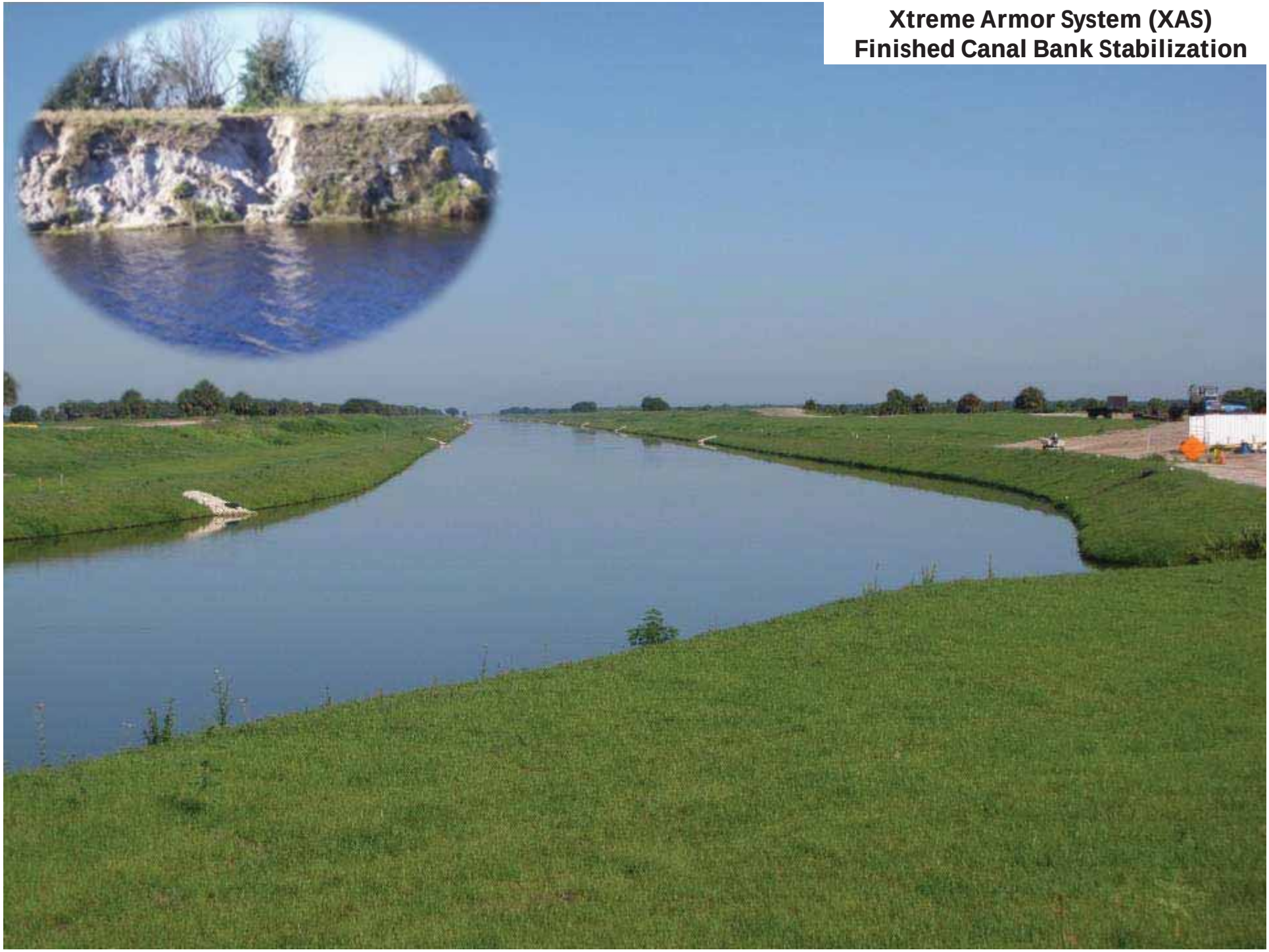
Xtreme Armor System (XAS)
Finished Canal Bank Stabilization

Xtreme Armor System (XAS)
Finished Canal Bank Stabilization



QUESTIONS

THANK YOU

Mechanical Solutions to Pump Station & Levee Components

Mark A Robertson PE

Mechanical Engineer

Louisville, KY

10 February 2016

US Army Corps of Engineers

BUILDING STRONG®

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- There is a design requirement for this in Corps of Engineers Engineering Manual EM 1110-2-3105; MECHANCIAL AND ELECTRICAL DESIGN OF PUMPING STATIONS.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- The EM can be found on the following website.

http://www.publications.usace.army.mil/

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Engineer Manuals

3105 Search

Pub Number	Proponent	Title	Pub Date	Exp Date	Info
EM 200-1-1	CEMP	Validation of Analytical Chemistry Laboratories	7/1/1994		
EM 200-1-2	CEMP-RT	Technical Project Planning (TPP) Process	8/31/1998		
EM 200-1-4	CEMP-RT	Risk Assessment Handbook - Volume I: Human Health Evaluation	1/31/1999		
EM 200-1-4	CEMP-RT	Risk Assessment Handbook: Volume II - Environmental Evaluation	12/31/2010		
EM 200-1-6	CEMP-RT	Chemical Quality Assurance for Hazardous, Toxic, and Radioactive	10/10/1997		

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EM 1110-2-3105	CECW-EE	Mechanical and Electrical Design of Pumping Stations (Change 2)	11/30/1999		

Page 1 of 1 First Previous [1] Next Last

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- **9-5. Equipment Protection:**

- There are five means to protect electrical equipment from moisture:

  - 1. Electric Heaters within the housing of the motors or switchgear.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- There are five means to protect electrical equipment from moisture:
  - 1. Electric Heaters within the housing of the motors or switchgear.
  - 2. Heating the operating room.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- 3. Dehumidification of the operating-room area, which includes sealing of the motor room and the application of vapor barrier material to the interior surfaces.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- 3. Dehumidification of the operating-room area, which includes sealing of the motor room and the application of vapor barrier material to the interior surfaces.

