Sixth International Conference on Scour and Erosion

Paris August 27-31, 2012

Full-Scale Testing of Levee Resiliency During Wave Overtopping

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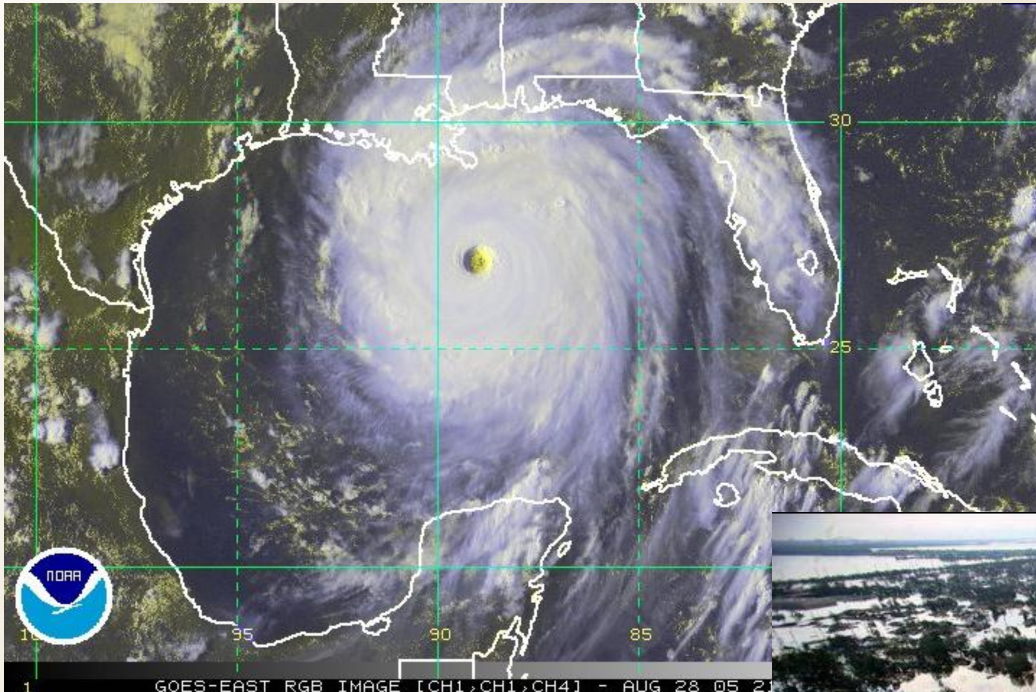
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NOAA
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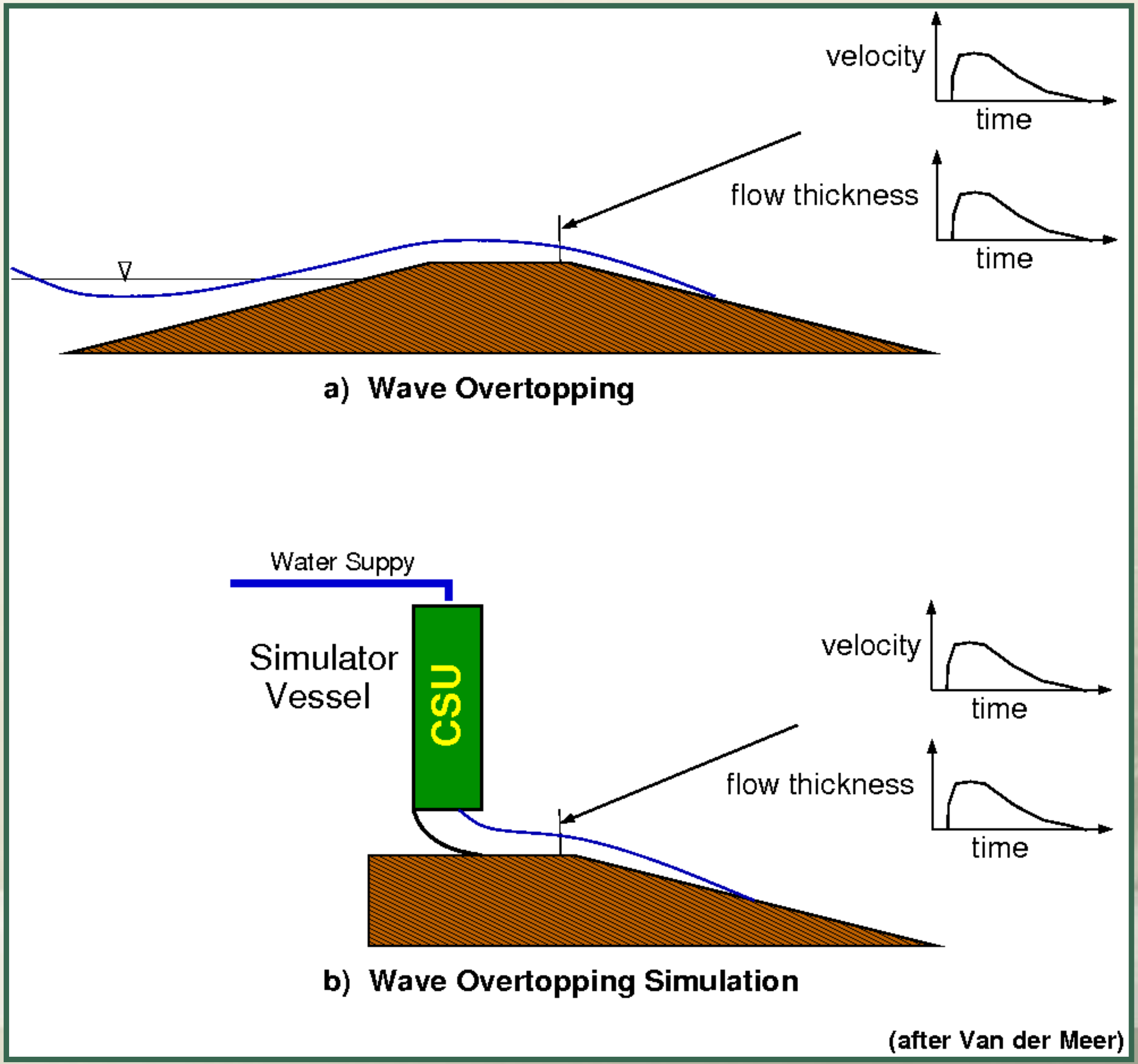
GOES-EAST RGB IMAGE [CH1,CH1,CH4] - AUG 28 05

