

Training Module for Designing and Constructing with Geosynthetics

LTAP
MINNESOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

LRRB
LOCAL ROAD RESEARCH BOARD

MINNESOTA DEPARTMENT OF TRANSPORTATION

MAKING A DIFFERENCE

Who are we?

- I am...

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Who Are We?

- You are…

- What do you want to learn today?

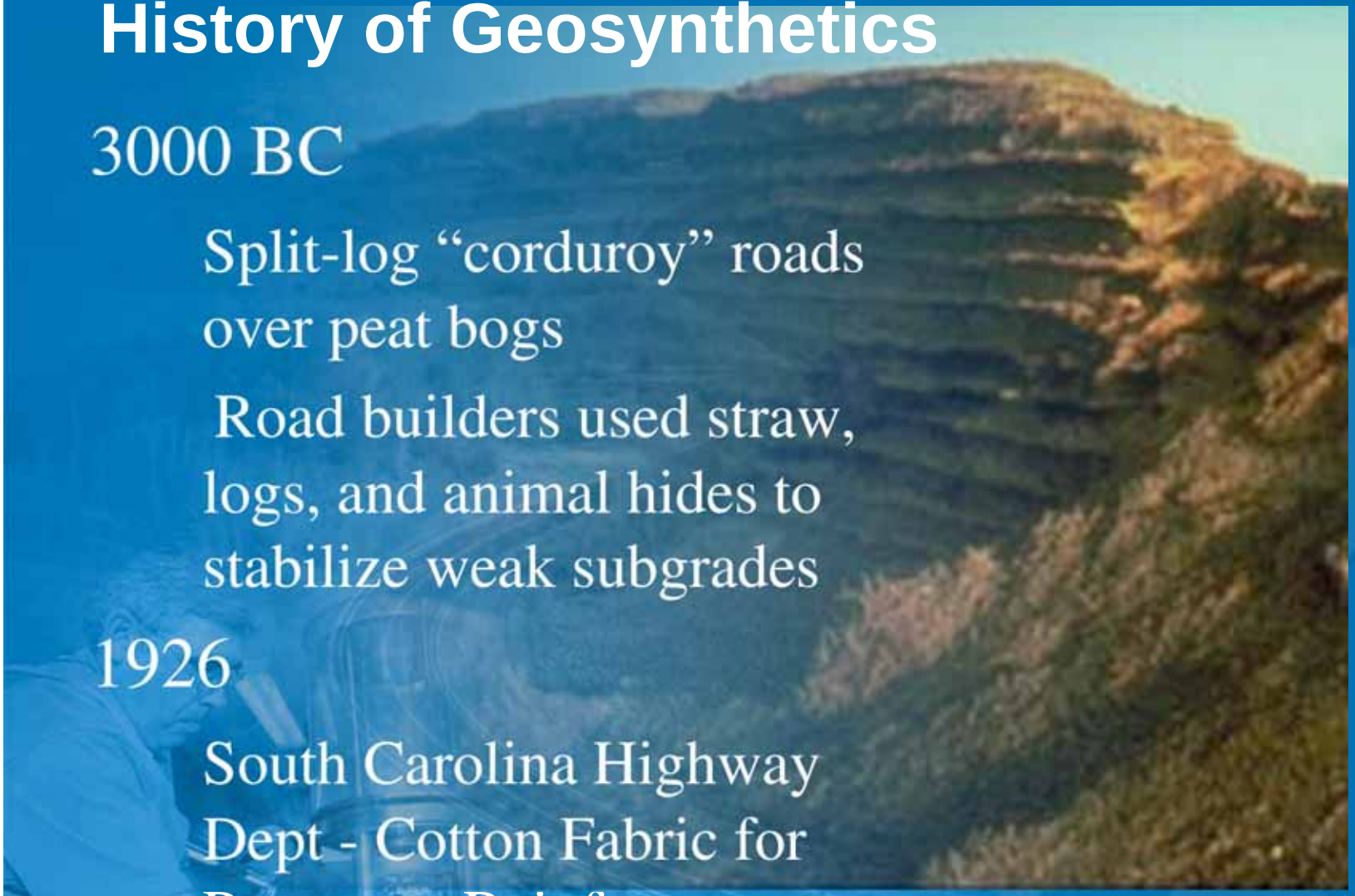
General order of the day

- Introduction
- History of Geosynthetics
- Geosynthetics Available in the Marketplace
- Geosynthetic Product Properties
- Geosynthetics in Roads
- Geosynthetics in Grade Separation Structures

What this class is about

- What are the PRODUCTS
- PLANNING to use geosynthetics in Highway projects
- DESIGN of geosynthetics beneath road subgrades and for grade separation structures
- INSTALLATION and INSPECTION of geosynthetics beneath roads and for grade separation structures

History of Geosynthetics



3000 BC

Split-log "corduroy" roads over peat bogs

Road builders used straw, logs, and animal hides to stabilize weak subgrades

1926

South Carolina Highway Dept - Cotton Fabric for Pavement Reinforcement

1957

Nico ter Kuile & Sons (Netherlands) produce first nylon sand bags for a hydraulic engineering project

1966

Experimental line of civil engineering fabrics is developed by Celanese(USA)

1970s

Construction of the national infrastructure and interstate system in United States provides a new market for the textile industry.

Market is established with a total of 3 million square yards installed in 1970.

2000s

Total geosynthetic sales reach over 700 million square yards in the US

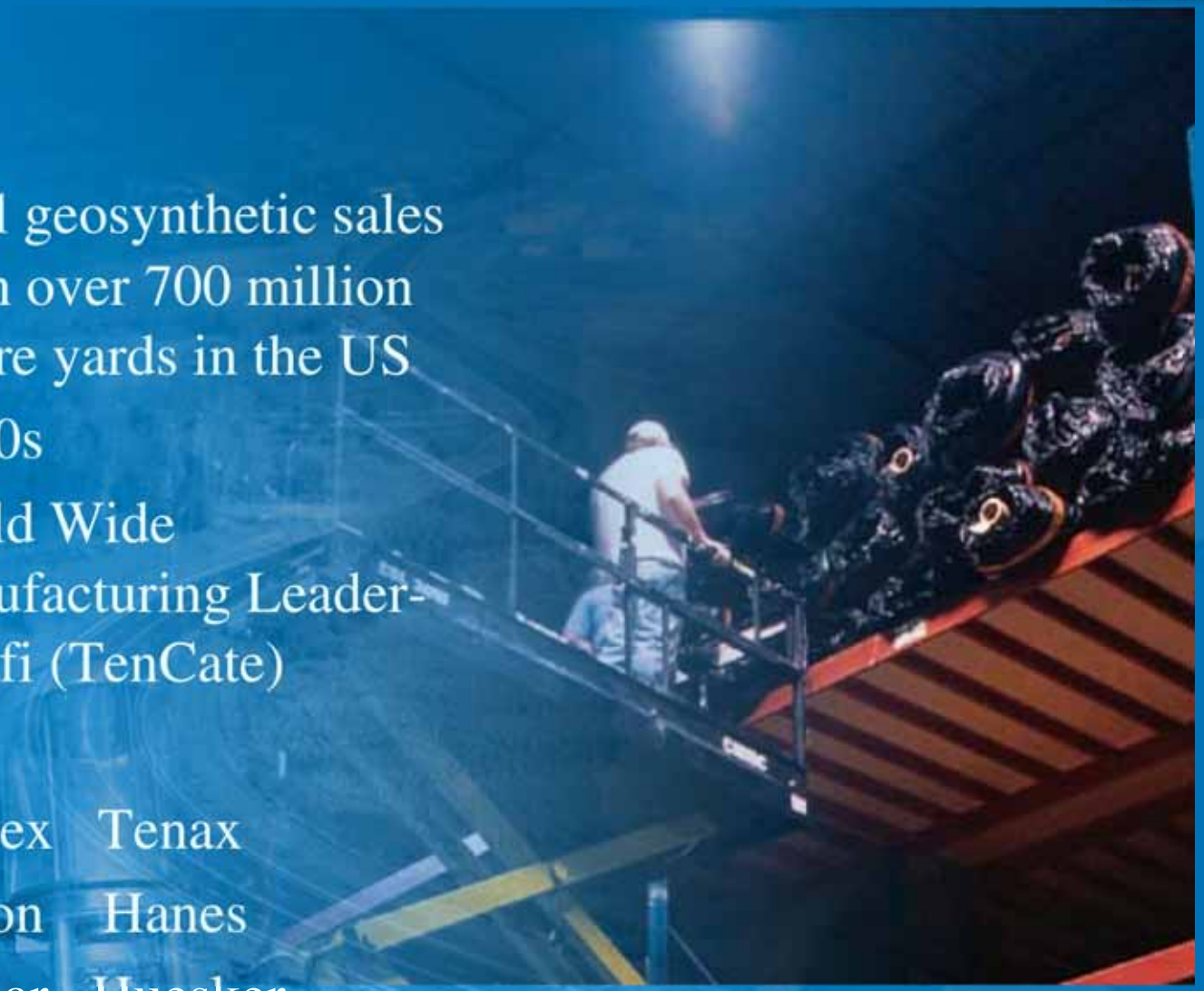
… 2000s

World Wide Manufacturing Leader- Mirafi (TenCate)

Propex Tenax

Belton Hanes

Tensar Huesker



Class Participation

- When did you first use a geosynthetic product?
- Where did you get the information you needed to use it?
- What product do you use the most?

Acknowledgments

- The following firms provided slides/photos for this course
- Geosynthetic Institute
- TenCate Geosynthetics (Mirafi)
- Tenax Corporation
- Mn/DOT Geotechnologies
- Gale-Tec Engineering, Inc.

Sources of Information

- Geosynthetic Engineering by Holtz, Christopher and Berg
- Designing with Geosynthetics by Koerner
- Geosynthetic Design and Construction Guidelines, participant notebook, NHI Course No. 13213, US Department of Transportation, Publication No. FHWA HI-95-038. Update published 2007
- Gale-Tec Engineering, Inc. Project Files
- MnDOT Project Files

More Sources of Information

- Contact Mn/DOT's Office of Materials for most recent information on specifications and approved products.
- Phone: (651) 366-5592
- http://www.mrr.dot.state.mn.us/materials/materials.asp

If nothing else, we want you to learn…

- PLANNING: there are cost and performance benefits to using these materials.
- DESIGNING: some projects can be specified based on experience and empirical data while others need to be designed by a licensed professional engineer trained in geotechnical/geosynthetic engineering
- INSTALLING: with training, these products can be installed successfully.

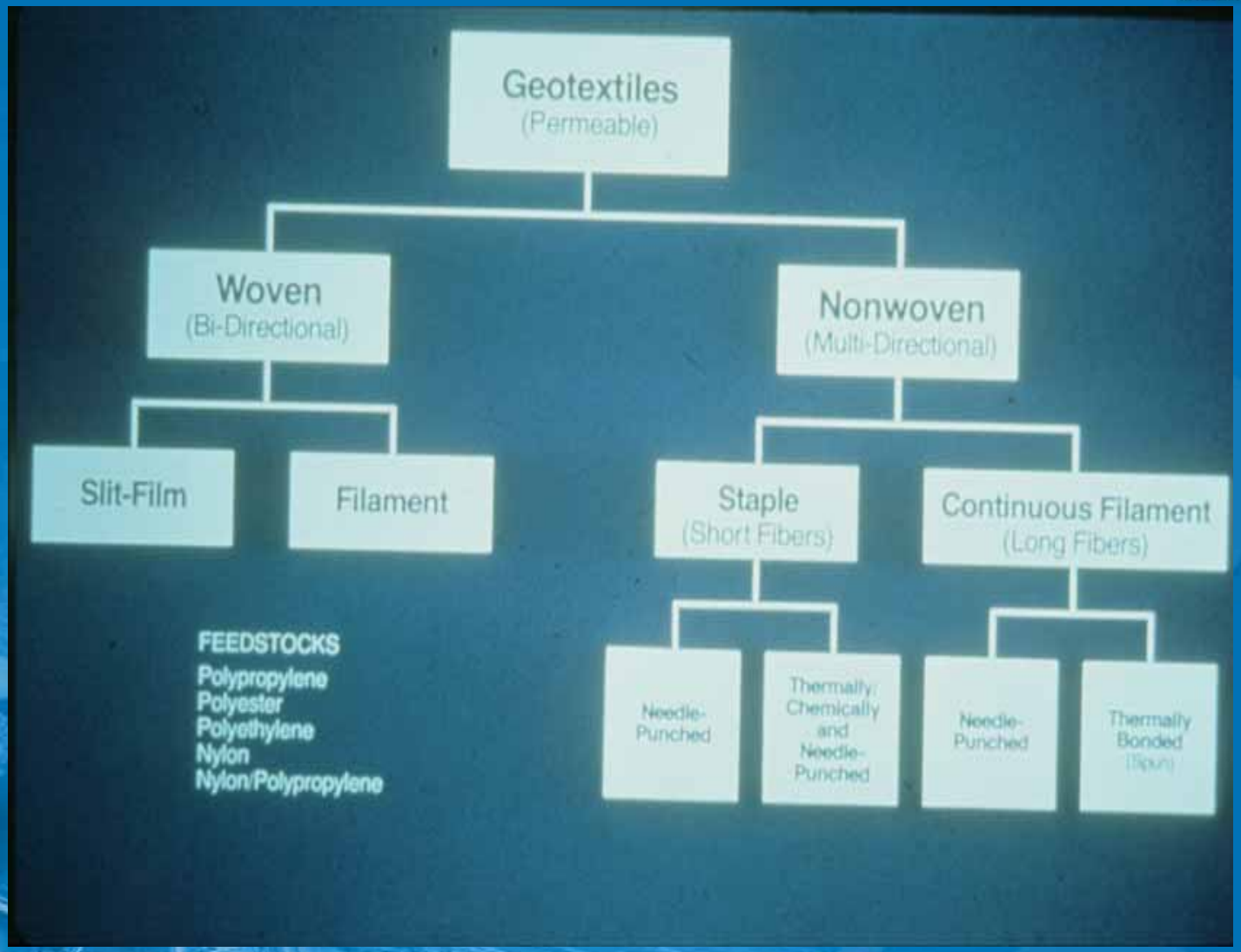
What are these things we call geosynthetics?

From Koerner, 1994, page 2:

Geosynthetic – a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

Geotextiles

- Permeable geosynthetic made of polypropylene or polyester resin
  - Woven geotextiles are composed of either single or bundles of yarns woven together by a loom
    - Monofilaments are round
    - Slit films are flat
  - Non-Woven geotextiles are random laid fibers that are needle punched or heated
- Used for separation, reinforcement, filtration, and drainage (Trampolines, car trunk liners, furniture backing, carpet backing, temporary covers for landfills)

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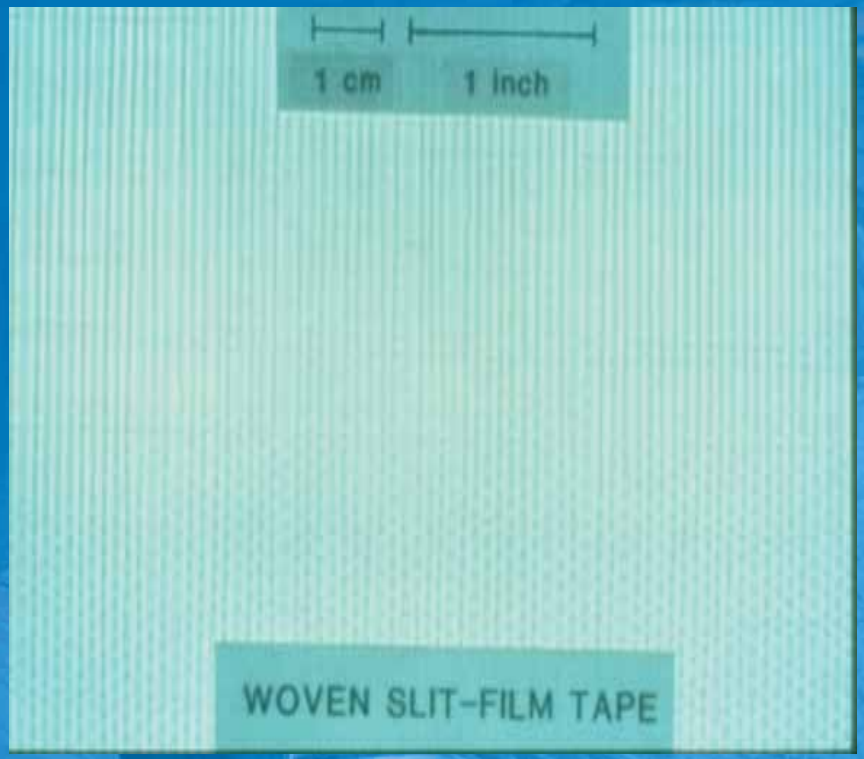
Woven Geotextile

Geotextiles

Woven Geotextiles



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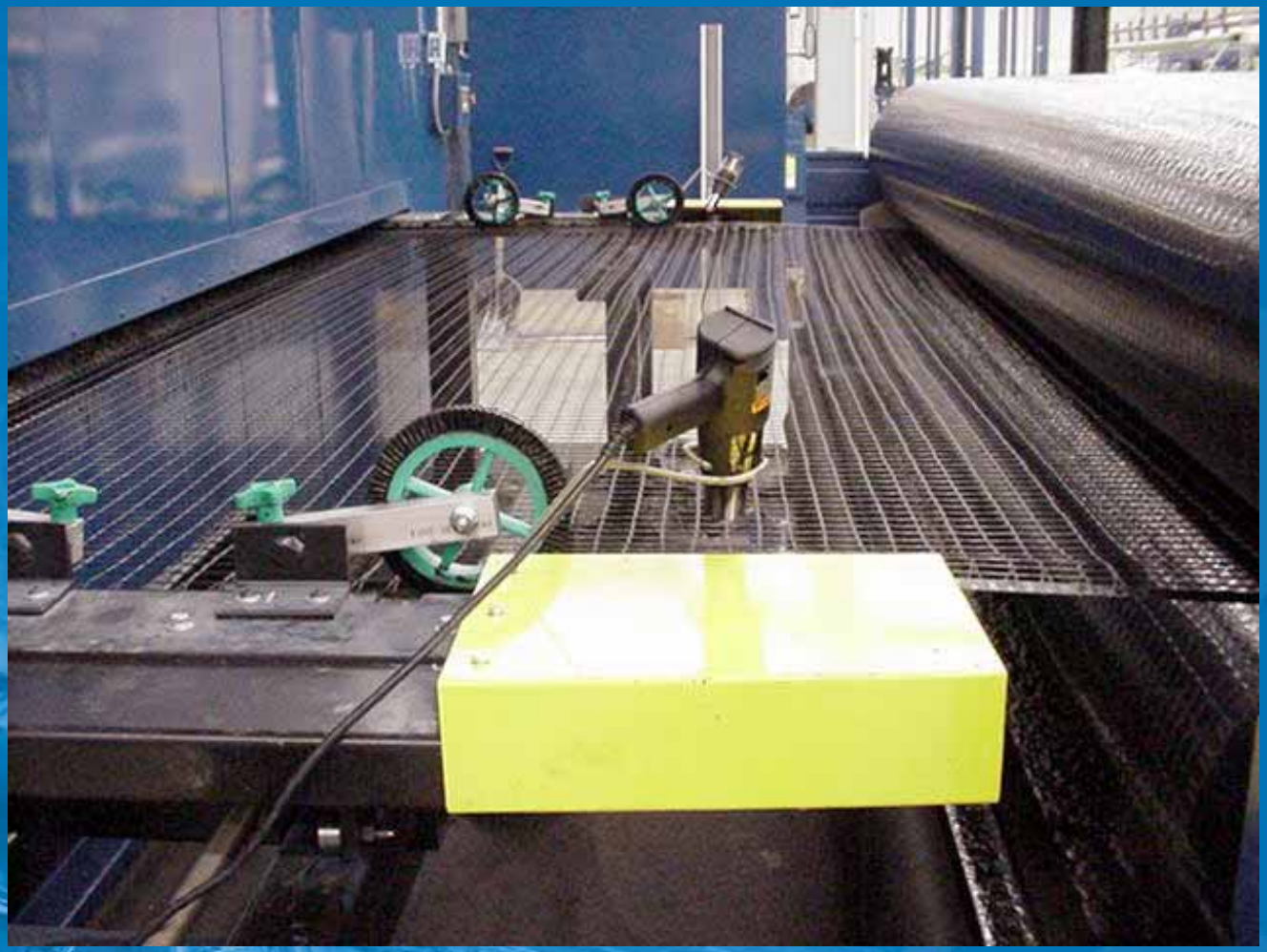
Geogrids