- 4. Heating the interior of the motors and switchgear by means of a central heating plant.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

- 5. Dehumidification of the interior of the motors and switchgear by means of individual dehumidifiers.

EQUIPMENT PROTECTION FROM DETERIORATION AND GENERAL MOSITURE

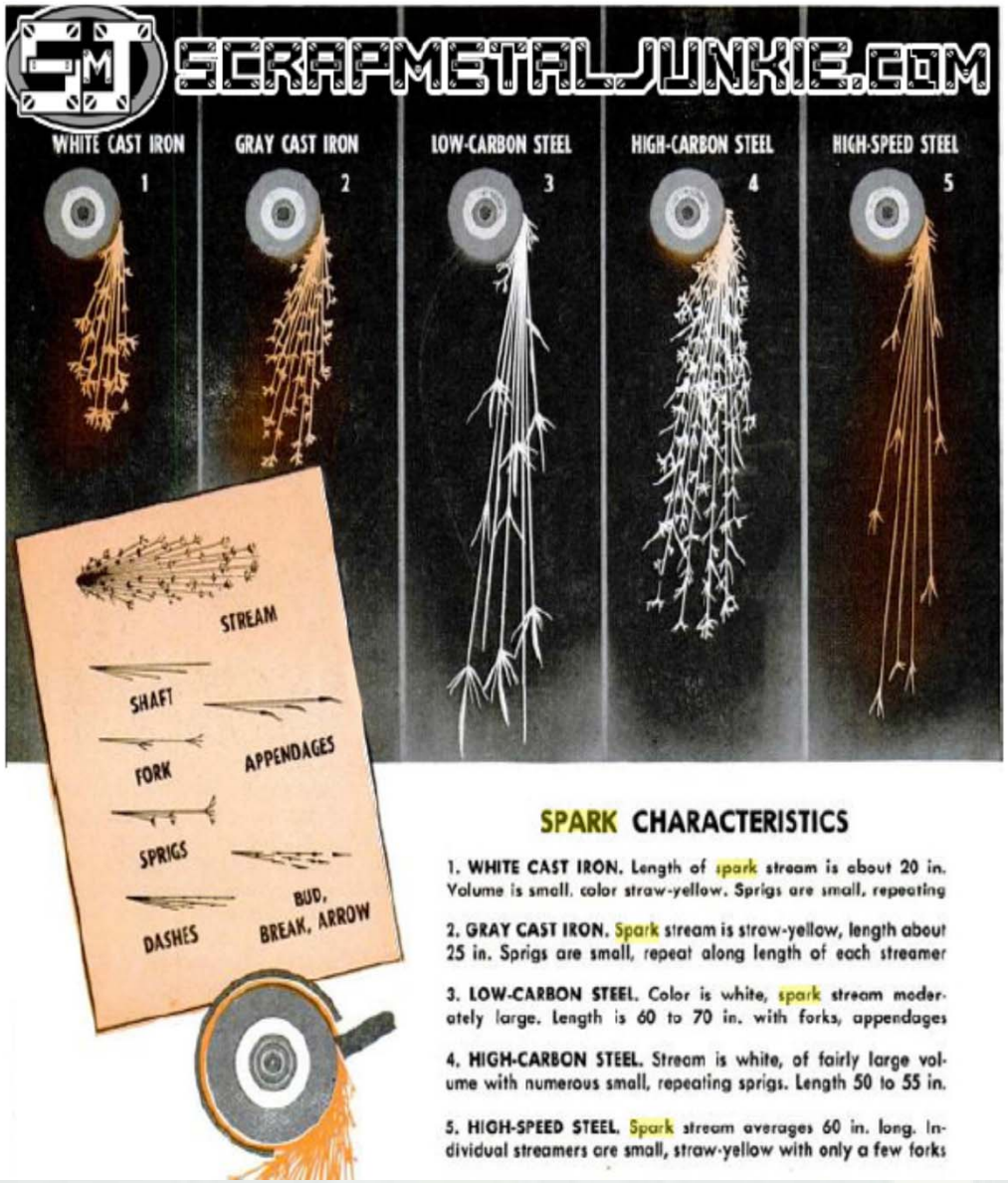
- Operating experience indicates that method (1) above is the most practical and economical for small- and medium-size stations. For the larger stations, using motors rated 1,500 kW (2,000 HP) and above, methods (4) and (5) may be feasible. Dehumidification methods are usually less costly to operate; however, maintenance and replacement costs are such that local users seldom keep the units running after initial failure. The sizing of electric heating elements in system (1) is done by the equipment supplier; however, the ambient conditions should be specified for this equipment.

MECHANICAL EQUIPMENT USED FOR PIPE LINE CLOSURE

- Crack found in sluice gate requiring repair or replacement.

MECHANICAL EQUIPMENT USED FOR PIPE LINE CLOSURE

- First thing is to determine the type of metal the gate is made of:
- This is done with a wheel grinder in a method called a spark test:



SPARK CHARACTERISTICS

1. **WHITE CAST IRON.** Length of spark stream is about 20 in. Volume is small, color straw-yellow. Sprigs are small, repeating

2. **GRAY CAST IRON.** Spark stream is straw-yellow, length about 25 in. Sprigs are small, repeat along length of each streamer

3. **LOW-CARBON STEEL.** Color is white, spark stream moderately large. Length is 60 to 70 in. with forks, appendages

4. **HIGH-CARBON STEEL.** Stream is white, of fairly large volume with numerous small, repeating sprigs. Length 50 to 55 in.

5. **HIGH-SPEED STEEL.** Spark stream averages 60 in. long. Individual streamers are small, straw-yellow with only a few forks

6. STAINLESS STEEL. Stream is moderate in volume, straw-colored near wheel and white near end. Streamers end usually in forks

7. TUNGSTEN (CHROMIUM). Stream is of small volume, 35 in. or so in length, red near wheel, white near ends. Forks are repeating

8. WROUGHT IRON. Stream is yellow, about 65 in. in length. Volume is fairly large, streamers ending in forks, appendages

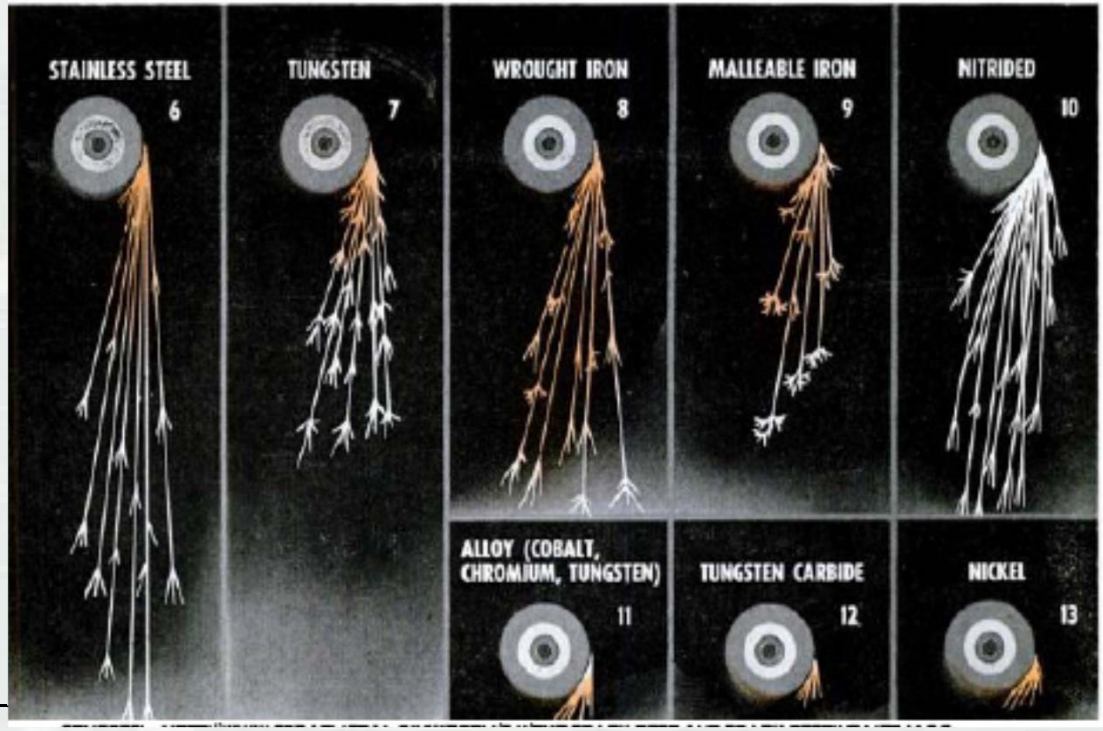
9. MALLEABLE IRON. Length, volume of stream is moderate, straw-yellow turning to white, ending in small, repeating sprigs

10. NITRIDED (ALLOY STEEL). Stream is large with curving streamers up to 50-60 in. long, white and ending generally in forks

11. ALLOY (COBALT, CHROMIUM, TUNGSTEN). Volume of stream is generally small with short streamers, usually red near wheel

12. TUNGSTEN CARBIDE (CEMENTED). Stream is very small, rarely more than 3 in. long and is light orange throughout length

13. NICKEL. Volume of stream is very small with occasional wavy streamers 2 to 3 in. long. Color is orange throughout



MECHANICAL EQUIPMENT USED FOR PIPE LINE CLOSURE

- Crack was repaired by welding without checking the material which was believed to be cast iron.

MECHANICAL EQUIPMENT USED FOR PIPE LINE CLOSURE

MECHANICAL EQUIPMENT USED FOR PIPE LINE CLOSURE

RESOLVING ISSUES FOR SOP MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON PIPELINES:

1. INSURE THAT PRESSURE TESTING REQUIREMENTS ARE INDICATED ON THE PLANS.

2. IF TEST PRESSURE IS DIFFERENT THAT 200 PSI OR 150% OF WORKING PRESSURE WHICHEVER IS GREATER THAN THIS IS THE TIME TO INDICATE THE LOWER PRESSURES FOR REVIEW BY THE CORPS OF ENGINEERS.