- Open grid-like structures, made of extruded polypropylene (U.S. patent), rubber coated polypropylene, PVC coated polyester, high density polyethylene, and laser welded polyester straps
- Used for reinforcement, aggregate interlock (snow fence, conveyor belts, mine and rock excavation covering, fish farming retention grids)

Polyester Yarn

Woven into Grid Pattern

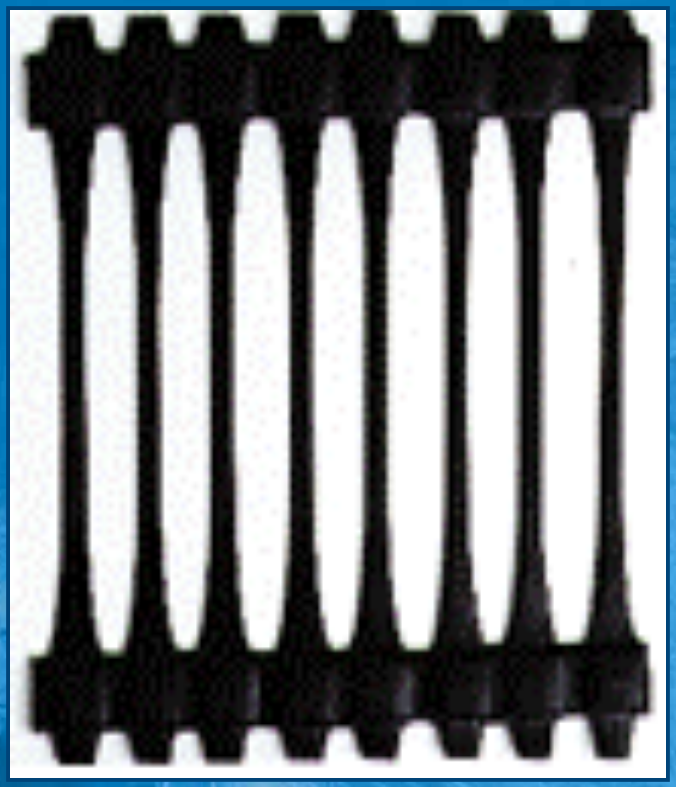
Coated with PVC

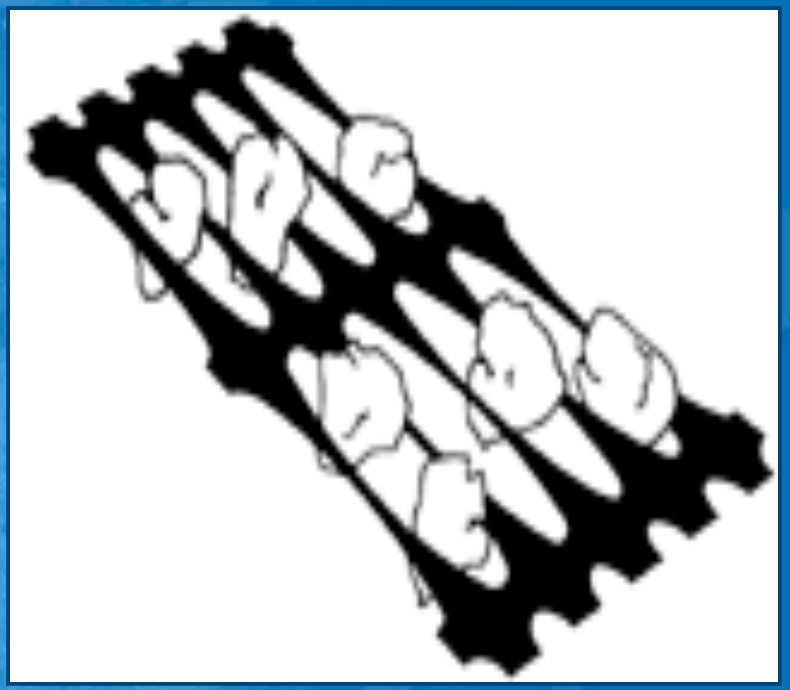


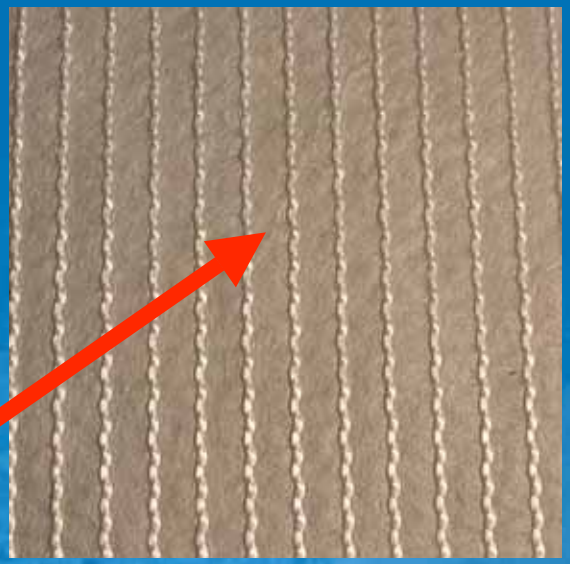
Tri-Packing Rolls

PVC Coated Polyester

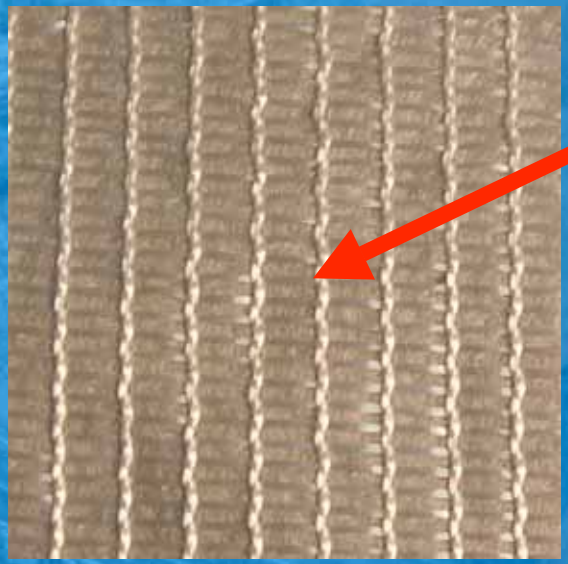
Extruded High Density Polyethylene







Uni-axial PEC



Bi-axial PEC

Geofoam

- Expanded Polystyrene
- Unit Weights between 1-3 pounds per cubic foot.
- Soil Unit Weight between 120-140 pounds per cubic foot
- Cost is $35-$45/cubic yard (1ft. thick x 4 ft x8 ft. piece costs $50

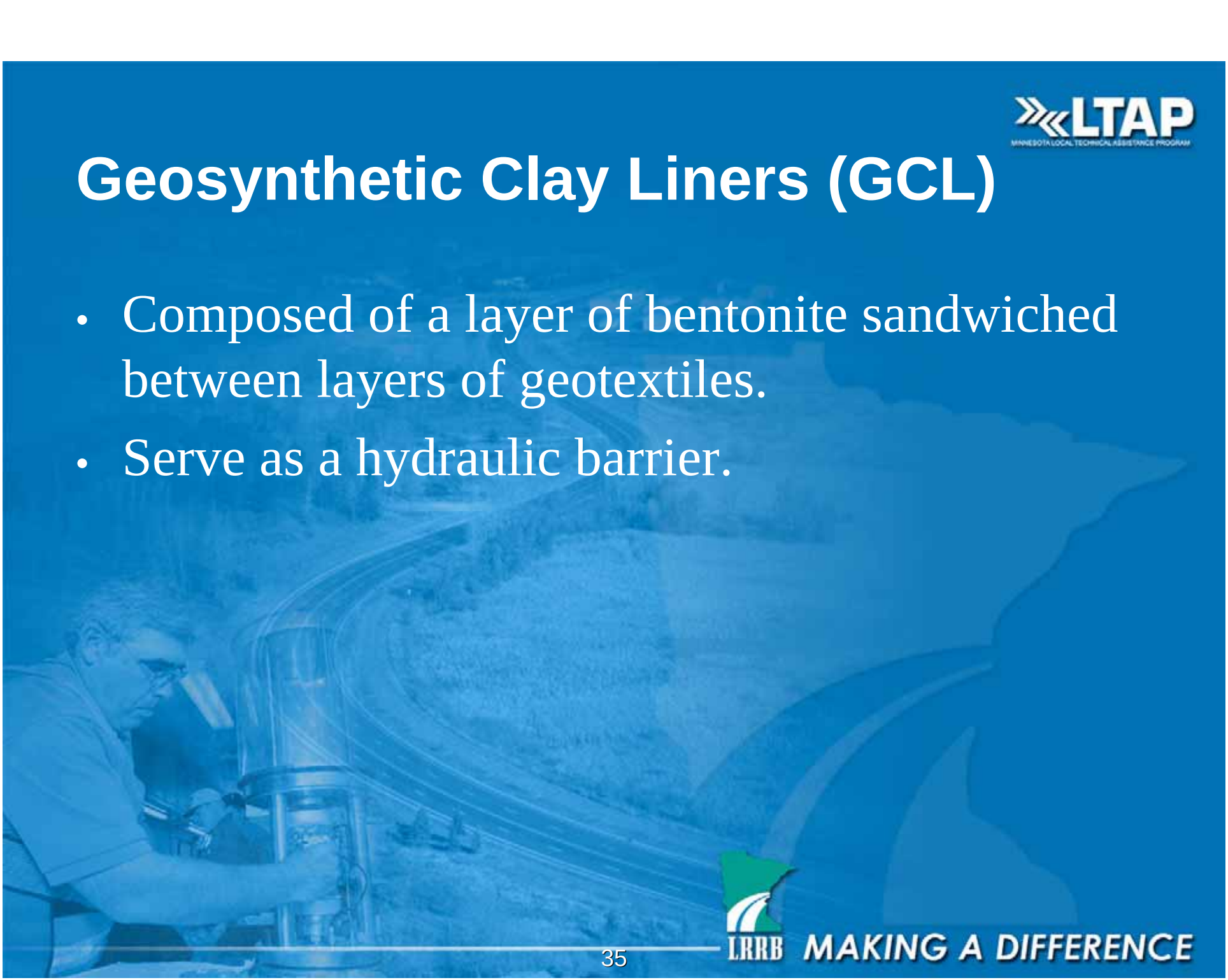
GEOFOAM-Hwy. 99, Southern MN

Geomembranes

- Impervious sheets of High Density Polyethylene, Linear Low Density Polyethylene, Poly Vinyl Chloride,
- Used to contain fluids
- Roads over MSE walls with metal reinforcement require a liner to reduce salt infiltration

Geosynthetic Clay Liners (GCL)

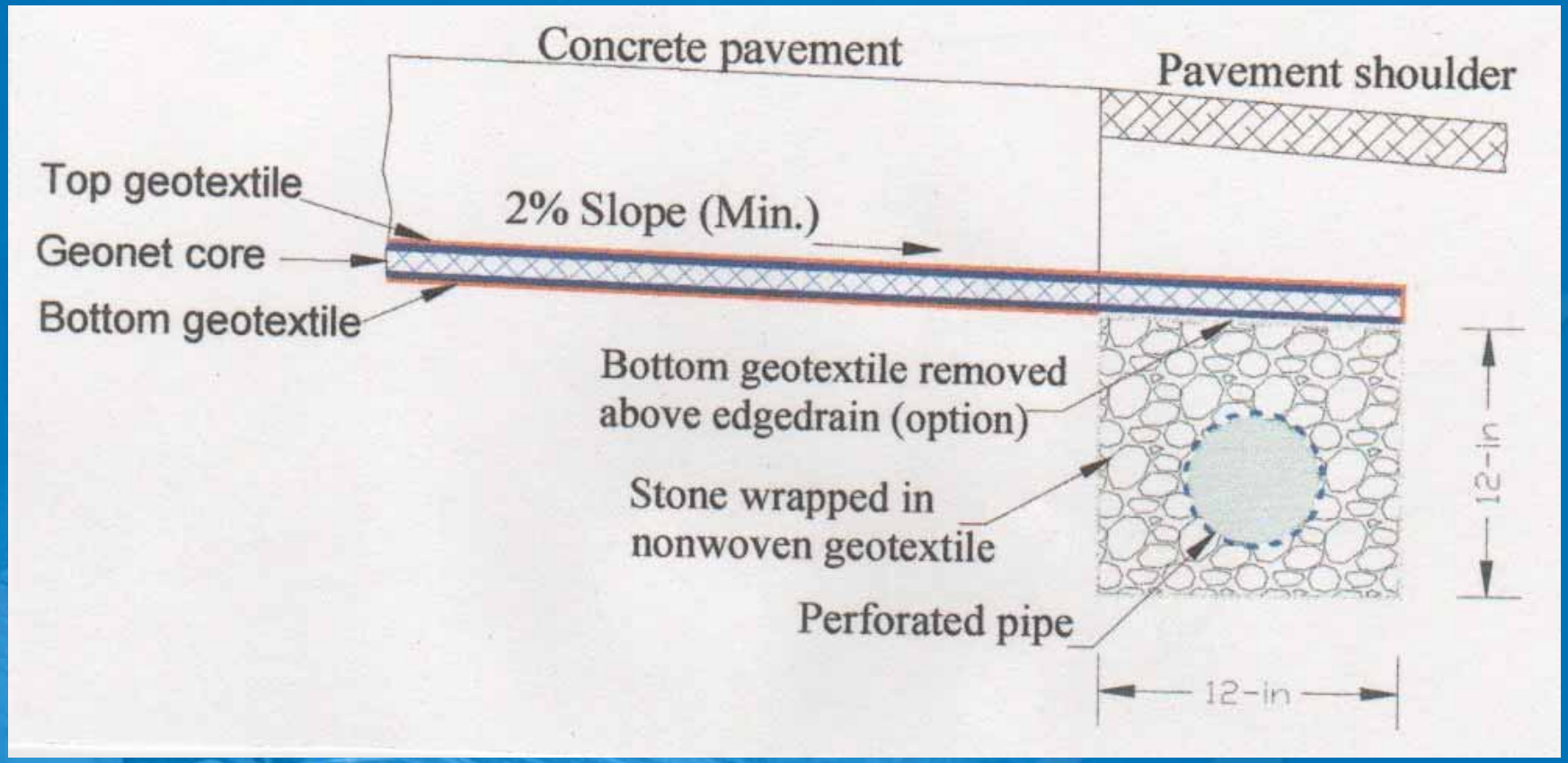
- Composed of a layer of bentonite sandwiched between layers of geotextiles.
- Serve as a hydraulic barrier.



Geonet and Other Composites

- Composed of a three dimensional structure of high density polyethylene sandwiched between one or two layers of needle punched Nonwoven or monofilament geotextiles

Geonet



Securing Dowel Baskets

Must have high compressive strength core.

Concrete Paver Tracks on Roadrain

Curb & Gutter

The finished project…

Laboratory Testing ASTM D-35

Properties of geotextiles and geogrids:

- Strength (Grab, Puncture, Tear, and Wide Width)
- Elongation
- Construction survivability
- Apparent opening size
- Permittivity / permeability

Wide-Width Tensile (ASTM D-4595)

Elongation

- Geotextiles will typically stretch (or elongate) more than geogrids will
- Polypropylene and Polyethelene stretch more than Polyester
- Non-woven geotextiles will typically stretch more than woven geotextiles
- It is important to look at the strength of the chosen material at various percent elongation (modulus) with respect to the anticipated strain of the underlying soil

Permittivity

Apparent opening size (AOS)

- Used to judge compatibility with the soil
- An AOS of 100 means that 95 % of glass beads with a size of the U.S. No. 100 sieve passed through the geotextile.
- THE AOS value should also be checked against the D_{85} (soil particle size for which 85% are smaller – in mm) of the soil

From Berg, 1997, Table 5-2 and pg 158

Permittivity / Permeability

- The permeability of the geotextile must be greater than that of the surrounding soil to function as a filter.
- Permittivity = Permeability of geotextile / geotextile thickness. Expressed in units of gallons per minute per square foot of the geotextile

Acceptance

- Check geotextile for proper identification and packaging
- Geotextile shall not be left exposed to the elements for more than 7 days
- The geotextile shall be inspected for uniformity in thickness, texture, and appearance
- Reject if the criteria is not met

From MnDOT Inspector's Job Guide for Construction, 2006 Edition

Section 3733.3: Certification, sampling, and testing

Section A: CERTIFICATE OF COMPLIANCE

- Along with each shipment of geotextile, a Certificate of Compliance shall be furnished by the supplier in accordance with 1603.
- This certificate shall be accompanied by a document stating the manufacturer's minimum average roll values (MARVs) for the geotextile. (MARVs are two standard deviations below the mean value of all rolls tested.)
- In addition, the manufacturer shall maintain test records and make them available to the Engineer upon request.
- A copy of the Certificate of Compliance must accompany each geotextile sample sent to the Materials Laboratory for testing.

From MnDOT Standard Specifications for Construction, 2000 Edition

Section 3733.3: Certification, sampling, and testing

Section B: SAMPLING AND TESTING

- Geotextiles must be sampled and tested prior to use, except in special circumstances with the Project Engineers approval.
- In the presence of the Engineer, sampling shall be by random selection in the field at the rate of one swatch (sample) per ten rolls or fraction thereof, or one swatch per 15 000 m (50,000 feet) of perforated pipe or fraction thereof.
- Swatches shall be full roll width and at least 1 m (yard) long (discard first 1 m (3 feet) of fabric from outside of roll) or 3 m (10 feet) long for pipe wrap.
- Samples shall be available for testing at least 21 days prior to intended use. Seam samples shall be at least 2 m (6 feet) long, in addition to the regular sample, and be joined in a manner and with a machine the same or equal to that to be used on the Project.

From MnDOT Standard Specifications for Construction, 2000 Edition

Why do we use Geosynthetics?

- Separation
- Reinforcement
- Filtration
- Drainage
- Liquid barriers

Where would we use these?

Geo-Type	Separation	Reinforcement	Filtration/ Drainage	Liquid Barrier
Geotextile	X	X	X	
Geogrid		X		
Membrane/ Liner	X			X
GCL	X			X
Geonet			X	

Where would we use these?

Geo-Type	Roadways	Slopes	Walls	Ponds / Landfills
Geotextile	X	X	X	X
Geogrid	X	X	X	X
Membrane	X			X
GCL				X
Geonet	X	X	X	X



Break Out Session #1

Material Identification

MAKING A DIFFERENCE

AASHTO M-288

- Subsurface Drainage Geotextile
- Silt Fence Geotextile
- Erosion Control Geotextile
- Separation Geotextile under Road

Mn/DOT Section 3733.1: Scope

- Type I - For use in wrapping subsurface drain pipe or for other specified drainage applications.
- Type II - For use in wrapping joints of concrete pipe culvert and as a cover over drain field aggregate.
- Type III - For use under Classes I and II random riprap, gabions and mattresses.
- Type IV - For use under Classes III and IV random riprap, hand placed riprap, and quarry-run riprap.
- Type V - For use in separating materials (stabilization).
- Type VI - For use in earth reinforcement and Class V random riprap.