RESOLVING ISSUES FOR SOP MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON PIPELINES:

3. INSURE THAT SHUT OFF VALVES ARE INSTALLED ON BOTH SIDES OF PROTECTION FOR PRESSURE LINES WITHIN 15 FEET OF TOES ON LEVEES OR FLOODWALL CENTERLINE.

RESOLVING ISSUES FOR SOP MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON PIPELINES:

4. PROVIDE THE FOLLOWING ON PLANS, TESTING PROCEDURES, TYPE OF PIPE, FITTINGS AND DETAILS (INCLUDING “LINK SEALS OR COUPLINGS), VALVE TYPES AND LOCATIONS, PAINTING OR COATING AS REQUIRED BY SPECIFIC SOP’S.

RESOLVING ISSUES FOR SOP MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON PIPELINES:

5. IF A SLEEVE IS USED FOR THE CARRIER PIPE INSURE THAT IS COATED INSIDE AND OUTSIDE WITH CORPS OF ENGINEERS FORMULA C-200A.

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON CLOSURES (SLUICE AND FLAP GATES):

1. PROVIDE ON PLANS SEATING AND UNSEATING HEADS, DETAILS OF TYPE AND INSTALLATION OF GATE, AND MANUAL/ELECTRIC OPERATOR. FLAP GATES ARE REQUIRED TO BE ATTACHED TO A HEADWALL STRUCTURE.

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

SOP ON CLOSURES (SLUICE AND FLAP GATES):

2. PROVIDE SPECIFICATIONS FOR EACH TYPE OF GATE. INCLUDING SLENDERNESS RATIO, CALCULATIONS FOR HEAD REQUIREMENTS AND FRICTION FACTOR (CORPS REQUIRES A MIN. OF 0.6).

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

General Design Info:

Component parts shall be designed for the seating and unseating heads specified herein using a minimum safety factor of 5. The gate stem be sized and guided, so that, the slenderness ratio (L/R) shall not exceed 200. The opening and closing forces for design of the stem and stem block anchorage shall include friction load based on the operating face pressure (55 feet), back pressure (20 feet) and operating pressure (20 feet) with coefficient of friction of not less than 0.6 in addition to the weight of the gate and stem. Stem design shall include a factor of safety of 5 against failure in addition to the column buckling strength reduction effects as given by the Euler formula.

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

Applicable Publications should be listed in contract specifications for desing, construction, installation and testing requirements:

AWWA C 560 Cast Iron Sluice Gates

AWWA C 561 Fabricated Stainless Steel Slide Gate

AWWA C 562 Fabricated Aluminum Slide Gate

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

The following website can be used for mechanical components used for repair/replacement of storm water pumps:

www.wbdg.org

Wbdg stands for whole building design guide

WBDG
WHOLE BUILDING DESIGN GUIDE
a program of the National Institute of Building Sciences

(/design/) DESIGN GUIDANCE | (/project/) PROJECT MANAGEMENT | (/om/) OPERATIONS & MAINTENANCE | (/references/) DOCUMENTS & REFERENCES | (/tools/) TOOLS | (/education/) CONTINUING EDUCATION | (/bim/) BIM

The Gateway to Up-To-Date Information on Integrated 'Whole Building' Design Techniques and Technologies

(design/designobjectives.php)

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POPULAR LINKS

- Unified Facilities Criteria (/ccb/browse_cat.php?o=29&c=4)
- Unified Facilities Guide Specifications (UFGS)(/ccb/browse_org.php?o=70)
- Construction Waste Management Database

NEW & UPDATED PAGES

Critical Equipment Identification and Maintenance (resources/criticalequipmentmaintenance.php)
Resource Page - 01/08/2016

Sustainable(design/sustainable.php) including Site Potential(design/site_potential.php), Energy Use (design/minimize_consumption.php), Protect and Conserve Water(conserve_water.php), Building Space and Material Use (design/env_preferable_products.php), Enhance Indoor Environmental Quality (IEQ) (design/ieq.php), and Operational and Maintenance Practices (design/optimize_om.php)
Design Objective - 12/14/2015

Achieving Results with a Mobile Infrastructure and Facilities Management System (resources/achievingwmobileinfrastructure.php)
Resource Page - 12/01/2015

Functional/Operational(design/func_oper.php) Building Account for Functional Needs (design/account_spatial.php), Ensure Appropriate Product/Systems Integration (design/ensure_integration.php), and Meet Performance Objectives (design/meet_performance.php)
Design Objective - 11/10/2015

(ccb/) CONSTRUCTION

PARTICIPATING AGENCIES

Select an agency below for more information on its building programs.

(references/pa_dod.php)
(references/pa_gsa.php)
(references/pa_doe.php)
(references/pa_va.php)
(references/pa_epa.php)
(references/pa_nasa.php)
(references/pa_aousc.php)
(references/pa_dhs.php)
(references/pa_dos.php)
(references/pa_nih.php)
(references/pa_nps.php)
(references/pa_smithsonian.php)

WBDG a program of the National Institute of Building Sciences

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Unified Facilities Guide Specifications (UFGS)

(/ccb/ccb.php)

The DoD Unified Facilities Criteria (UFC) program represents the facilities and infrastructure component of the Defense Standardization Program established by DoD Instruction 4120.24. For more information on the program including annual reports, visit dod.wbdg.org(http://dod.wbdg.org/).

UFGS Master Updated November 12, 2015; Posted November 19, 2015

As of June 2008, updated UFGS will be posted quarterly in February, May, August and November.

Unified Facilities Guide Specifications (UFGS) are a joint effort of the **U.S. Army Corps of Engineers(http://www.hnc.usace.army.mil/Missions/Engineering/TECHINFO.aspx)** (USACE), the **Naval Facilities Engineering Command(/references/pa_dod_cieng.php)** (NAVFAC), the **Air Force Civil Engineer Center(http://www.afcec.af.mil/)** (HQ AFCEC) and the **National Aeronautics and Space Administration(http://www.nasa.gov/about/highlights/index.html)** (NASA). UFGS are for use in specifying construction for the military services.

The Unified Facilities Guide Specifications (UFGS) are published only in electronic format and are intended to be used with **SpecsIntact**(/tools/specsintact.php) software. The UFGS Master uses the latest CSI MasterFormat, therefore, as of January 2012, the UFGS Working Group decided to discontinue support of MasterFormat 1995. SpecsIntact version 4.5.1

WBDG a program of the National Institute of Building Sciences

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As of May 2013: The May 2013 release incorporates Automatic Paragraph Numbering. Versions of Specsintact older than 4.5.0 are not compatible with this feature. Existing jobs can be converted to the new automatic numbered format. The conversion is a one-way process. To convert, select the job or master, select process menu, choose convert Job/Master to Automatic numbering. More information about **Automatic Paragraph Numbering (http://si.ksc.nasa.gov/WebHelp/SI300main/SI_Explorer_s_Process_Menu_--_Convert_to_Automatic_Numbering.htm)** is available on the **Specsintact website (http://specsintact.ksc.nasa.gov)**.

For Specsintact Technical Support, please contact them directly:
Phone: 321-867-8800, E-mail(mailto:KSC-SpecsIntact@nasa.gov), or visit their Website(http://specsintact.ksc.nasa.gov)

In addition, the SpecsIntact Knowledge Base(http://specsintact.ksc.nasa.gov/KnowledgeBase/TechHelp.htm) can be found on their website. This is the first resource recommended for those who encounter any problems while using SpecsIntact, including those having problems publishing to Word or PDF formats.

UFGS that have been unified for use by all participating agencies have a level 3 or level 4 MasterFormat™ number. UFGS that are agency-specific have a fifth level number indicating it as an agency specific specification. A specification that has a fifth level number "10" indicates USACE, a "20" indicates NAVFAC, a "30" indicates AFCEC, and a "40" indicates NASA. Preparing agencies are indicated in the UFGS header of each specification. The user should follow this order of precedence in selecting UFGS sections:

1. Regional UFGS specific to their Agency
2. UFGS identified as specific to their Agency
3. Unified UFGS if one is available
4. UFGS identified as specific to another DoD Agency (for DoD projects only)
5. UFGS from another agency.

Points of contact and procedures for the development and maintenance of UFGS documents are prescribed in the latest edition of **MIL-STD-3007(/ccb/FEDMIL/std3007f.pdf)**.

Section templates for MasterFormat 2010 and MasterFormat 1995(http://specsintact.ksc.nasa.gov/Software/templates.shtml): These templates are provided to assist the user in creating a new section.

SpecsIntact for NMCI Users(/references/pa_dod_si.php)

Questions, comments, suggestions and recommended changes for guide specifications are welcome and should be submitted as a Criteria Change Request. To submit a Criteria Change Request, click on the CCR link next to the document below. If a CCR does not fit cleanly into an existing section, submit a CCR to the section most closely related to the CCR.

View Archived UFGS(/ccb/browse_cat.php?c=3&a=1)

These documents are available in the following formats:
Adobe Acrobat (PDF) | SpecsIntact (SEC) in compressed ZIP

Title	Date	Downloads	CCR
UFGS MASTER	11-12-2015	16 MB(/ccb/DOD/UFGS/UFGS_M.zip)	
UFGS in PDF - All sections combined into one document.	11-19-2015	53.4 MB(/ccb/DOD/UFGS/UFGS_COMPLETE.pdf)	

UFGS: Division 22 - Plumbing

UFGS 22 10 00.00 10 Vertical Pumps, Axial-Flow and Mixed-Flow Impeller-Type	07-2007	163 KB(/ccb/DOD/UFGS/UFGS 22 10 00.00 10.pdf)
UFGS 22 11 23.00 10 Submersible Pump, Axial-Flow and Mixed-Flow Type	07-2007	93 KB(/ccb/DOD/UFGS/UFGS 22 11 23.00 10.pdf) |
UFGS 22 13 29 Sanitary Sewerage Pumps	02-2011	100 KB(/ccb/DOD/UFGS/UFGS 22 13 29.pdf) | 20

RESOLVING ISSUES FOR MECHANICAL REQUIREMENTS FOR LOCAL SPONSORS DURING MODIFICATION REVIEWS

ANY COMMENTS OR QUESTIONS?