From MnDOT Standard Specifications for Construction, 2005 Edition

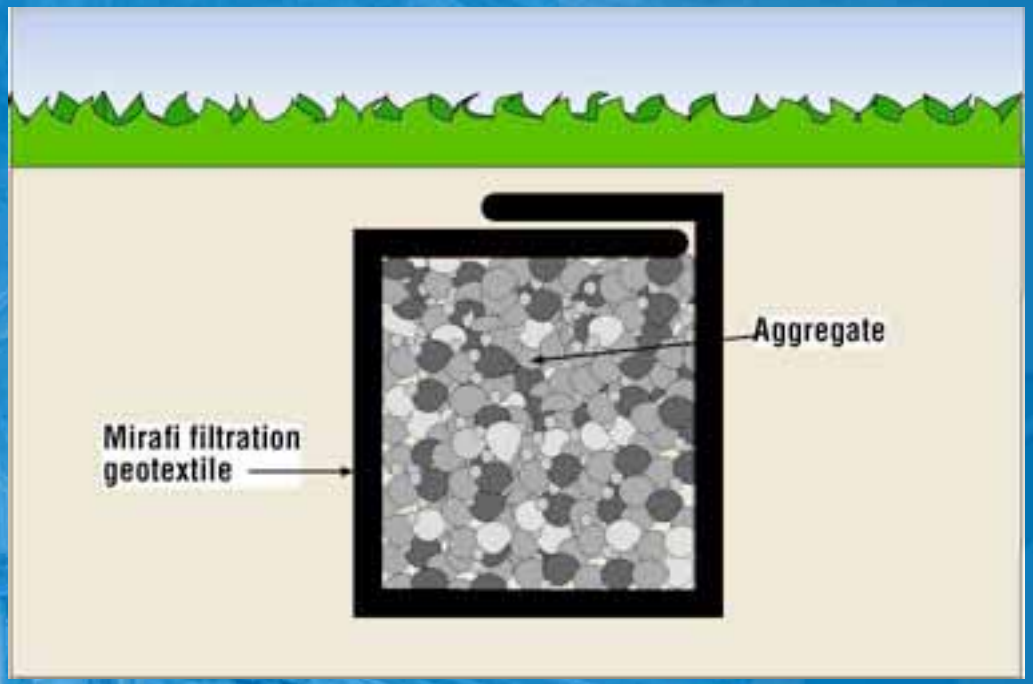
Pavement Drainage

Drainage and Filtration

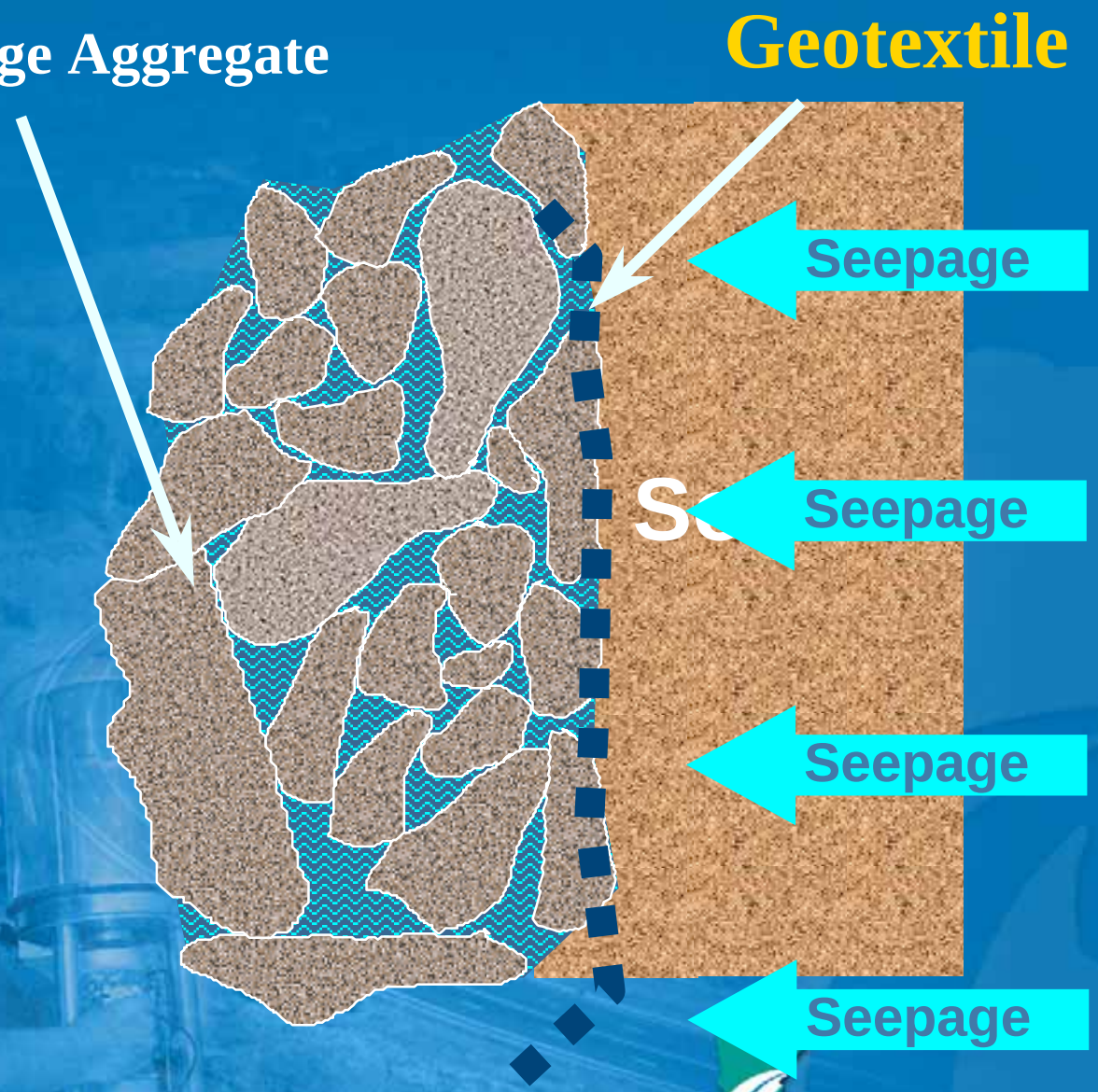
- fabric to soil system that allows for free liquid flow across or through the plane of the fabric over an indefinitely long period of time, while preventing soil loss (filtration).
- *filtration - *the ability of a geotextile to prevent excessive migration of soil particles*

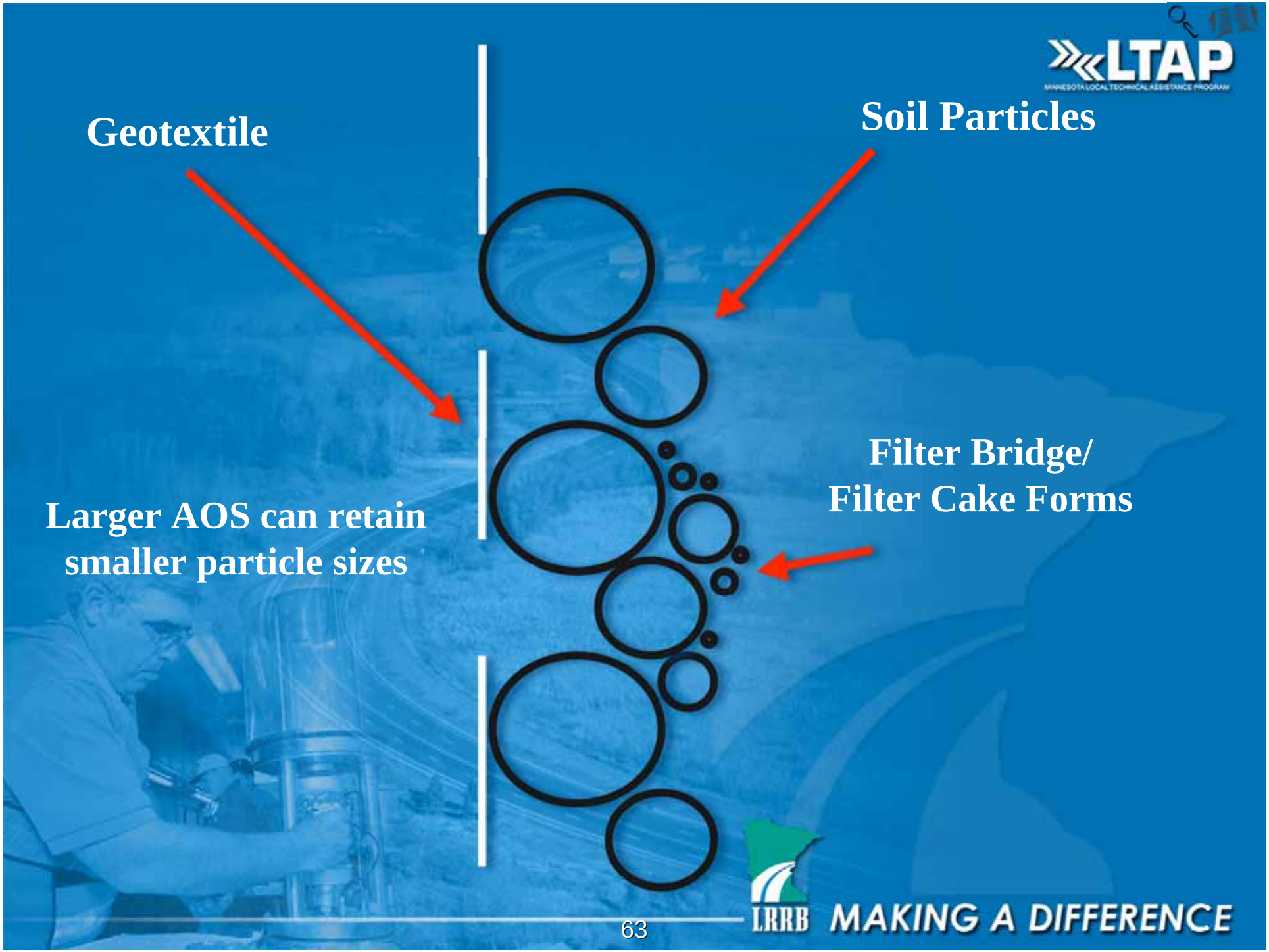
Basic Pavement Drainage

Separation - between soil and aggregate while allowing free liquid flow



Filtration




Geotextile
Soil Particles
Filter Bridge/
Filter Cake Forms
Larger AOS can retain
smaller particle sizes

Geotextile

Soil Particles Escaping

No Filter Bridge Forms

Too large an AOS Can Cause piping

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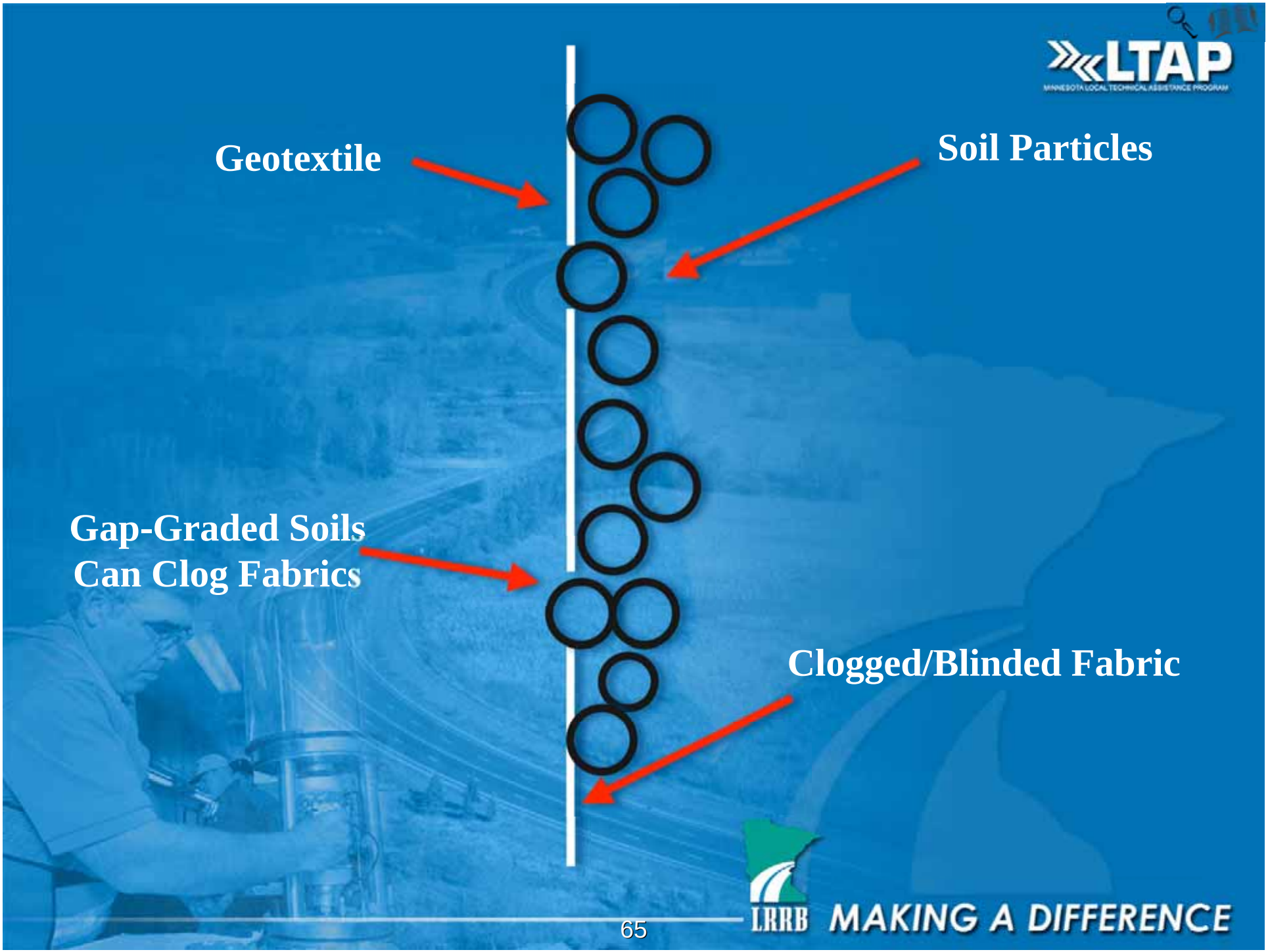

Geotextile
Soil Particles
Gap-Graded Soils
Can Clog Fabrics
Clogged/Blinded Fabric

Designing for Drainage/ Filtration

Step 1: Define the Application Filter Requirements

Step 2: Define Boundary Conditions

Step 3: Determine Soil Retention Requirements

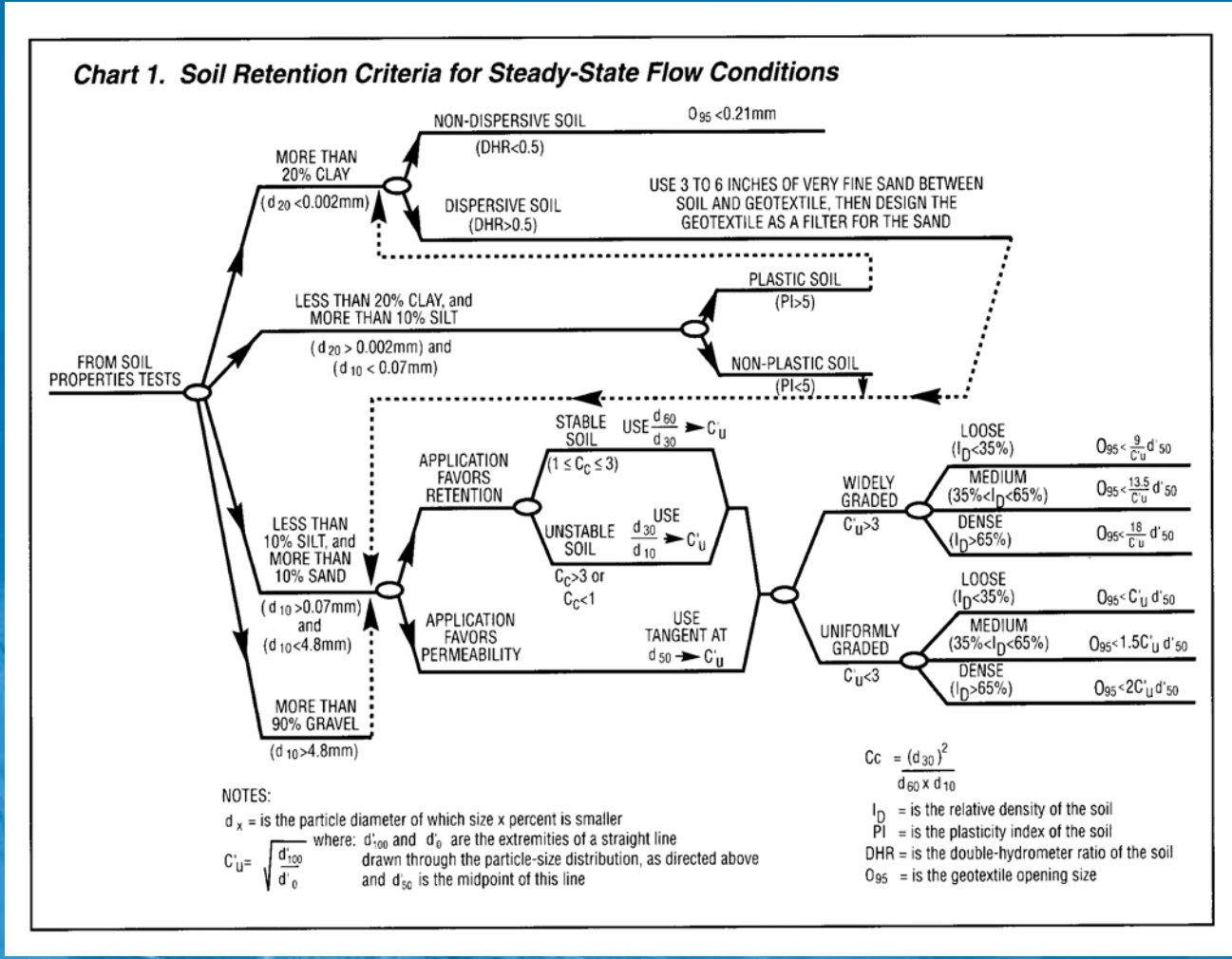
Step 4: Determine Permeability Requirements

Step 5: Determine Anti-Clogging Requirements

Step 6: Determine Survivability Requirements

Step 7: Determine Durability Requirements

Determine Soil Retention Requirements



Source: *Geosynthetic Design and Construction Guidelines*, FHWA

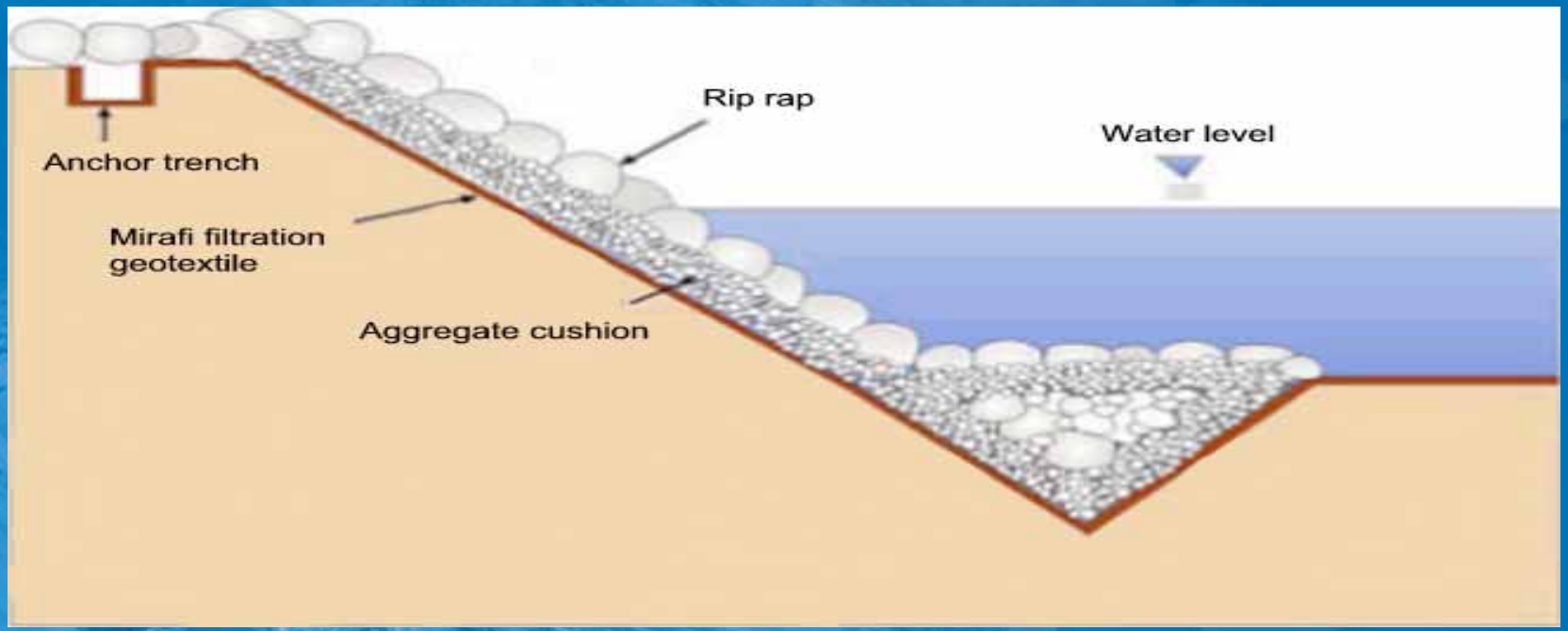
Erosion Control

Erosion Control Products

Basic Principle

Erosion Control Geotextile

Separation - between soil and riprap/armor protection while allowing free liquid flow both directions



Application: Under Riprap

Application: Monofilament Woven Under Revetment Systems

Benefits of Geotextile Erosion Control

- Resists clogging while maintaining high flow rate in dynamic flow and high gradient conditions
- Maintains separation of layers
- High survivability in aggressive installation conditions

Geosynthetics in Road Projects

- Type I - For use in wrapping subsurface drain pipe or for other specified drainage applications.
- Type II - For use in wrapping joints of concrete pipe culvert and as a cover over drain field aggregate.
- Type III - For use under Classes I and II random riprap, gabions and mattresses.
- Type IV - For use under Classes III and IV random riprap, hand placed riprap, and quarry-run riprap.
- ***Type V - For use in separating road base material from subgrade (light stabilization).***
- Type VI - For use in earth reinforcement and Class V random riprap.