Revised Wabash River Discharges and their Community Impacts

Richard Pruitt

Chief, Hydrology & Hydraulic Design Section

Louisville District Office

February 10, 2016

US Army Corps of Engineers

BUILDING STRONG®

100-Year Peak Discharges

	Coordinated Flows with IDNR	1969-2015	Change in Flow (CFS)	Change in Elev (Feet)
Huntington	11,000	10,800	-200	Minimal
Wabash	30,000	24,400	-5,600	1.2
Peru	31,300	23,100	-8,200	1.7
Logansport	65,000	47,000	-18,000	2.7
Lafayette	95,000	96,200	+1,200	+ 0.1
Covington	108,000	110,900	+2,900	+ 0.2
Montezuma	141,000	147,400	+6,400	+ 0.5
Terre Haute	152,000	141,400	-10,600	0.8
Riverton	159,000	135,200	-23,800	1.3
Vincennes	149,000	116,400	-32,600	1.4
Mt. Carmel	315,000	306,300	-8,700	0.3

Other Durations Studied

1913, 1940-2008

1940-2008

1969-2008

1969-2011

1969-2013

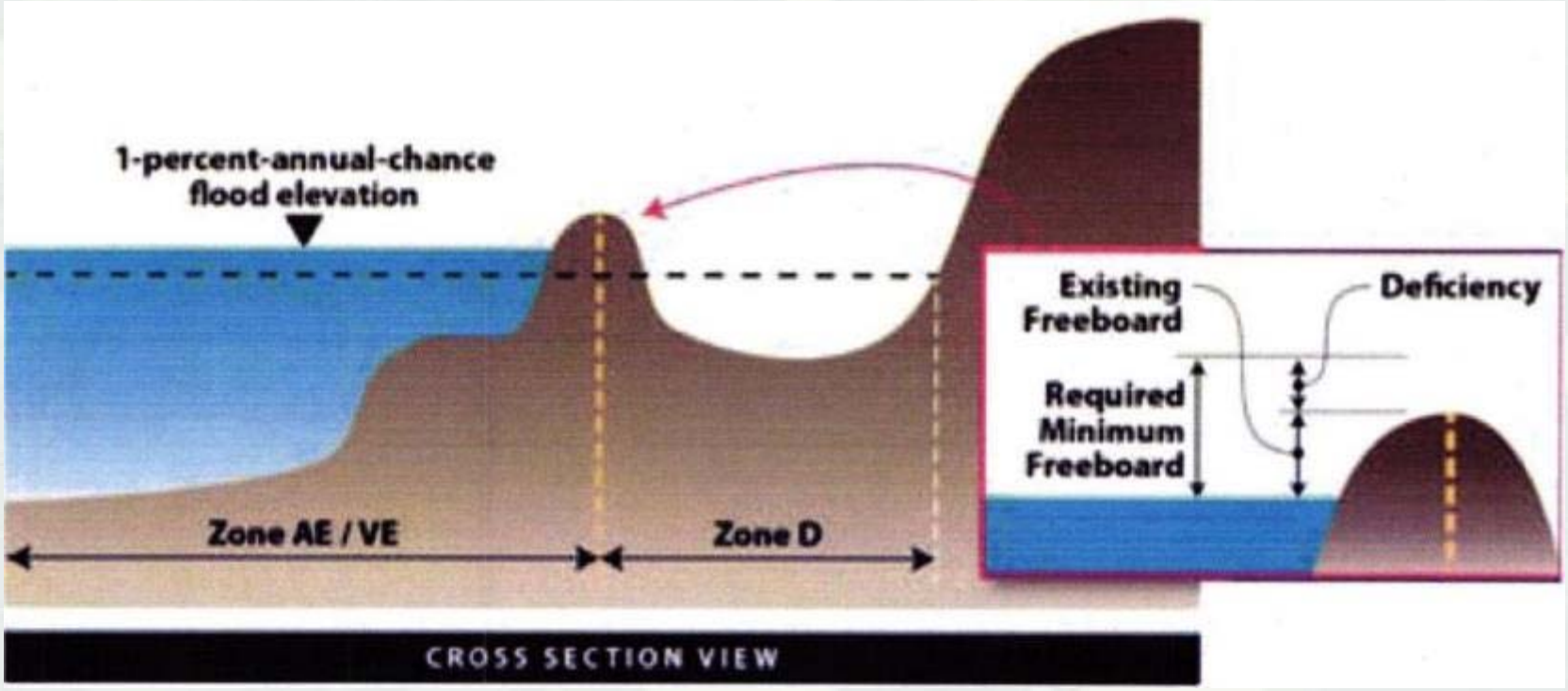
Proposed Schedule for Wabash River Hydraulic Modeling

- Illinois – Mouth to where Wabash River diverges from Illinois (near Terre Haute).
  - Starting this spring – may be optimistic
- Indiana – Will begin where Illinois study ends.
  - No definite schedule – trying to decide what areas should be studied first
- Existing Corps of Engineers hydraulic modeling.
  - Mt. Carmel to Vincennes