From MnDOT Standard Specifications for Construction, 2005 Edition

Geosynthetics in Road Projects

- Unpaved Roads
  - Design Criteria is a ***2-inch rut***
- Design Formulas by
  - U.S. Forest Service
  - Bender and Barrenberg (Mirafi)
  - Giroud and Han (Tensar)

Geosynthetics in Road Projects

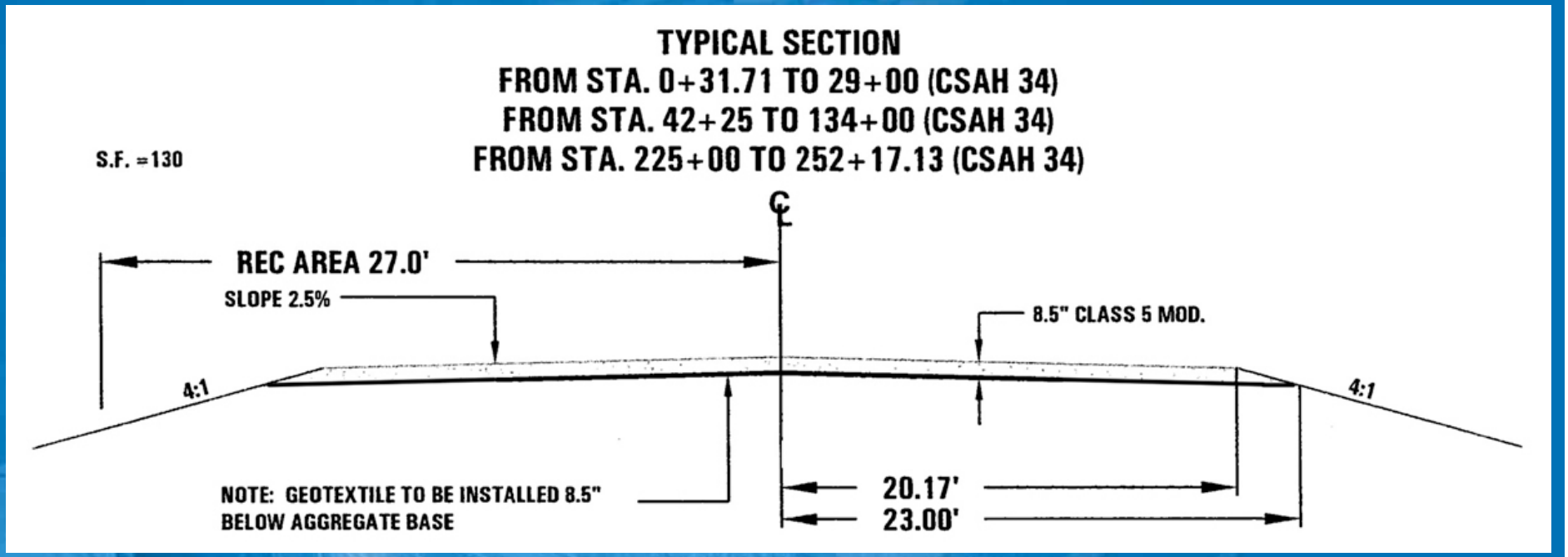
- Paved Roads
- The first lift of a paved road is an unpaved road. Design to stabilize pad and then Pavement Design by Mn/DOT procedure.

AASHTO M-288

- Subsurface Drainage Geotextile
- Silt Fence Geotextile
- Erosion Control Geotextile
- Separation Geotextile
- THERE IS NO REINFORCEMENT GEOTEXTILE OR GEOGRID IN AASHTO OR IN MN/DOT SPEC 3733, 2005 EDITION

R > 10, CLAY OR SILT SUBGRADE- USE SEPARATION GEOTEXTLE-MnDOT Type V
R > 10, SAND SUBGRADE- NO SEPARATION GEOTEXTILE NEEDED

Typical Section



Hwy. 55-Buffalo

Geotextile for separation

Studies by Federal Highway Administration (FHWA), Transportation Research Board (TRB) & Geosynthetic Research Institute (GRI)

- Geotextile separator preserves layer separation under traffic
- Geotextile separated pavements last longer than no geotextile
- Separation Geotextile must have openings small enough to prevent the migration of subgrade fines into the base.
- Separation Geotextile openings must be large enough to not adversely affect the flow of water either up or down.
- Separation Geotextile must be strong enough to survive installation without ripping.

Basis for Pavement Reinforcement- MnDOT Type VI

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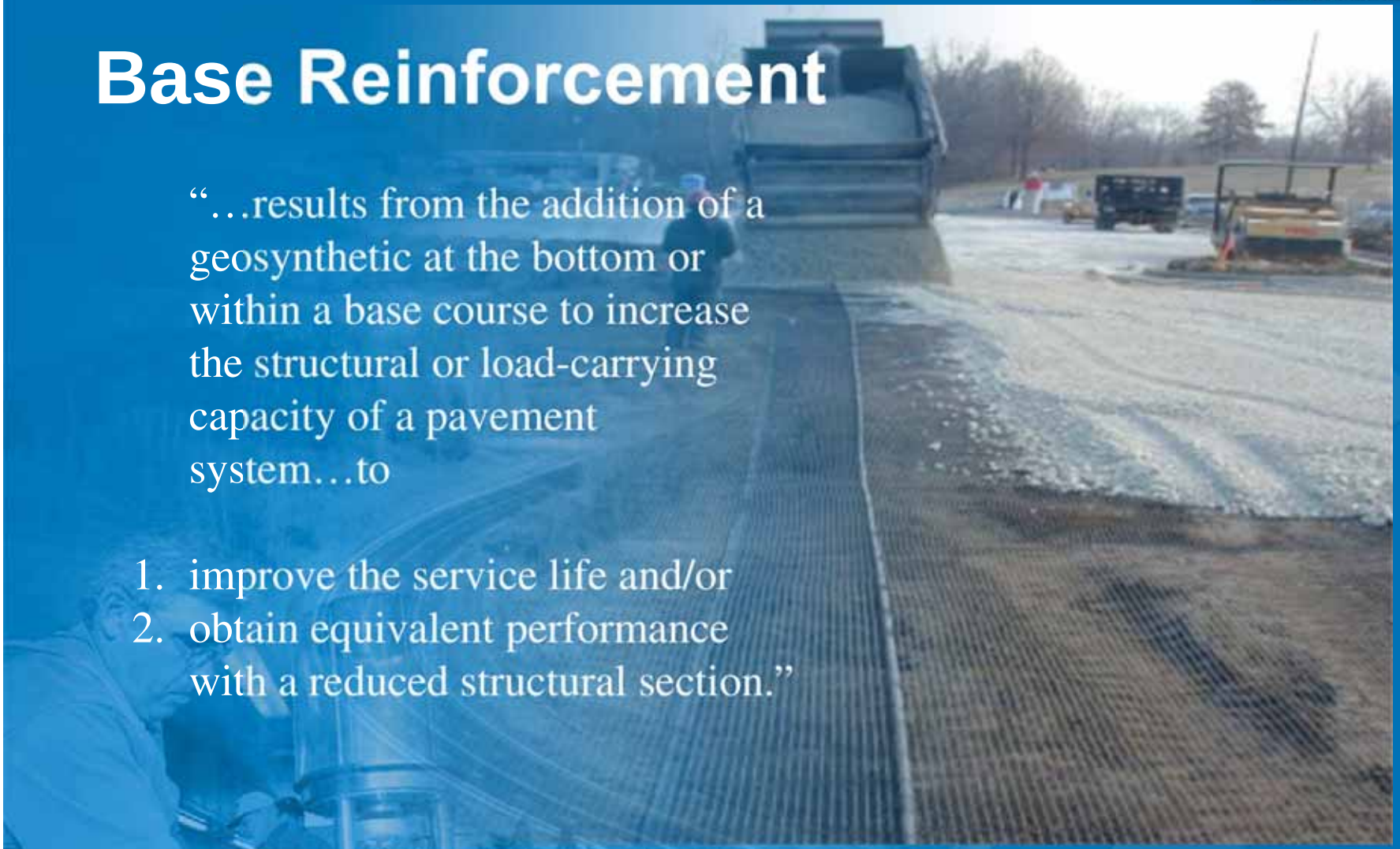
Geosynthetic Reinforcement
Applications

- Base Reinforcement on Firm Subgrade
- Sub Base Stabilization on Soft Subgrade

Base Reinforcement



"…results from the addition of a geosynthetic at the bottom or within a base course to increase the structural or load-carrying capacity of a pavement system…to

1. improve the service life and/or
2. obtain equivalent performance with a reduced structural section."

Base Reinforcement Benefits

Geosynthetic placed as a tensile element at the bottom of or within a base aggregate

- Improves service life
- Obtains equivalent performance with reduced section
- Reduces undercut, disturbance of subgrade
- Reduces aggregate required for stabilization

Subgrade Stabilization Benefits

Geosynthetic placed as a tensile element at the interface of a base aggregate/subgrade or the interface of a granular subbase/subgrade

- Improves service life
- Obtains equivalent performance with reduced section
- Reduces undercut, disturbance of subgrade
- Reduced aggregate required for stabilization
- Provides access & constructability over very soft soils
- Helps to establish a well-compacted, non-yielding platform - uniform support

Geosynthetic Stabilization
Mechanisms

I. Lateral Restraint on Firm Subgrade

II. Bearing Capacity Increase on Soft Subgrade

III. Tension Membrane Support on Soft Subgrade

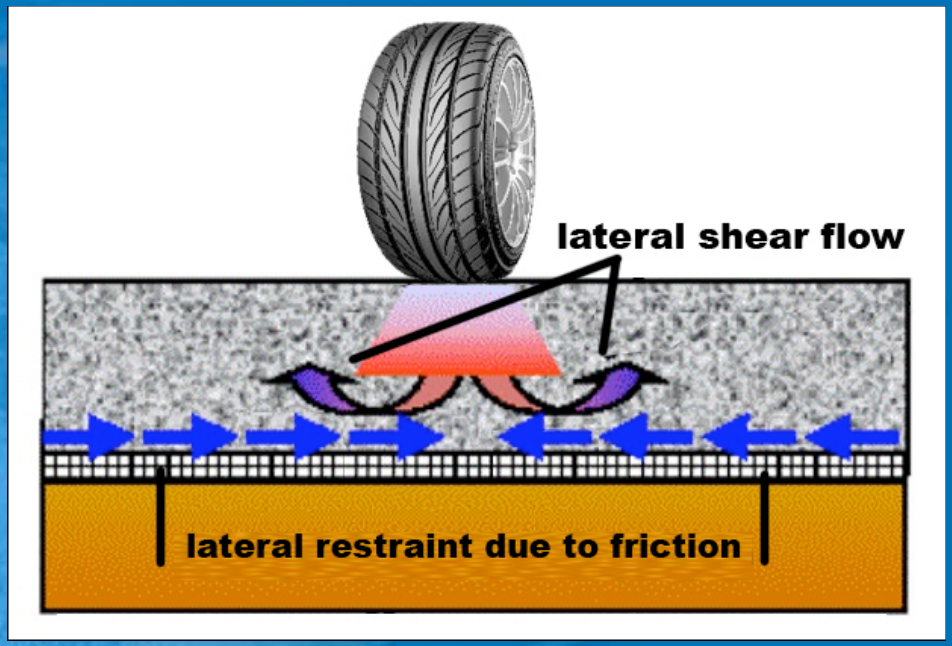
I. Lateral Restraint on Firm Subgrade

Restraint of the lateral movement of base, or subbase, aggregate (confinement)

Increase in modulus of base aggregate due to confinement

Improved vertical stress distribution on subgrade due to increased base modulus

Reduced shear strain along the top of the subgrade

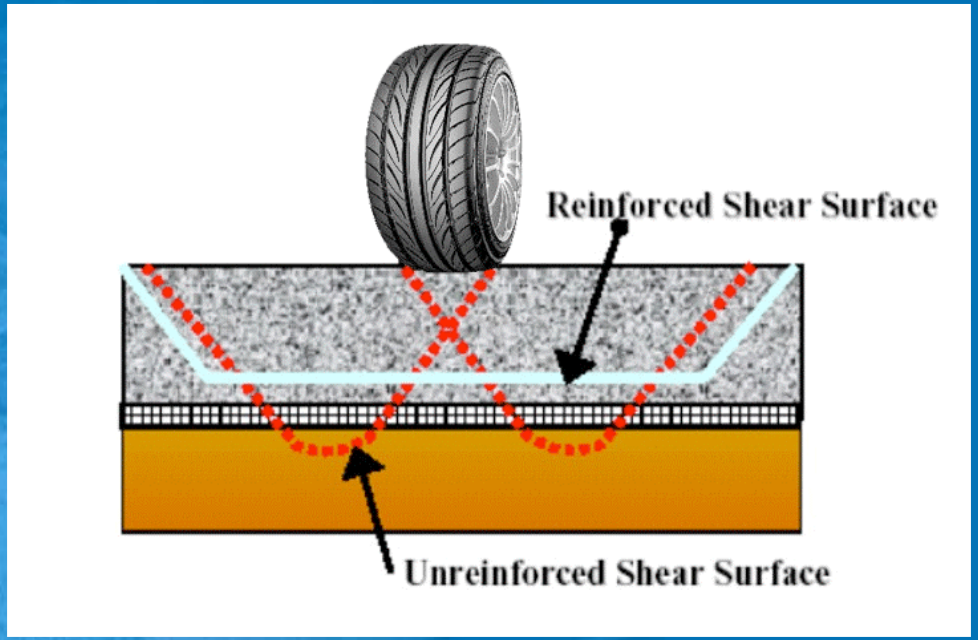


(From GMA White Paper II)

Lateral Restraint

II. Bearing Capacity Increase on Firm or Soft Subgrade

By forcing the potential bearing capacity failure surface to develop along alternate, higher shear strength surfaces.

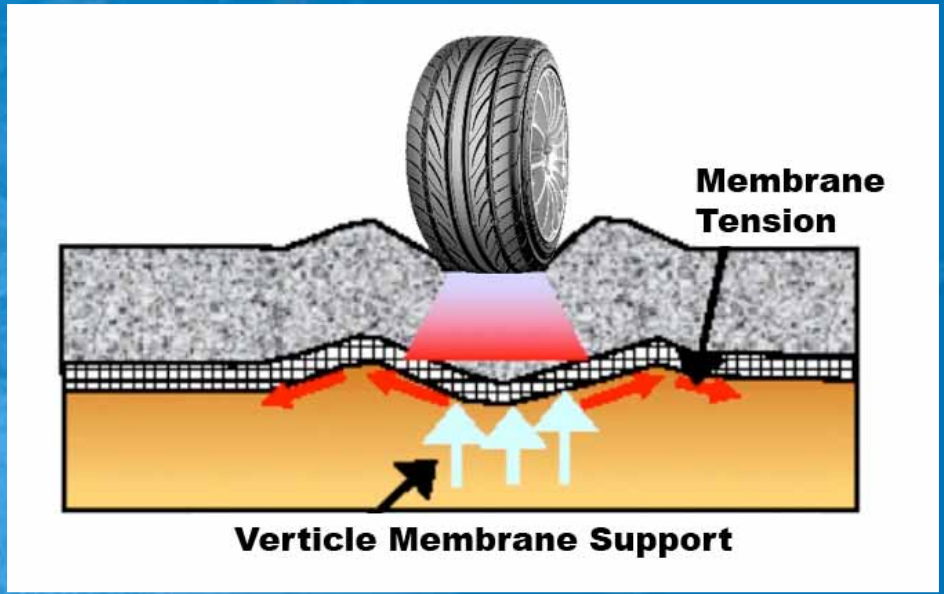


(From GMA White Paper II)

Bearing Capacity Increase

III. Tensile Membrane Support on Soft Subgrade

Mechanism mobilized under high deformation conditions.



(From GMA White Paper II)

Tension Membrane Support

Reinforcement Geogrids vs. Reinforcement Geotextiles vs. Separation Geotextiles

- Reinforcement geogrids are used to reinforce the aggregate base. They should be within the gravel section and within 10 inches of the pavement surface
- Reinforcement Geotextiles of high strengths should be placed on soft subgrade to separate and reinforce
- Separation Geotextiles should be used to separate clay and silt subgrades from the aggregate base

CBR > 3 USE GEOGRID WITHIN AGGREGATE LAYER Mn/DOT Type VI

Geogrids

Geogrids

Geogrids

Geogrid use with roadways

Geogrid use with roadways

Geogrid with Nonwoven Geotextile underlayment

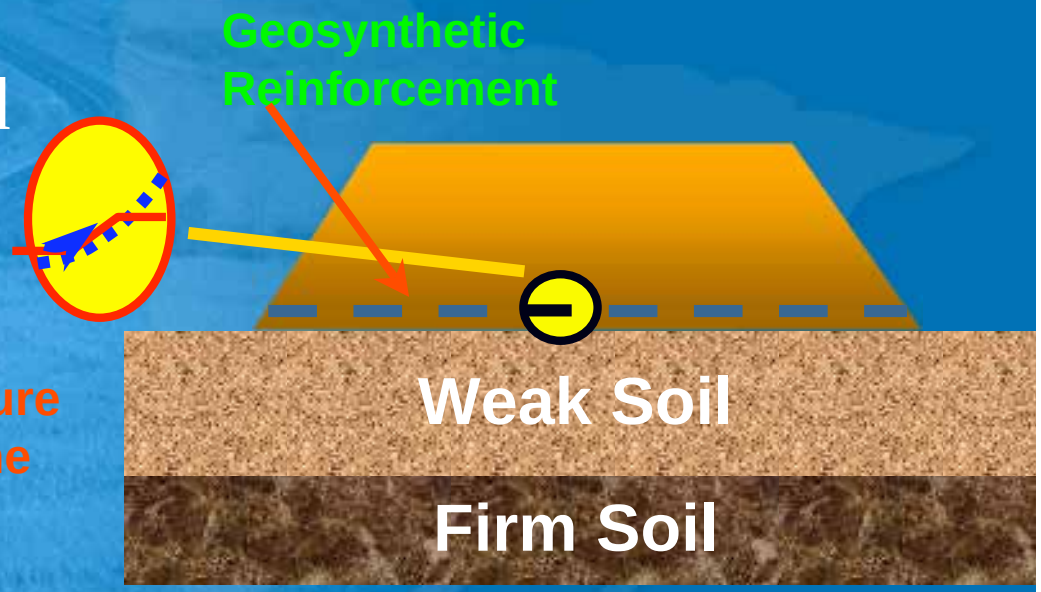
CBR < 3 Use a Reinforcement Geotextile Mn/DOT Type VI

HIGH STRENGTH GEOTEXTILE-UNIFORM OPENINGS ALLOW WATER TO PASS THROUGH AND HIGH STRENGTH FOR STABILITY MN/DOT Type VI

Geogrids Vs. High Strength Geotextiles

Considerations:

- Material Strength
  - Drained or Undrained
- Equipment Loads
- Bearing Capacity
- Limit Equilibrium
- Elastic Deformation
- Geotextile Modulus



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Sept. 2006 Iowa DOT Test Section

Background

The new interchange at the South end of the Sibley Bypass in Osceola County (Project Number NHSX-60-4(51)—3H-72) is located in a swamp area. Before the construction started, there was a deep layer of standing water during the spring. Of course, construction activities were very limited with this much water in place. Ditches were cut and trenches were placed to drain and pump the water away. Finally the area was dry enough to strip the topsoil. The design was to strip 2 ft. of topsoil and place 2 ft. of sand blanket back. Nevertheless, this means that there would be about 2 ft. of a silty clay layer left in-place. There is a concern on the performance of the new road.

Drains were cut into the subgrade

Pumps drained water out even during the August, 2006 drought

The Site was Graded

The original design helps dry out the area significantly. However, there is a 2 ft-layer of silty clay that has very low stability. Should this layer be excavated? Or is there another option?

Two geotextile options were selected for comparison: Option No. 1: place 2 ft. of the sand blanket on top of the geotextile.
Option No. 2: place 1 ft. of the sand blanket on top of the geotextile.

Reinforcement Geotextile Placed

A multifilament high strength geotextile with high permittivity was selected

Geotextile Deployed

- Strength (**ASTM D-4595**) & Permittivity (ASTM D-4491)

Filling over Geotextile

- Ground is Stable-No Mud Waves

Will Subgrade be Stable in the Spring

Wait for consolidation to occur before paving!!!

Embankment crossing soft ground-Reinforcement Geogrid or Reinforcement Geotextile?

Installation

Biaxial Geogrid Test Section

CMD = 95 lbs/inch @ 5% Strain

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Installation

Geotextile Test Section

CMD = 430 Strain lbs/inch @ 5%

Fabricated Panel 150 ft. x 540 ft.

Installation

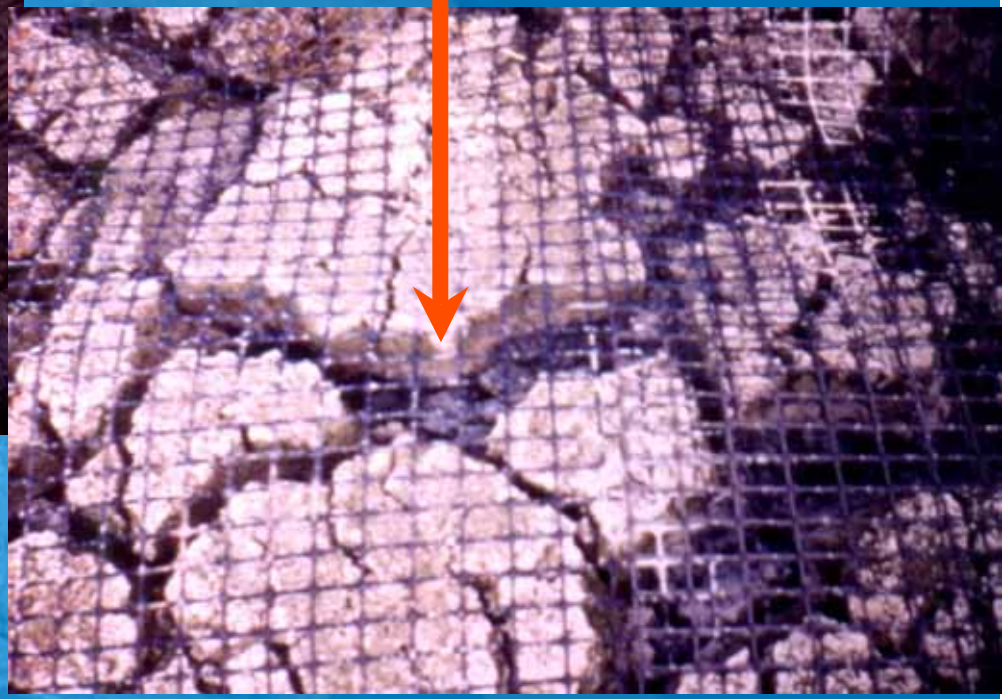
Sewn Seams

Double Row of Stitching = 250 lbs/inch

Installation

No snowshoe effect

Good Visibility



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Installation

Biaxial Geogrid no Separation

Geotextile good Snowshoe effect

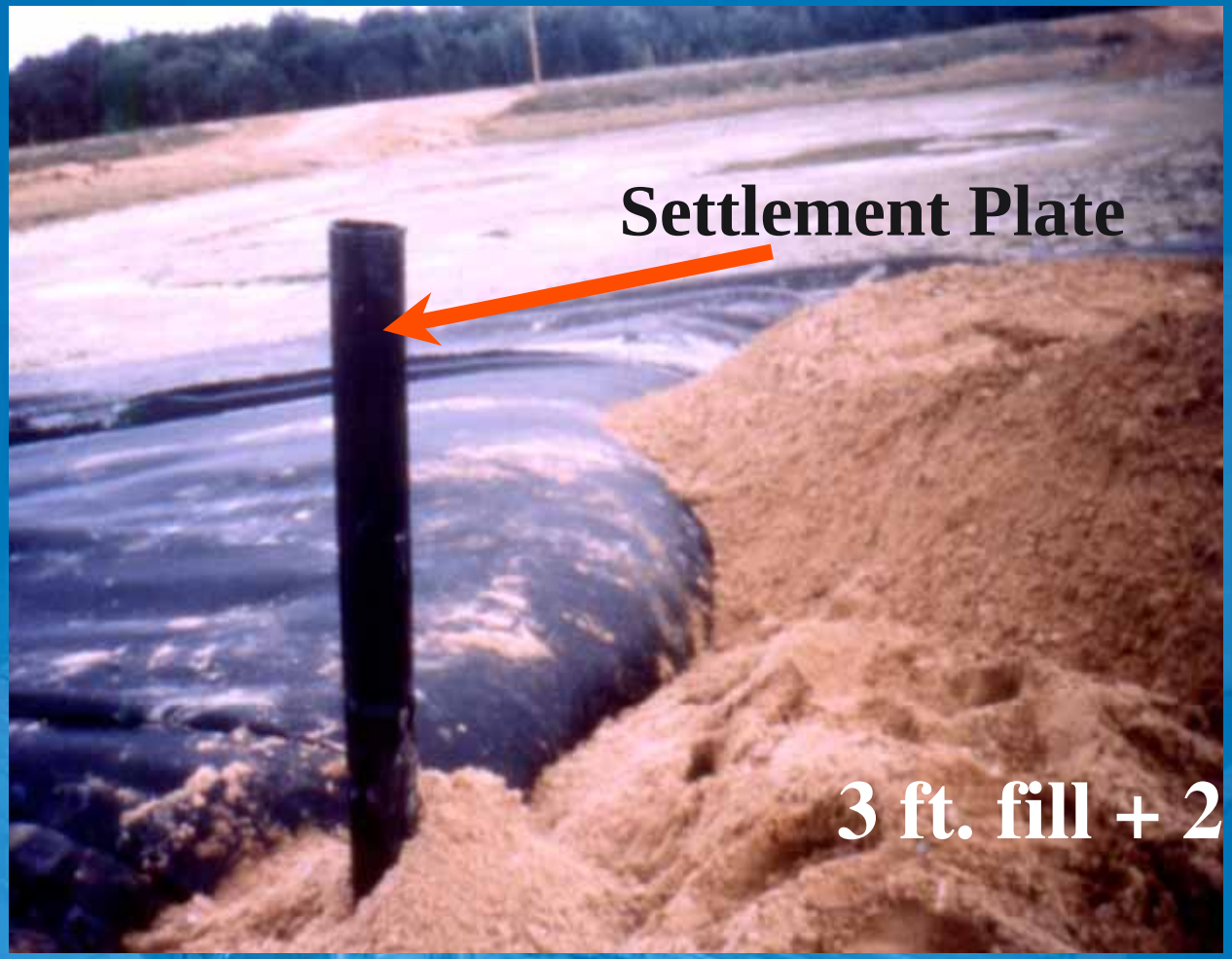
Installation

Initial Fill Placement

No Displacement

LRRB MAKING A DIFFERENCE

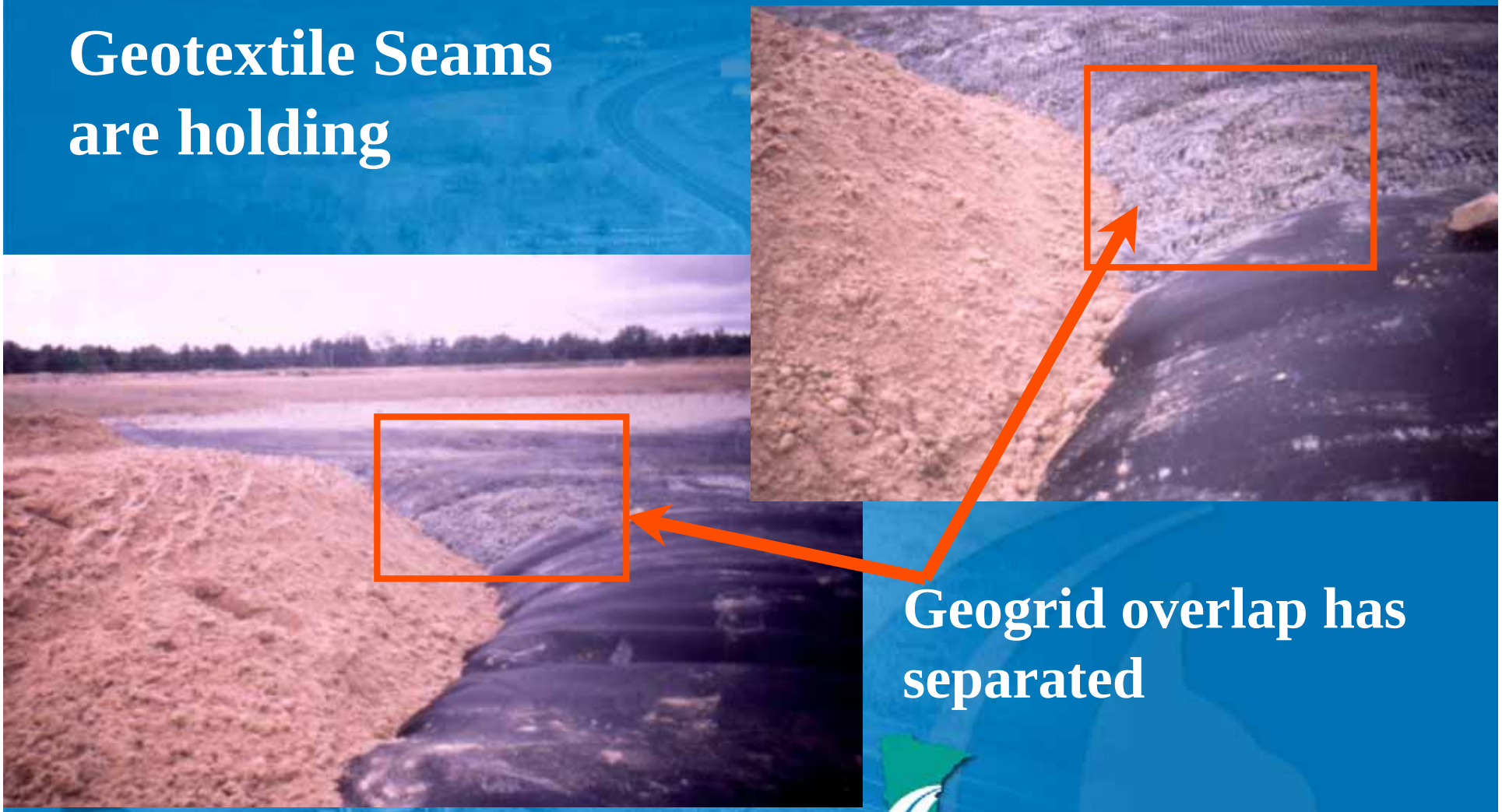
Installation



3 ft. fill + 2 ft. settlement

Installation

Geotextile Seams are holding



Geogrid overlap has separated

Installation

Biaxial Geogrid too stiff

Cellular Confinement
TH 72 Upper Red Lake

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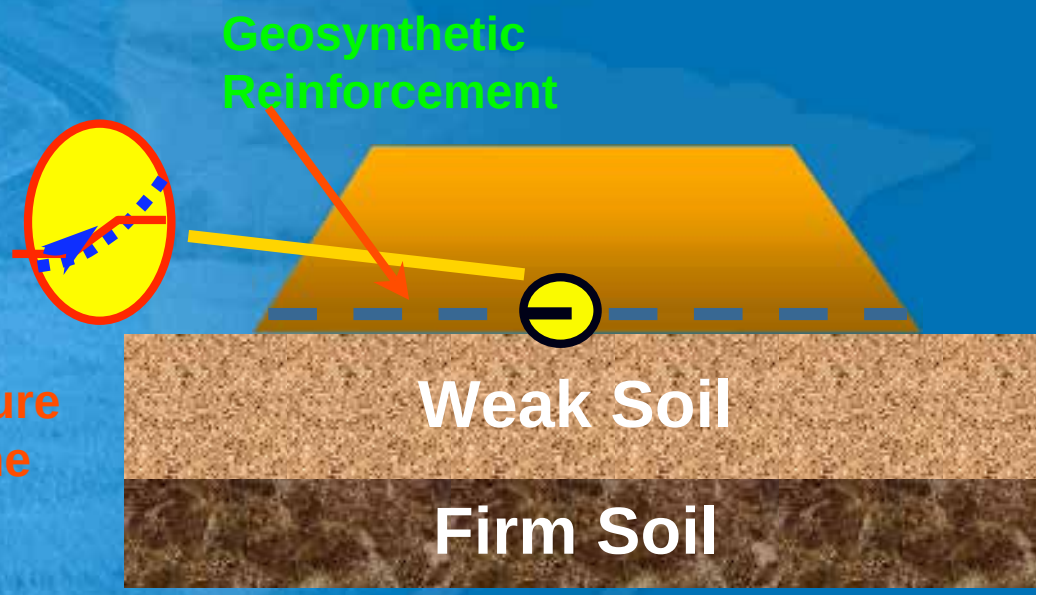
A separation geotextile was used for this road construction project. What went wrong??

The Right Way to have done it!!!

Geogrids Vs. High Strength Geotextiles

Considerations:

- Material Strength
  - Drained or Undrained
- Equipment Loads
- Bearing Capacity
- Limit Equilibrium
- Elastic Deformation
- Geotextile Modulus



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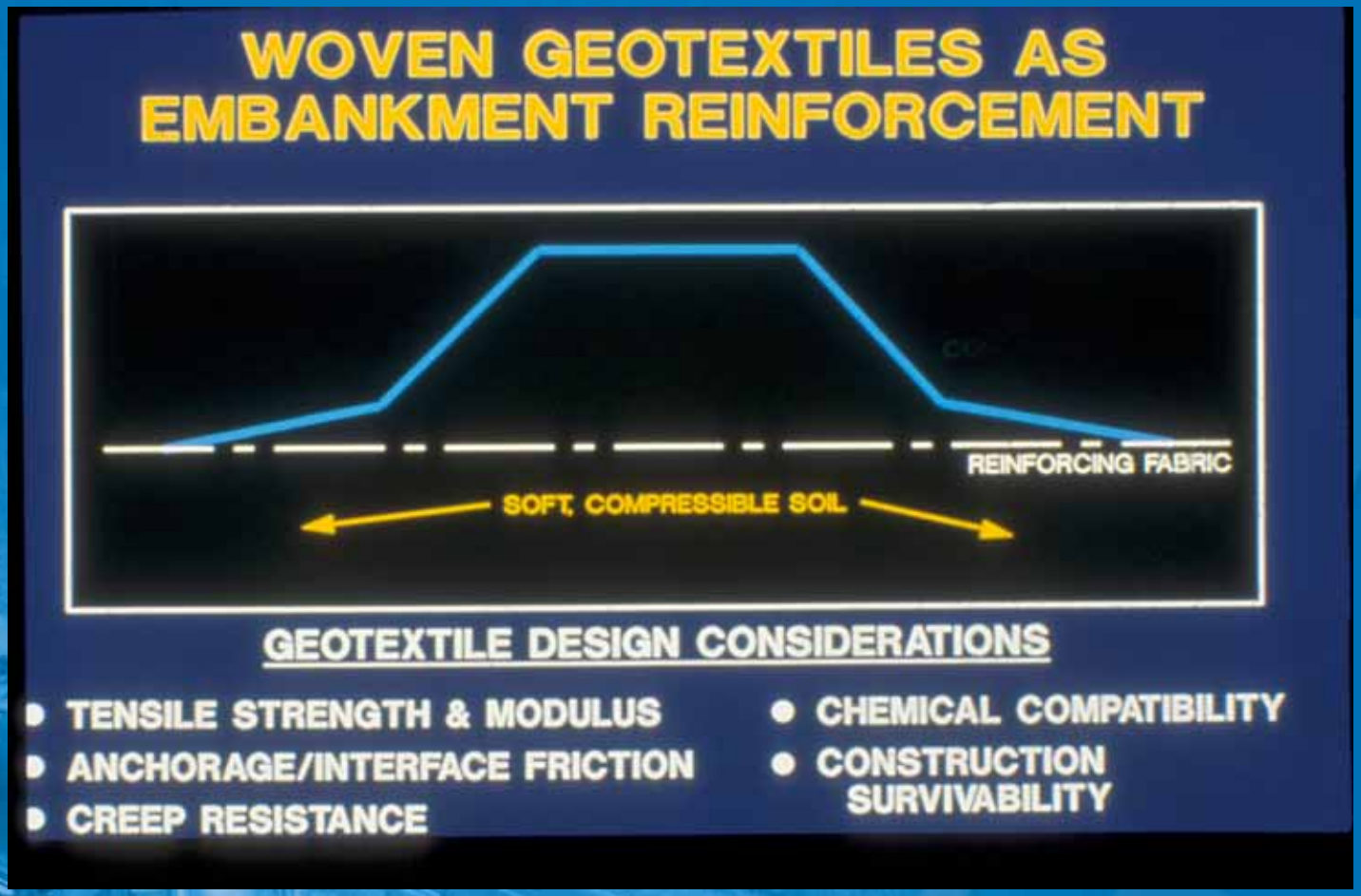
Embankment Design



Widening a Road Into a Pond

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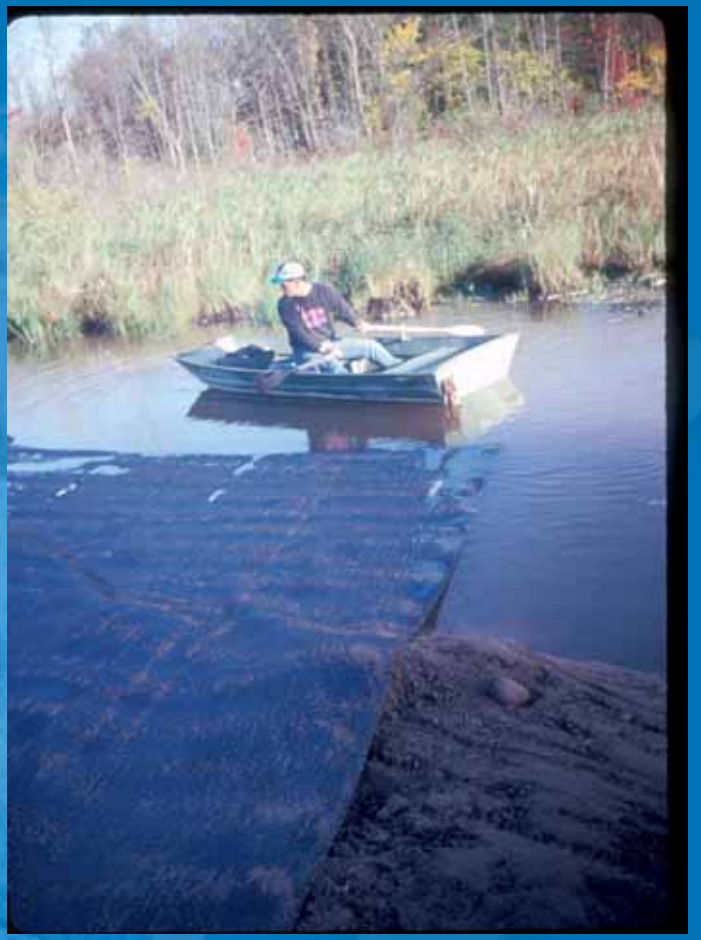
Mud Wave!!!!!!!!