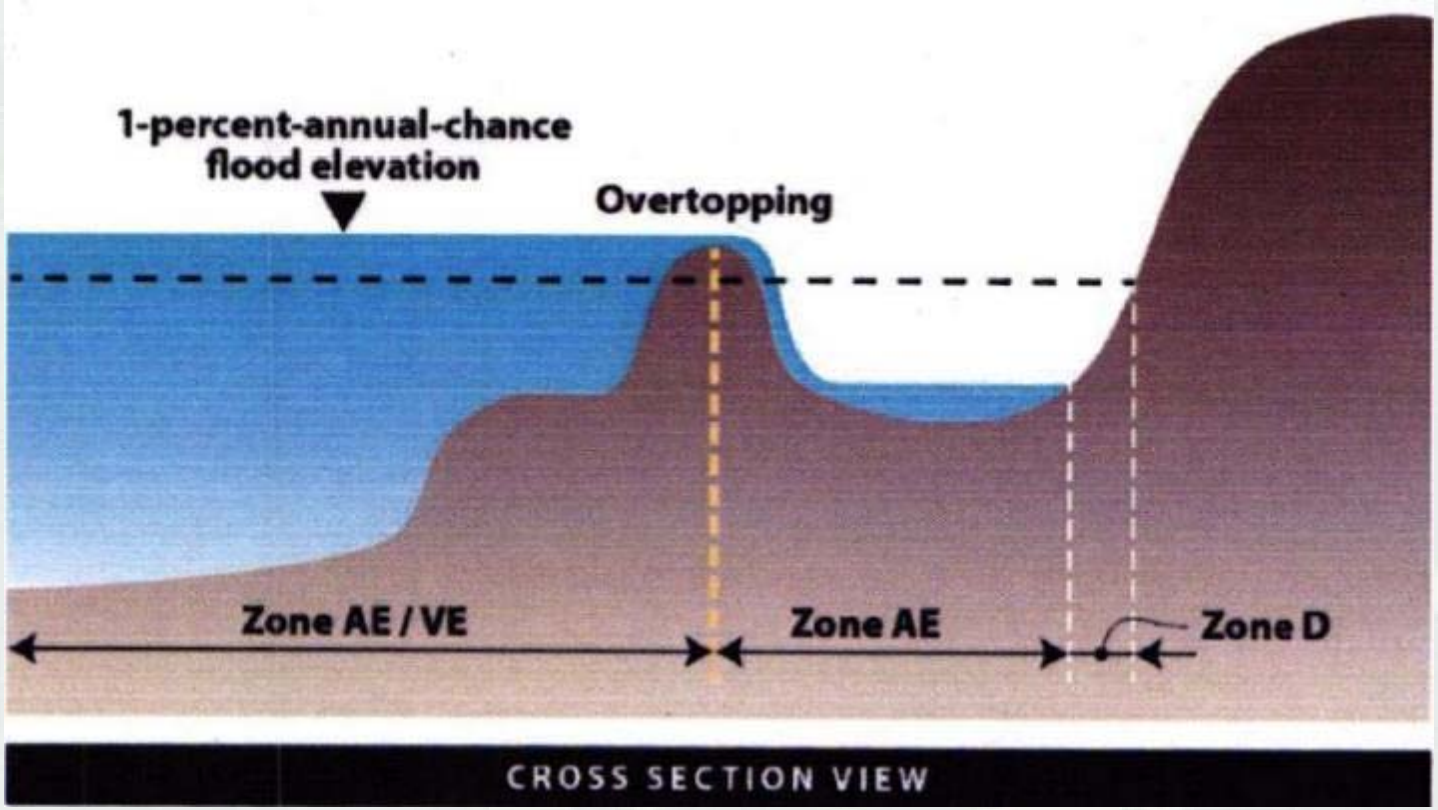
Impacts to Updated Wabash River Flows and Elevations