Repair with HP Geotextile



Field Sewing of Panels

YOU CAN WALK ON WATER WITH HIGH STRENGTH-POLYPROPYLENE GEOTEXTILES

Geotextile use with roadways

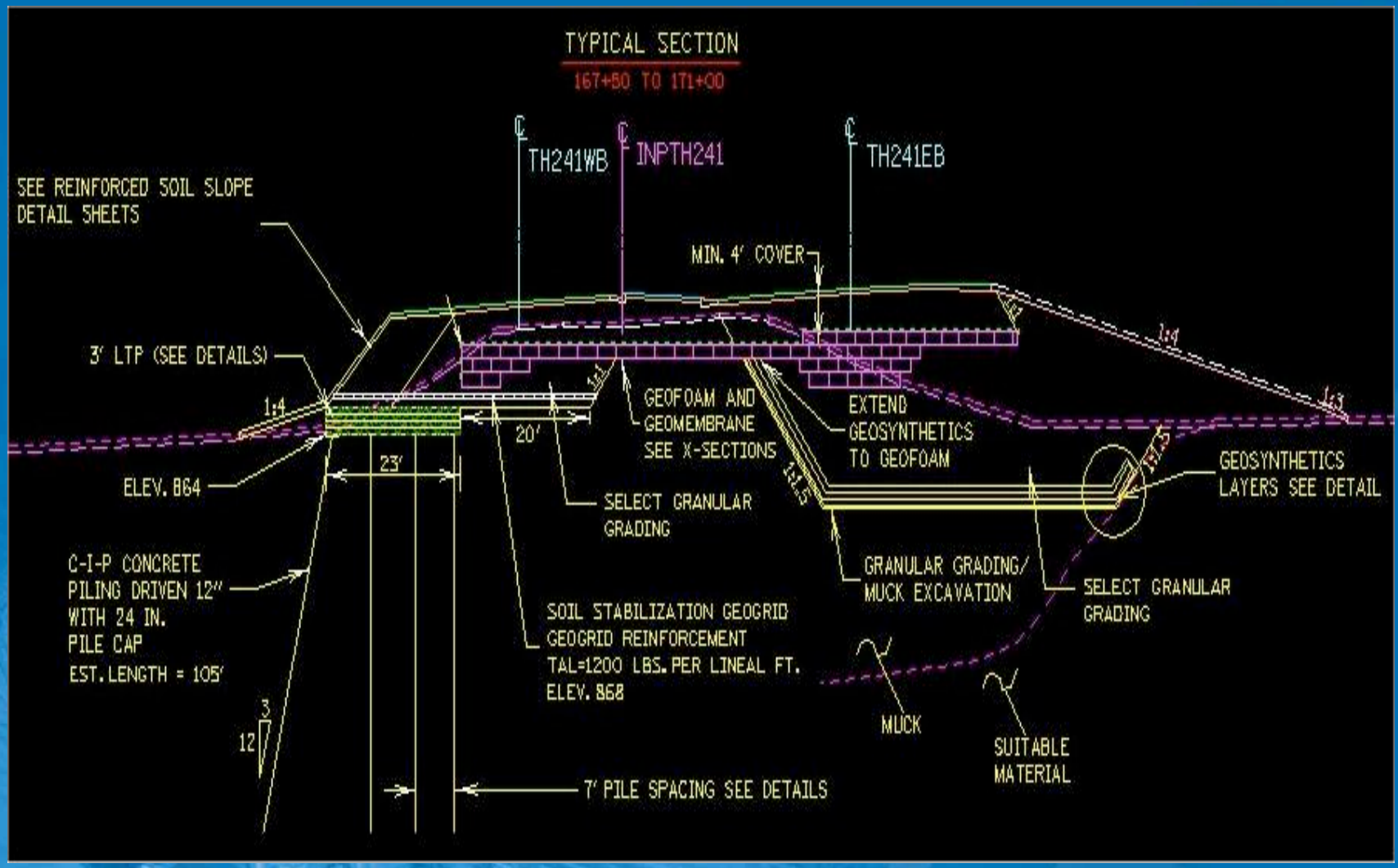
Geotextile use with roadways

Sewing

Sewing

Take trees out prior to construction…

Geotextile use with roadways


TYPICAL SECTION
167+80 TO 171+00
TH241WB
INPTH241
TH241EB
SEE REINFORCED SOIL SLOPE DETAIL SHEETS
MIN. 4' COVER
3' LTP (SEE DETAILS)
1:4
1:4
1:3
1:1.5
1:1.5
20'
23'
GEOFOAM AND GEOMEMBRANE SEE X-SECTIONS
EXTEND GEOSYNTHETICS TO GEOFOAM
GEOSYNTHETICS LAYERS SEE DETAIL
ELEV. 864
SELECT GRANULAR GRADING
C-I-P CONCRETE PILING DRIVEN 12" WITH 24 IN. PILE CAP
EST. LENGTH = 105'
GRANULAR GRADING/ MUCK EXCAVATION
SELECT GRANULAR GRADING
SOIL STABILIZATION GEOGRID
GEOGRID REINFORCEMENT
TAL=1200 LBS. PER LINEAL FT.
ELEV. 868
3
12
MUCK
SUITABLE MATERIAL
7' PILE SPACING SEE DETAILS

Geosynthetics in overlays

- Advantages of use:
  - Increase overlay and roadway life
  - Decrease roadway maintenance costs
  - Increase pavement serviceability
- Disadvantages of use:
  - Will not help much if existing roadway is structurally inadequate
  - Will not solve water problems, subgrade problems, freeze-thaw problems, or thermal cracking problems

From Berg, 1997, Chapter 6

To Overlay or Not To Overlay

- Some controversy exists in using geosynthetics in overlays
  - May complicate mill and overlay operations
  - If improperly installed, can move-in-place and cause pavement cracks
- Future research needed in MN to resolve issues of benefits / drawbacks

Pavement Restoration



Pavement Restoration

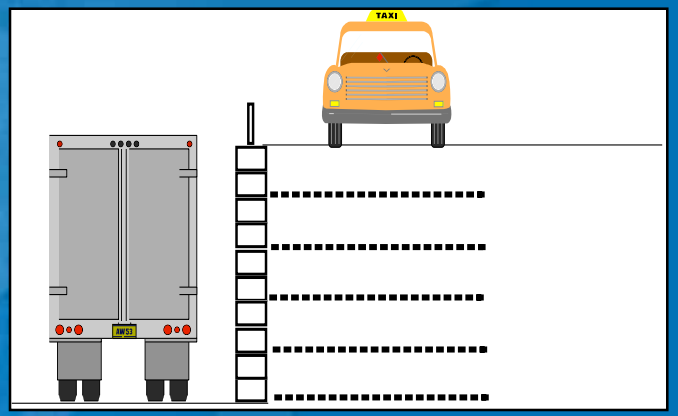
The addition of a geosynthetic fabric onto existing pavement to form an impermeable membrane that prevents the penetration of surface water through the pavement and also provides a stress relieving layer which inhibits reflective crack growth.

Paving Fabric System

A polypropylene non-woven fabric, heat bonded on the surface and designed to accept the optimum quantity of asphalt cement to provide a moisture barrier and stress relief membrane layer

Grade Separation Structures

- Traditional Methods
  - concrete gravity walls
  - steel sheet piling
  - reinforced brick walls
  - pre cast concrete panel retaining walls
- Geosynthetic Solutions
  - Segmental Retaining Walls
  - Wrap-Face Retaining Walls
  - Vegetated –Faced Walls and Slopes
  - Web Faced Walls and Slopes
  - Gabion Faced Walls



Mechanically Stabilized Earth (MSE)

Mechanically stabilized earth walls and slopes are constructed with **"reinforced soil"** and consist of horizontal soil reinforcing elements including such things as steel strips, steel or **polymeric grids**, and **geotextile sheets** and a *facing* to prevent erosion.

Mechanically Stabilized Earth: an old experience

2,000 year old soil reinforcement by wood with stone facing

Mechanically Stabilized Earth: an old experience

Ziggurat: 3,300 years

Clay reinforcement with straw

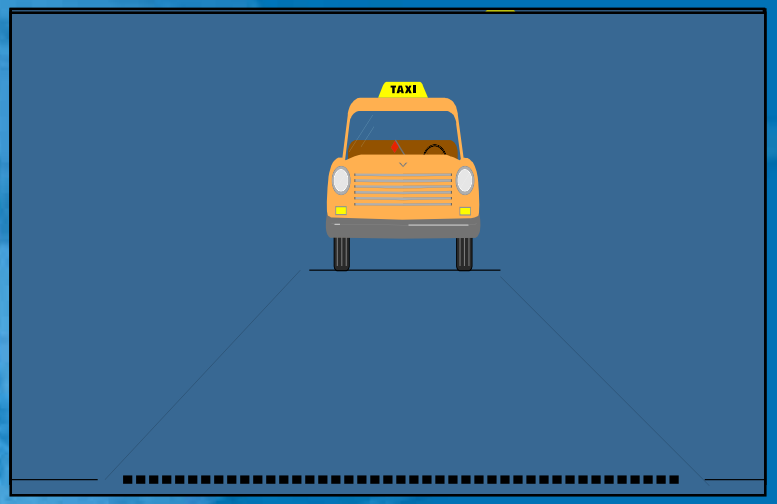
Mechanically Stabilized Earth: an old experience

1976 : Prapoutel, France

1970 : Rouen, France

Mechanically Stabilized Earth (MSE)

- Mechanically Stabilized Earth Walls (MSEW)
- Reinforced Soil Slopes (RSS)



Mechanically Stabilized Earth (MSE)

- Mechanically stabilized earth walls (MSEW)
- A face inclination greater than, or equal, to 70 degrees from horizontal
- Includes multiple planar layers of man-made reinforcing elements that act as reinforcement for soils placed as infill materials.

Mechanically Stabilized Earth (MSE)

- Mechanically stabilized earth walls (MSEW)
- Segmental Retaining Walls
- Wrapped Face Walls
- Temporary Retaining Walls

Wrapped Face Walls

Temporary Walls

Mechanically Stabilized Earth (MSE)

- Reinforced Soil Slopes (RSS)
- A face inclination less than 70 degrees from horizontal
- Includes multiple planar layers of man-made reinforcing elements that act as reinforcement for soils placed as infill materials

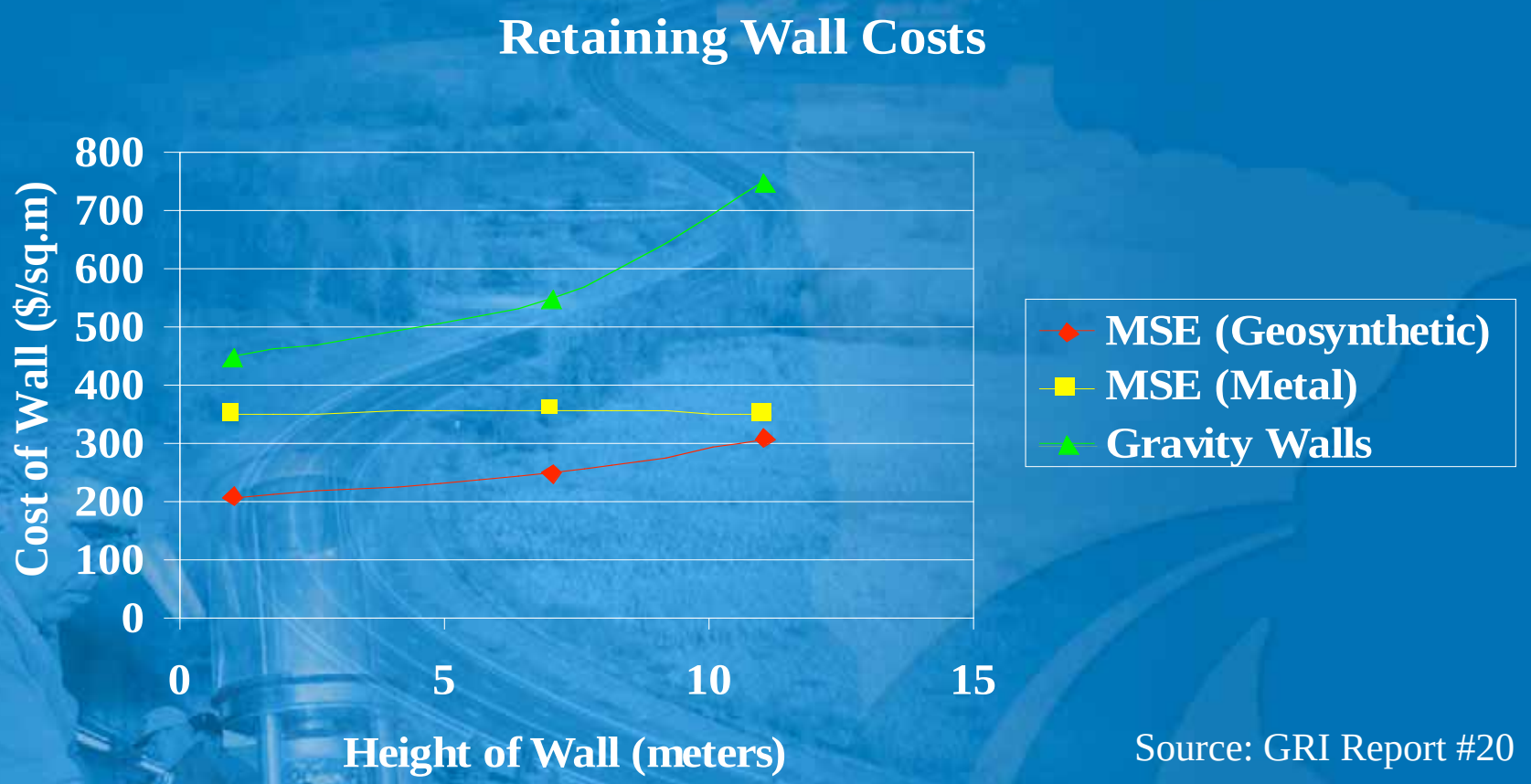
Wrapped Face Slopes

Vegetated Slopes

Mn/DOT Design Standards

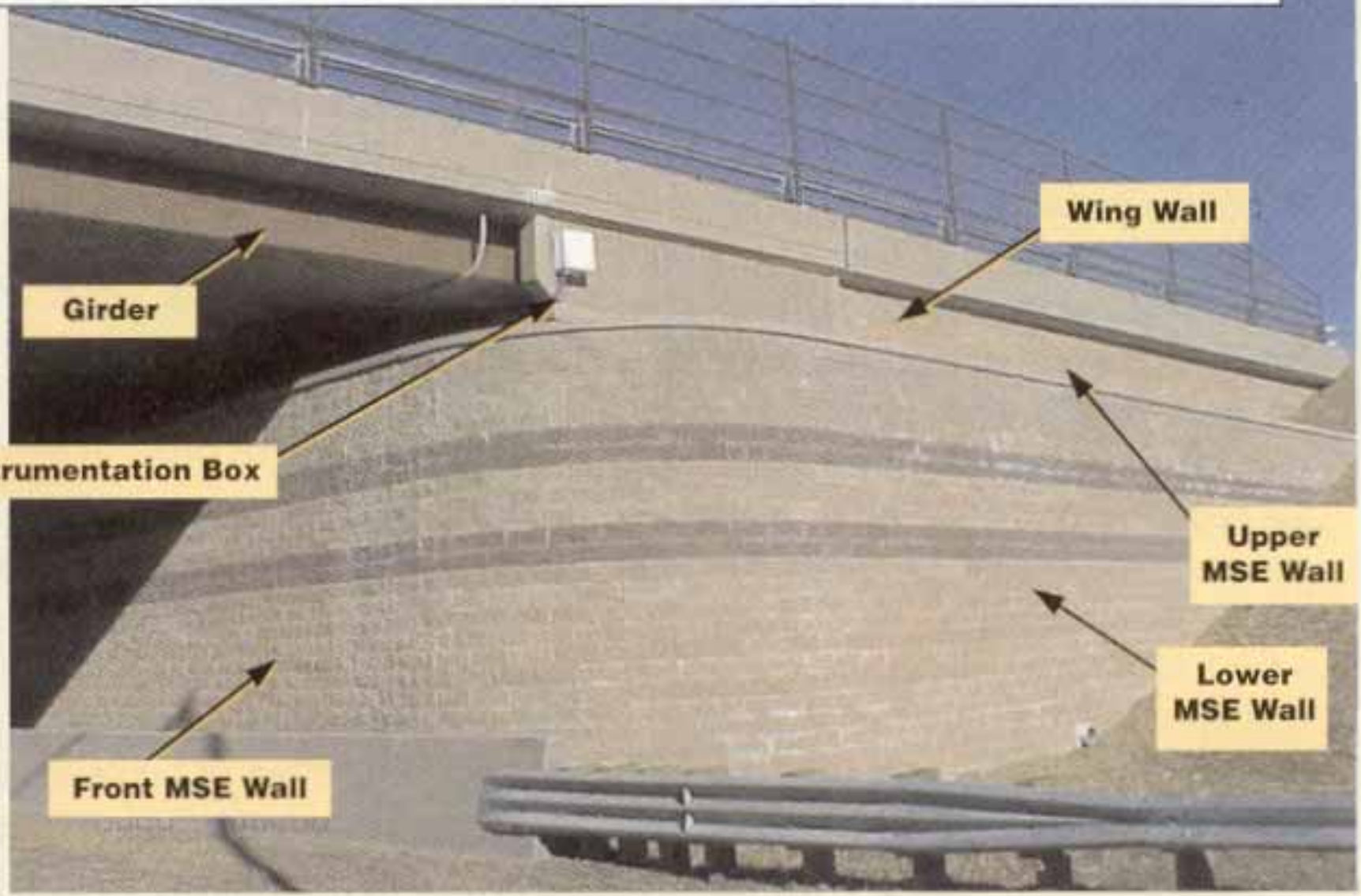
- MBW (Modular Block Wall)
- RSS (Reinforced Soil Slope)

Segmental Retaining Walls



Source: GRI Report #20

Photo 1. Segmental retaining wall (SRW) components of a completed bridge abutment.



Engineering

Properly engineered and installed RSS are works of art!

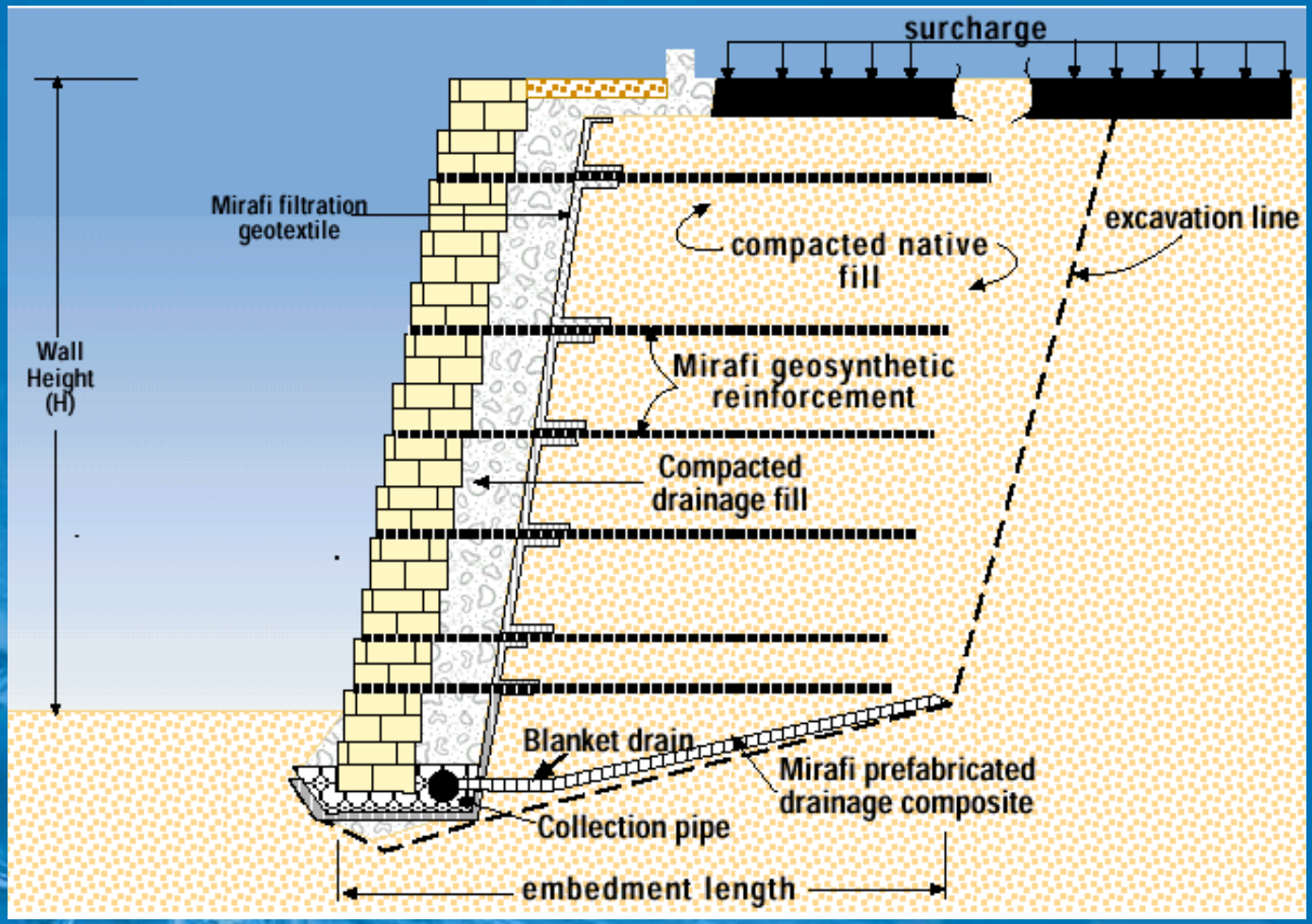
Engineering

Poorly engineered and installed RSS are a lot of work!