- Non-Leveed areas
- Leveed Areas

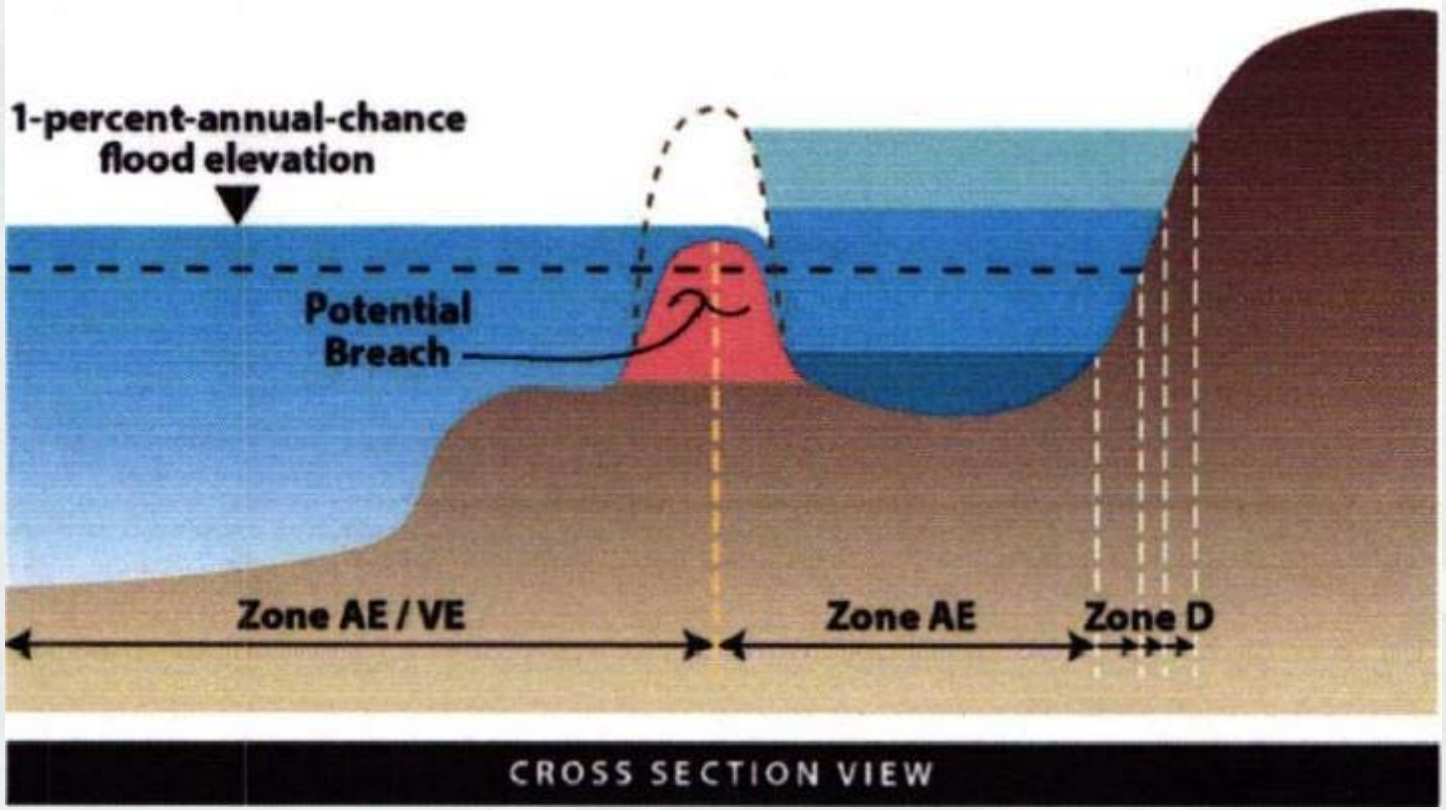
Freeboard Deficient Procedure



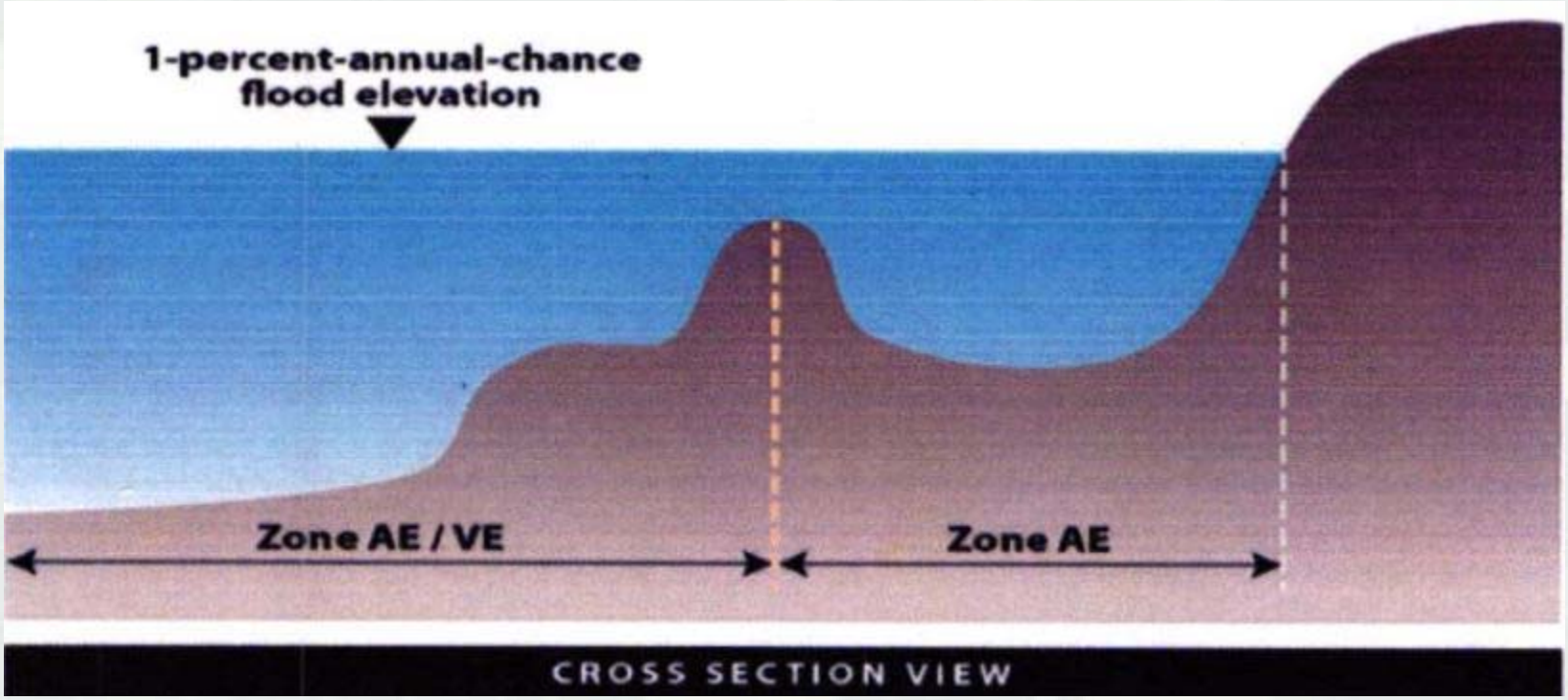
Overtopping Procedure



Structural-Based Inundation Procedure



Natural Valley Procedure



Proposed Ohio River Frequency Discharge Update to 1976 Study

- Very early in planning stages.
- Four districts involved in analysis (Louisville, Nashville, Huntington, Pittsburgh).
- Final results minimum to 2-3 years.
- Impacts similar to those of Wabash River
  - Non-Leveed areas
  - Leveed areas

Thank You