Key Components

- Engineering
- Geosynthetic Reinforcement
- Facing Material
- Installation

Geogrid Reinforcement



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Key Components

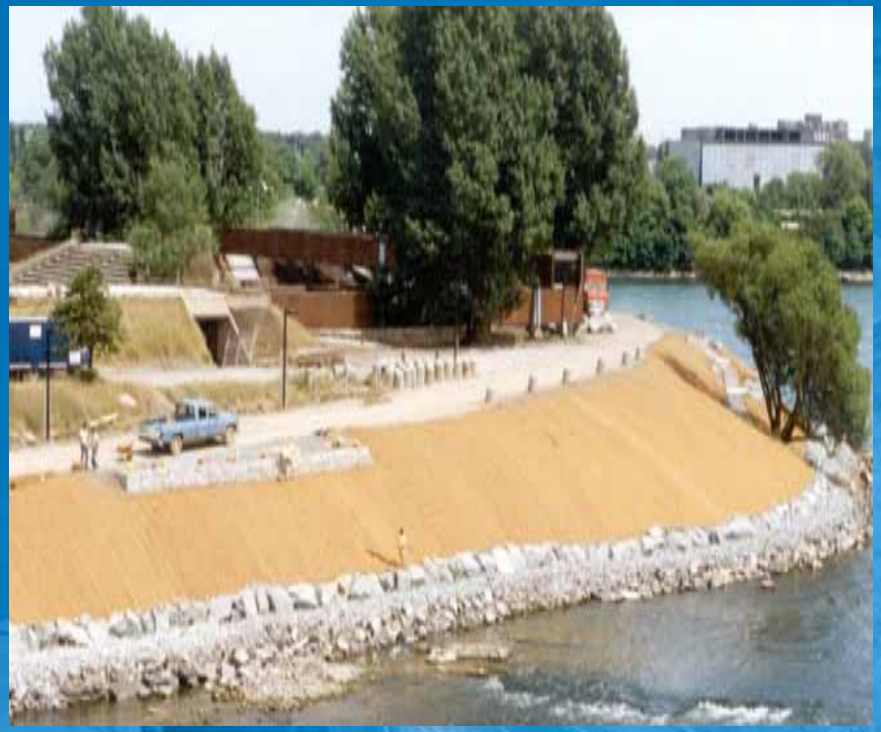
- Engineering
- Geosynthetic Reinforcement
- **Facing Material**
- Installation

Facing Options

SRW Unit

Open-face SRW Unit

Facing Options



Erosion Blanket

Cellular Confinement

Facing Options

Wire Basket

Gabion Basket Facing

Key Components

- Engineering
- Geosynthetic Reinforcement
- Facing Material
- **Installation**

Installation Issues

- Make sure engineered structures are engineered
- Make sure the correct geogrid is placed at the indicated location in the wall
- Make sure the embedment length of the geogrid is correct
- Make sure the orientation of the geogrid is correct
- Most geogrids should be rolled perpendicular to the slope/wall face
- Make sure the geogrid is tensioned before placing soil
- Drainage!, Drainage!, Drainage!
- Make sure facing is stable

Installation Issues

No reinforcement

Roll direction!

Installation Issues

Poor Compaction

Incorrect reinforcement

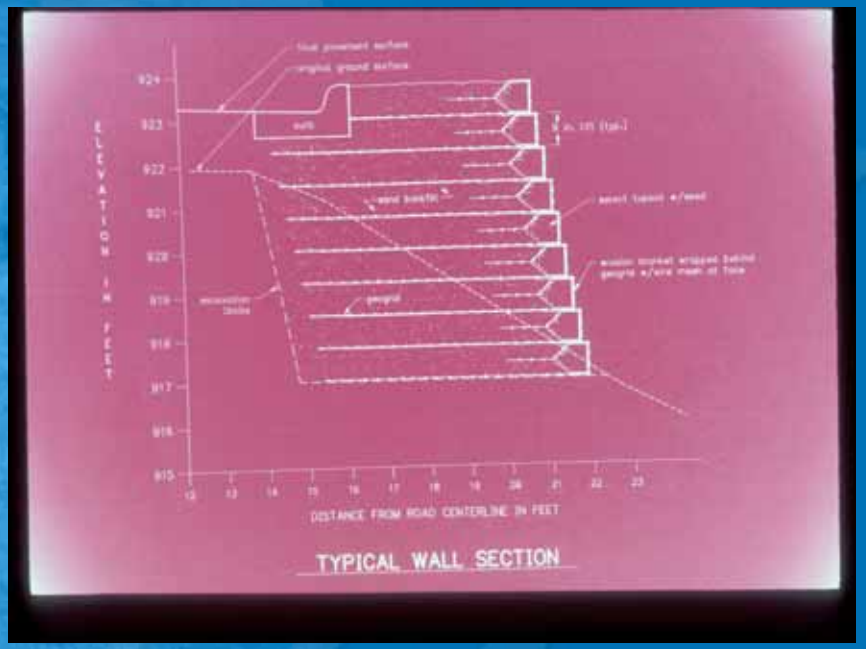
Installation Issues

Incorrect drainage

Reinforcement spacing

First State Aid Geogrid Reinforced Wire Basket Wall in MN

Edina, MN



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LTAP
MINNESOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

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Natural Look-View from Interlachen Golf Club

Mn/DOT RSS


TAMROC

Designed Reinforced Slope and Wire Basket Wall

W 78th Street Edina, MN

Reinforced Slope-Landslide Repair

2004 MPWA Project of the Year

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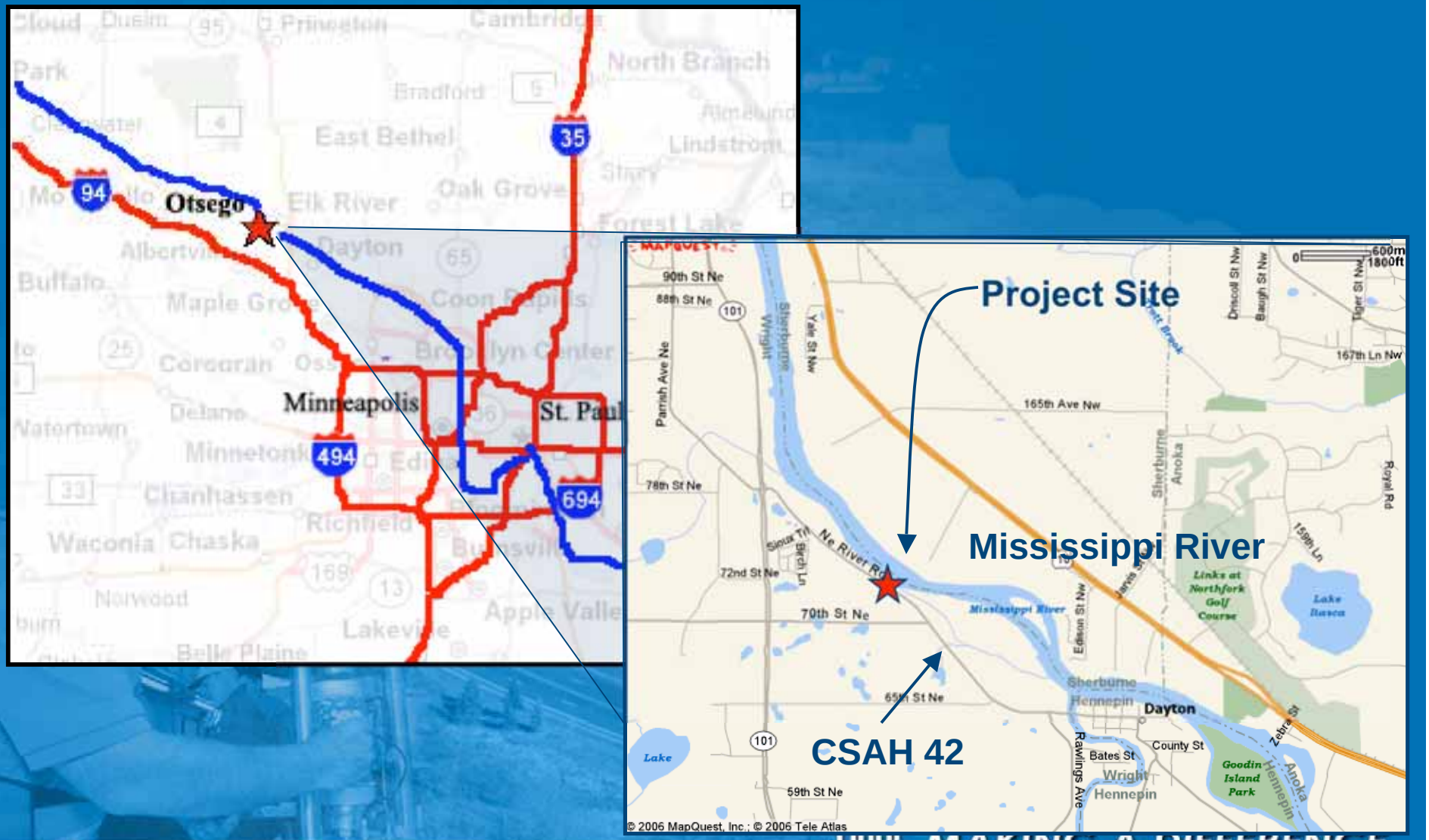
Location


Otsego
Minneapolis
St. Paul
94
35
494
694
Project Site
Mississippi River
CSAH 42
90th St Ne
88th St Ne
78th St Ne
72nd St Ne
70th St Ne
65th St Ne
59th St Ne
165th Ave Nw
167th Ln Nw
Parrish Ave Ne
Yale St Nw
Sherburne
Wright
Anoka
Hennepin
Dayton
County St
Bates St
Rawlings Ave
Edson St Nw
Links at Northfork Golf Course
Lake Rasca
Goodin Island Park
Royal Rd
159th Ln
Zebra St
Lake
101
© 2006 MapQuest, Inc.; © 2006 Tele Atlas

Background

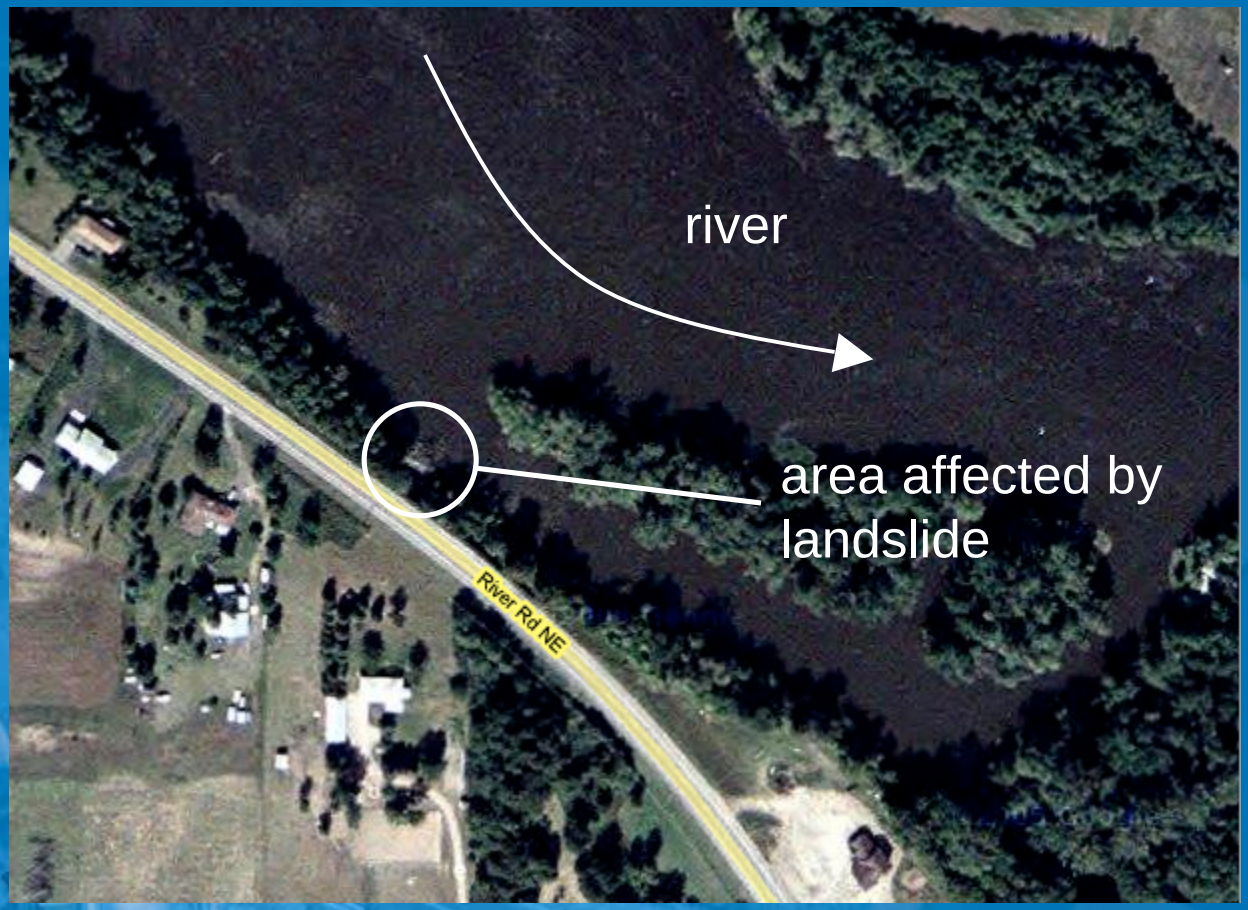
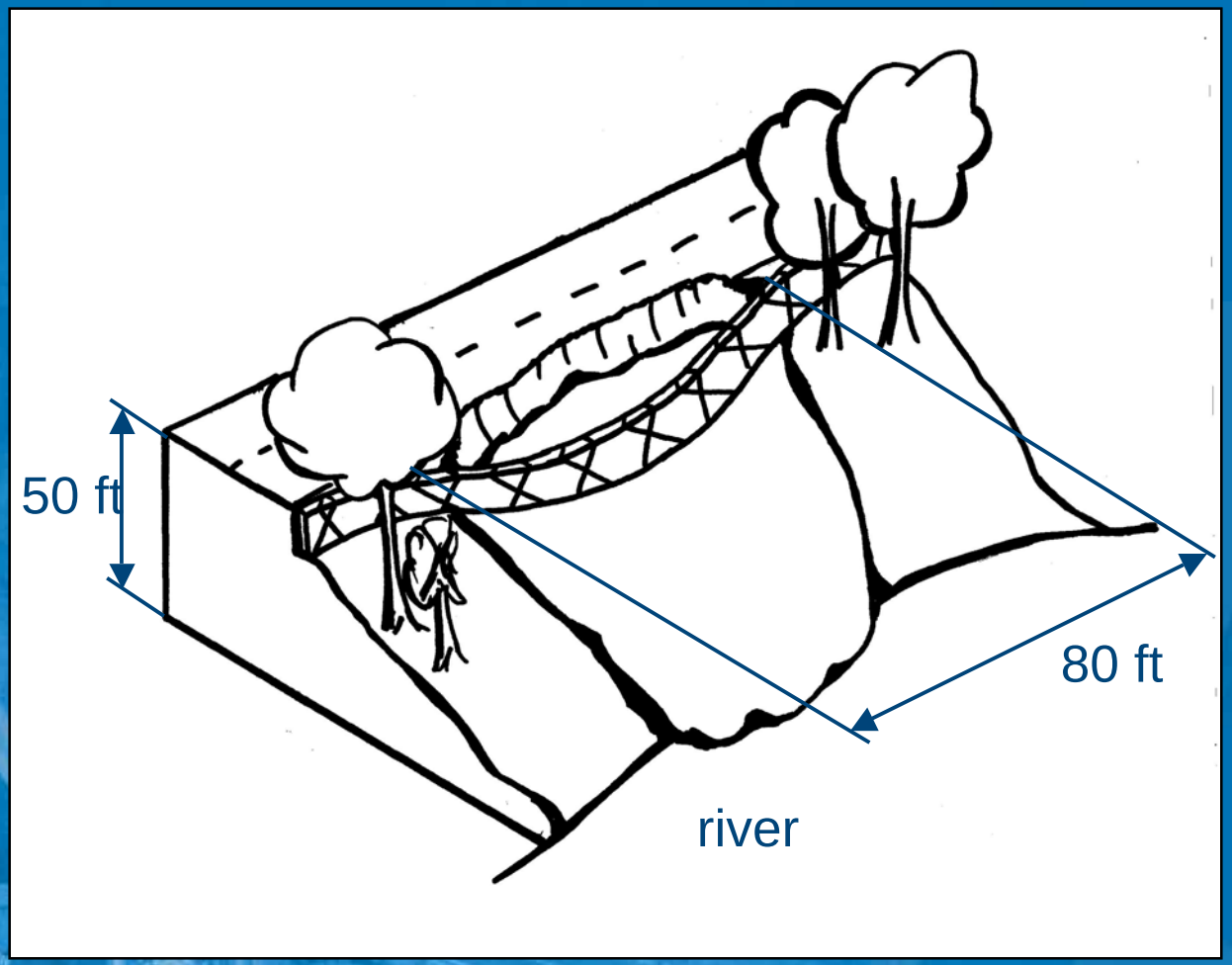


Image from http://maps.google.com/

Background



Stability of road in jeopardy

Late May 2003

Scarp continues to creep into the northbound lane

Late June 2003

Landslide repair must proceed quickly

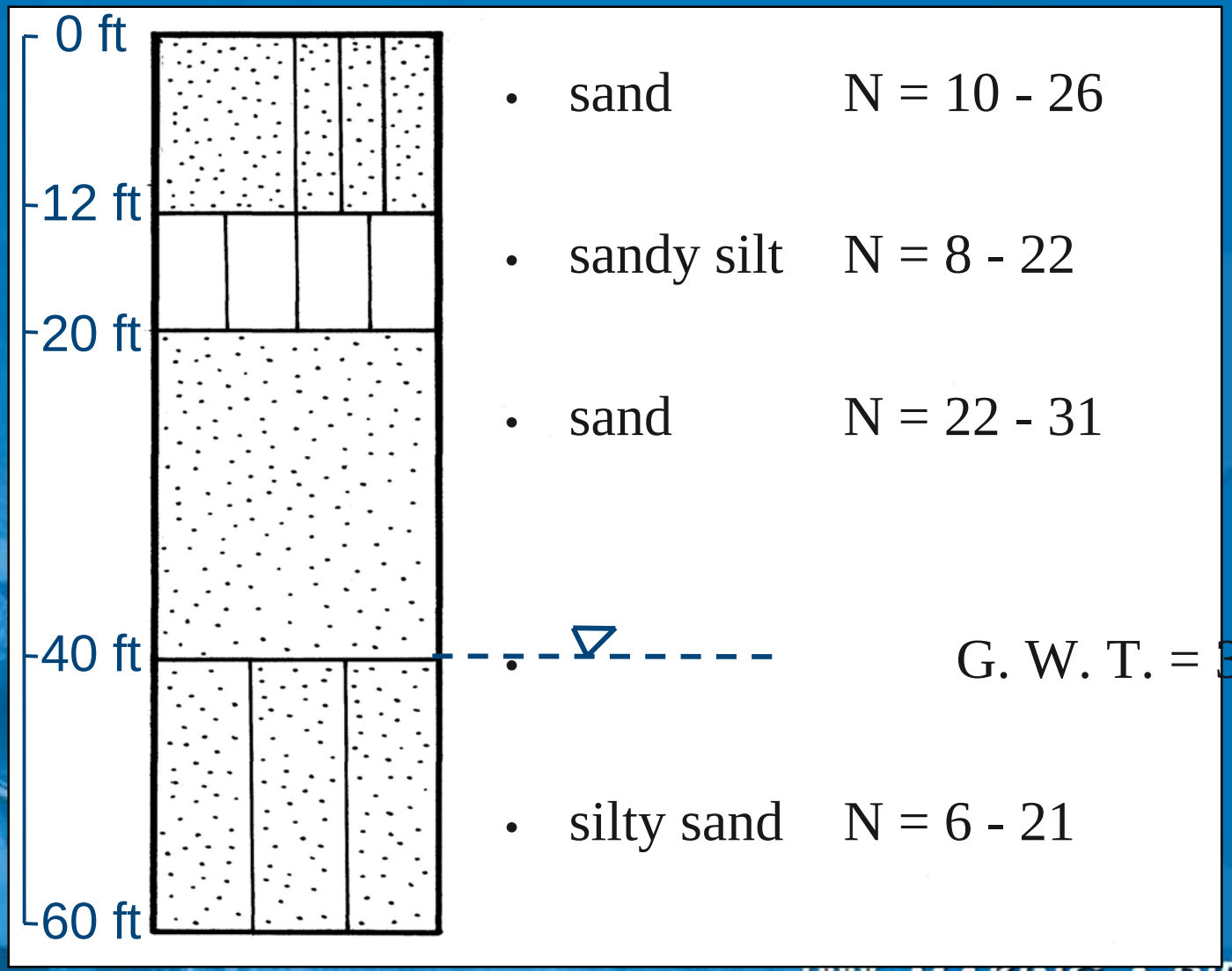
Gabion wall ready to collapse

Temporary Repair

Emergency Repair of CSAH 42

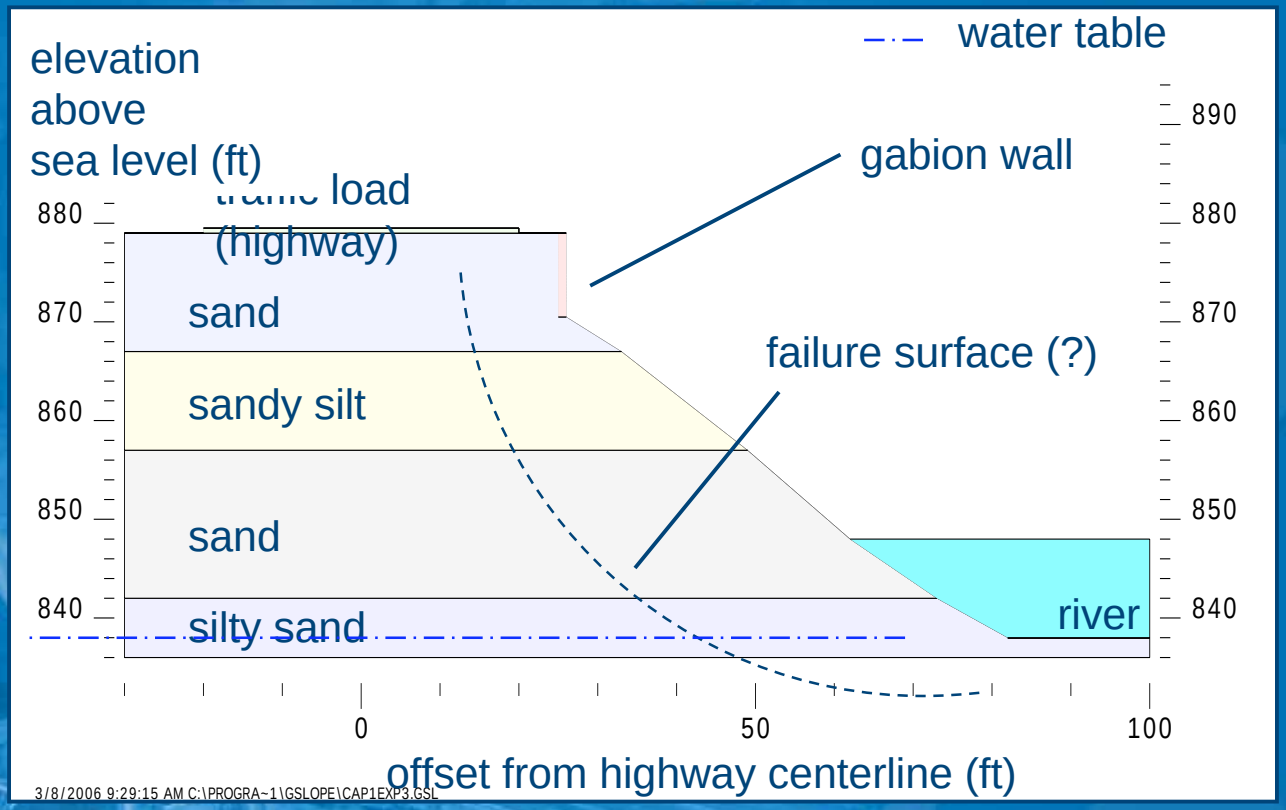
- Shut Road Down
- Collect Data
- Analyze
- Review Options and Costs
- Select Design
- Permit Design
- Prepare Plans and Specifications
- **CONSTRUCT**

Soil boring log



Failure analysis

Cross-section of nearby station based on topographic survey and bore logs from site.



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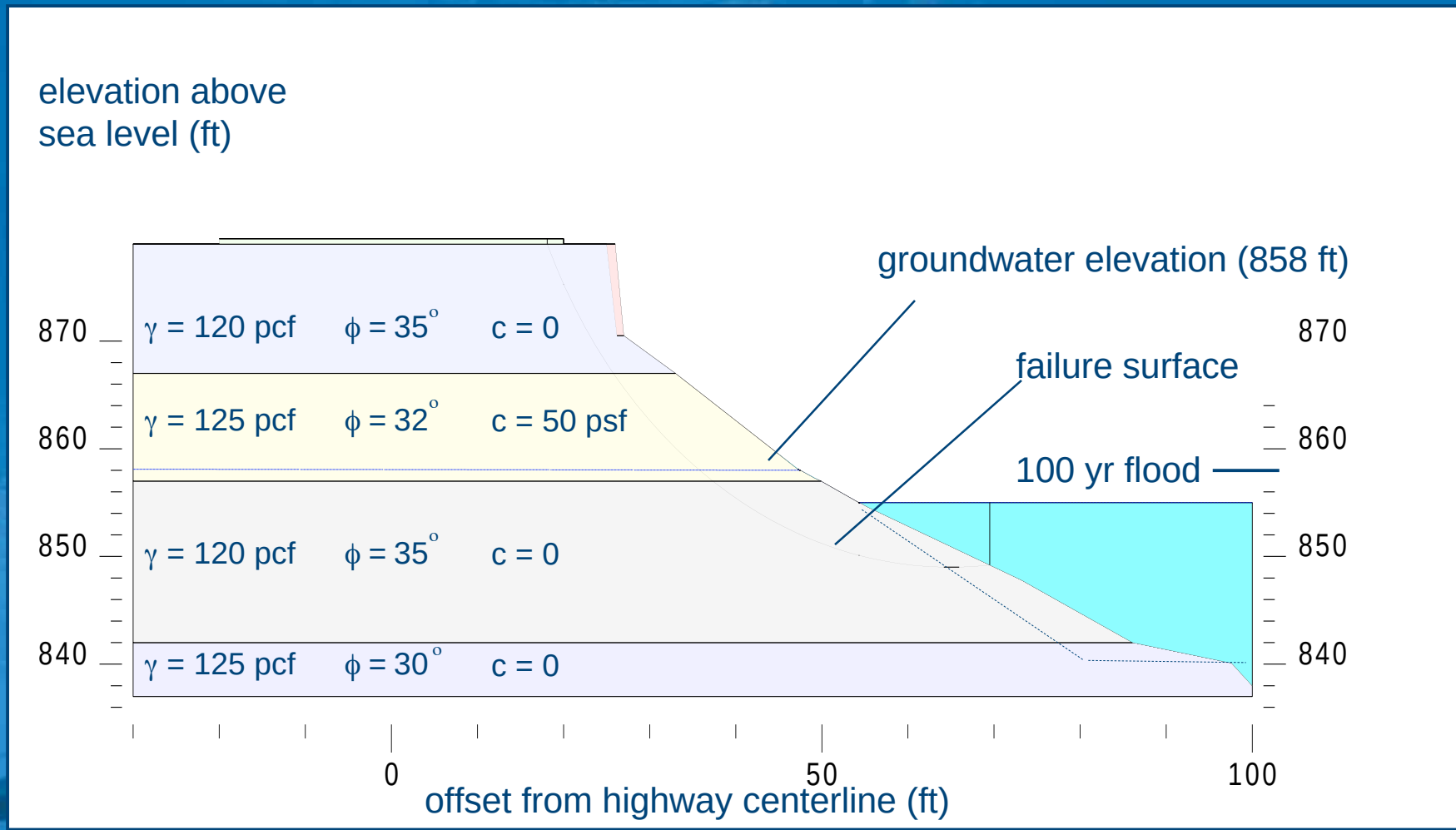
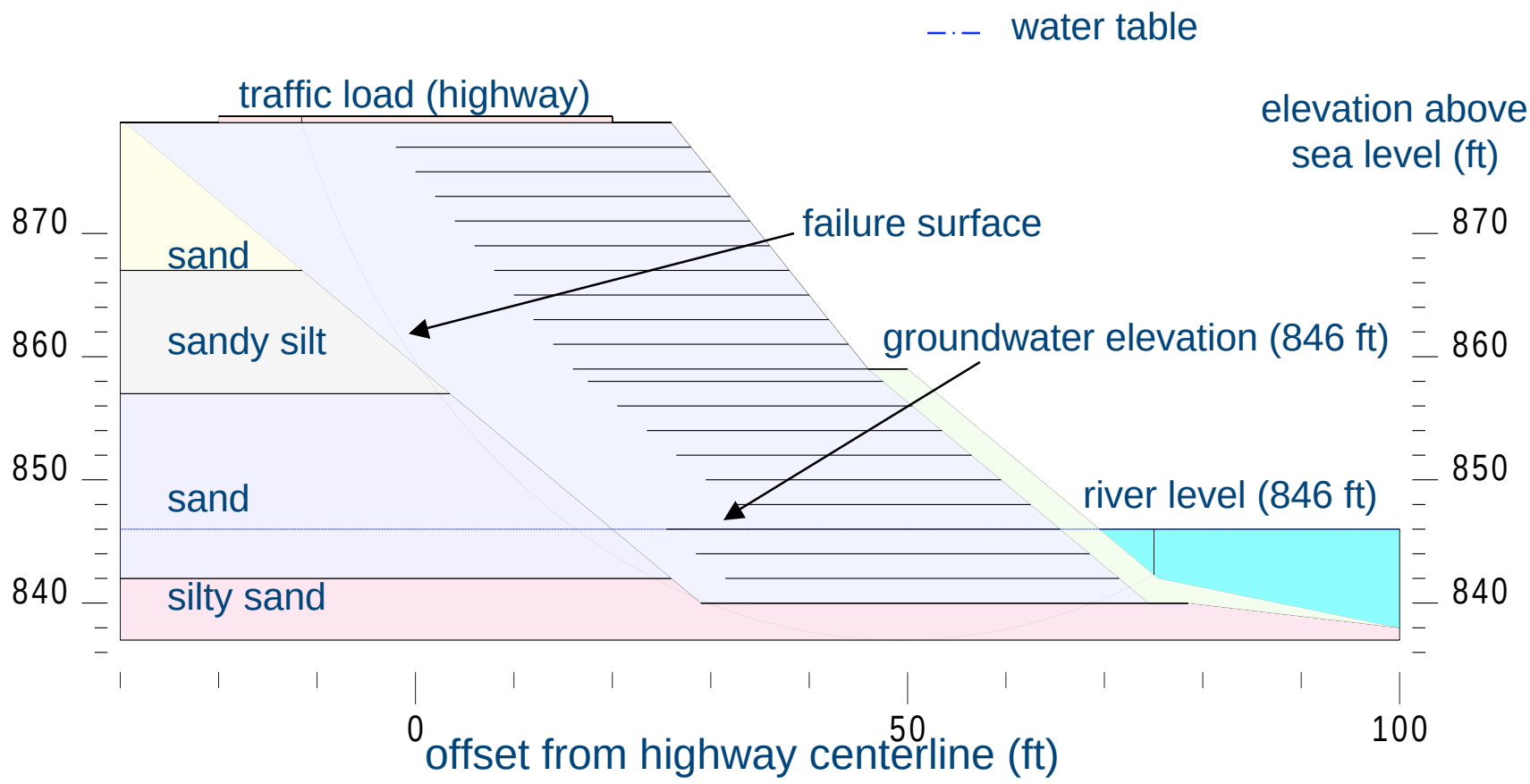
Results of analysis

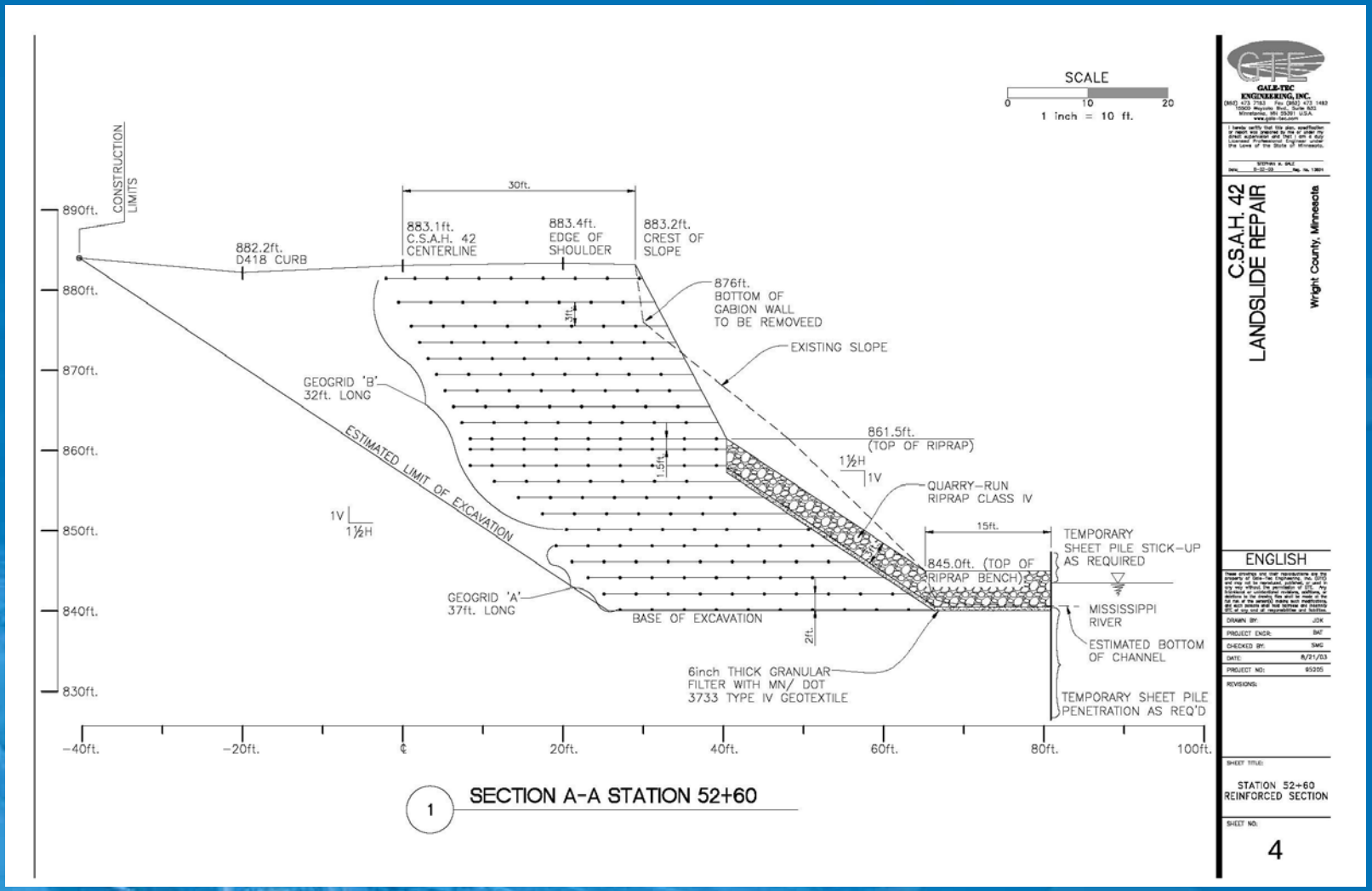
Critical scenario: Rapid drawdown



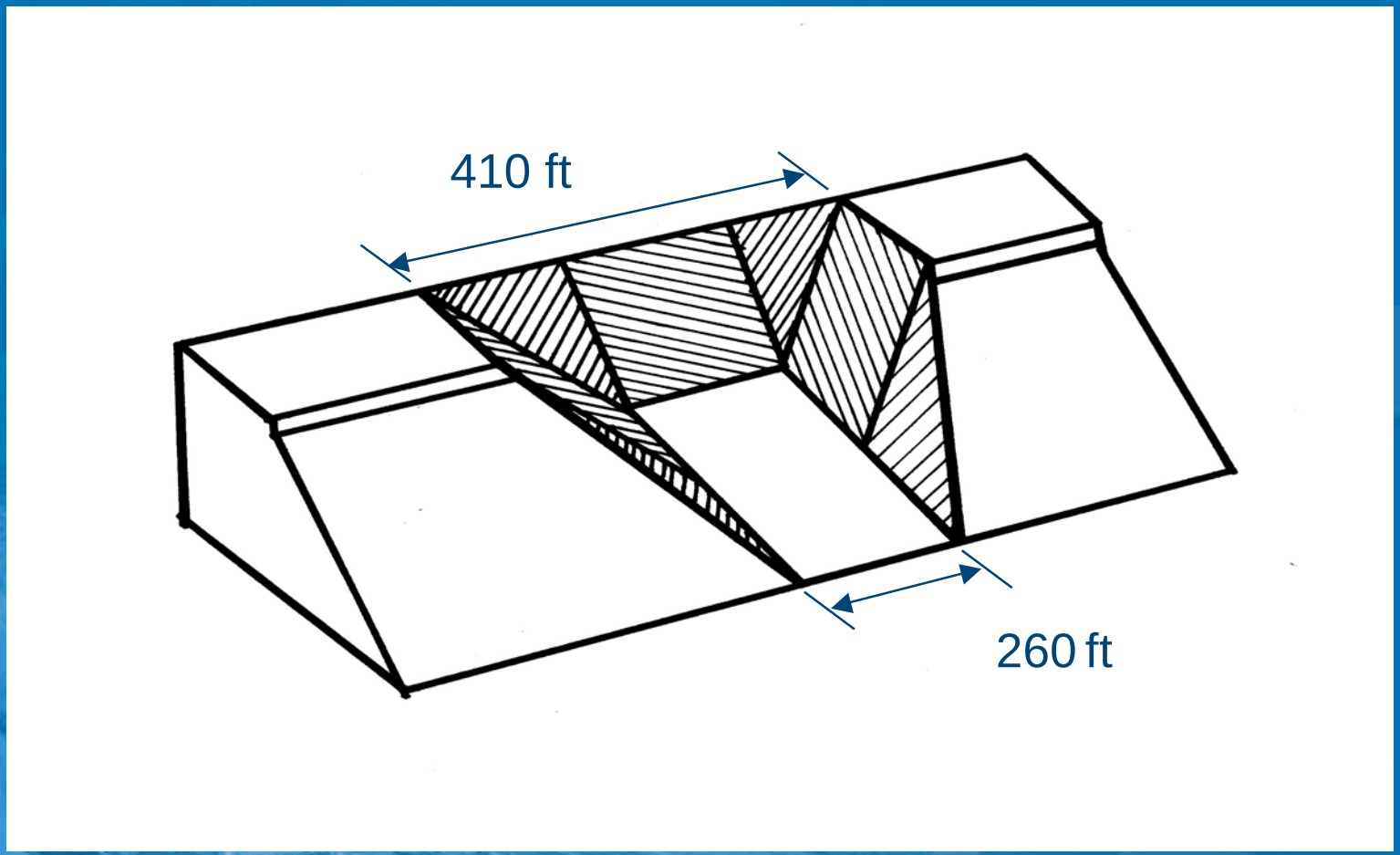
Design analysis

Long term analysis (FS- 1.5)




SCALE
0 10 20
1 inch = 10 ft.
GALE-TEC ENGINEERING, INC.
C.S.A.H. 42
LANDSLIDE REPAIR
Wright County, Minnesota
ENGLISH
STATION 52+60
REINFORCED SECTION
4
CONSTRUCTION LIMITS
890ft.
880ft.
870ft.
860ft.
850ft.
840ft.
830ft.
30ft.
882.2ft.
D418 CURB
883.1ft.
C.S.A.H. 42
CENTERLINE
883.4ft.
EDGE OF
SHOULDER
883.2ft.
CREST OF
SLOPE
876ft.
BOTTOM OF
GABION WALL
TO BE REMOVEED
EXISTING SLOPE
GEOGRID 'B'
32ft. LONG
ESTIMATED LIMIT OF EXCAVATION
1V
1½H
861.5ft.
(TOP OF RIPRAP)
1½H
1V
QUARRY-RUN
RIPRAP CLASS IV
15ft.
TEMPORARY
SHEET PILE STICK-UP
AS REQUIRED
845.0ft. (TOP OF
RIPRAP BENCH)
GEOGRID 'A'
37ft. LONG
BASE OF EXCAVATION
MISSISSIPPI
RIVER
ESTIMATED BOTTOM
OF CHANNEL
6inch THICK GRANULAR
FILTER WITH MN/ DOT
3733 TYPE IV GEOTEXTILE
TEMPORARY SHEET PILE
PENETRATION AS REQ'D
-40ft.
-20ft.
℄
20ft.
40ft.
60ft.
80ft.
100ft.
1
SECTION A-A STATION 52+60

Excavation



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Establishing the Base


CSAH 42
Oct 1, 03


CSAH 42
Oct 1, 03

Geogrid Reinforcment

Riprap and Cellular Confinement Web Face

Thank you