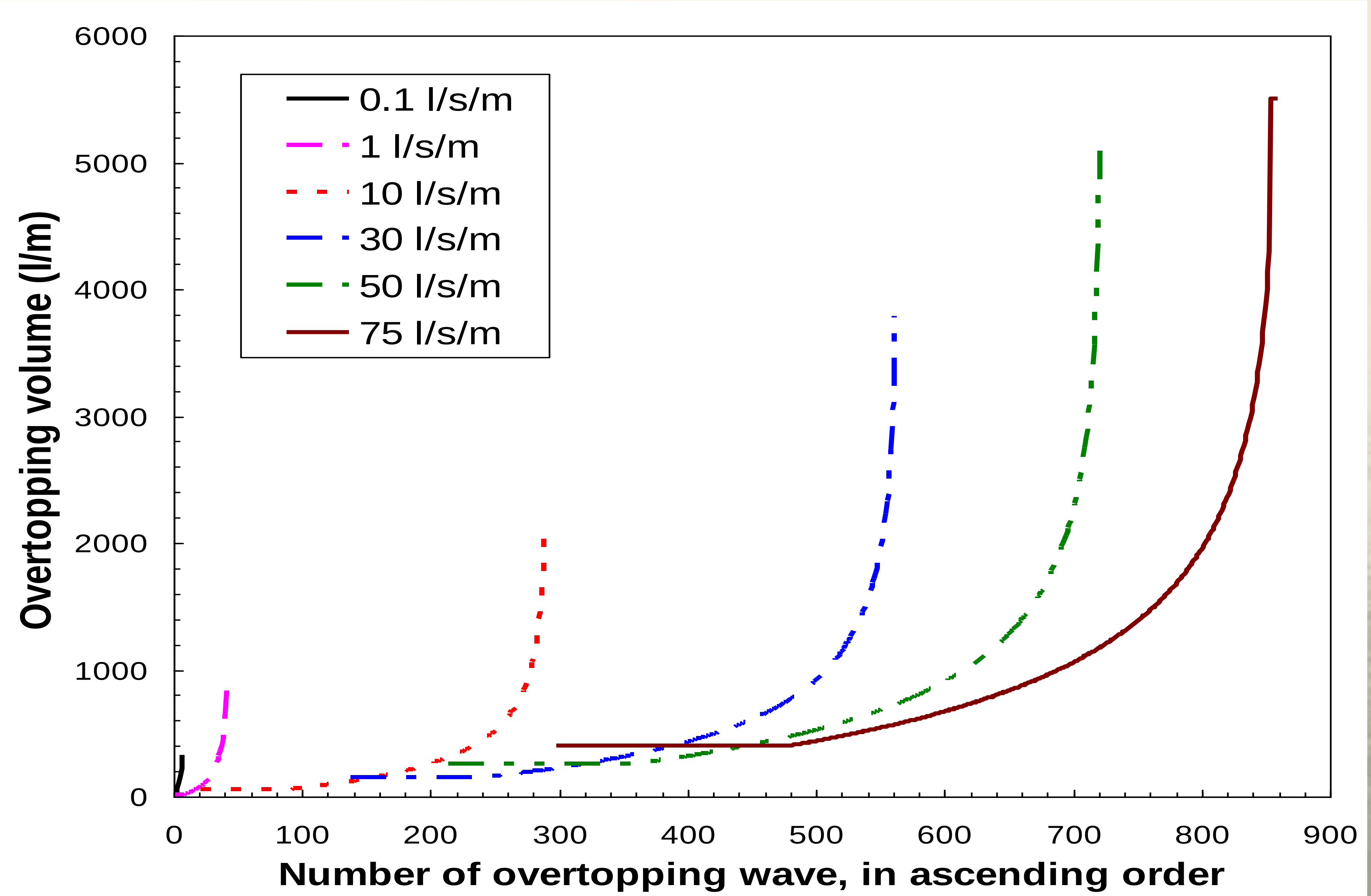
Project Overview

- **Requirements:**
  - Simulate large wave overtopping discharges
  - Replicate New Orleans levee grass slopes
  - Test alternative slope protection products
- **Design Issues:**
  - Overtopping simulator design
  - Planter trays to simulate soil/grass/TRMs
  - Operating procedures
  - Measurements

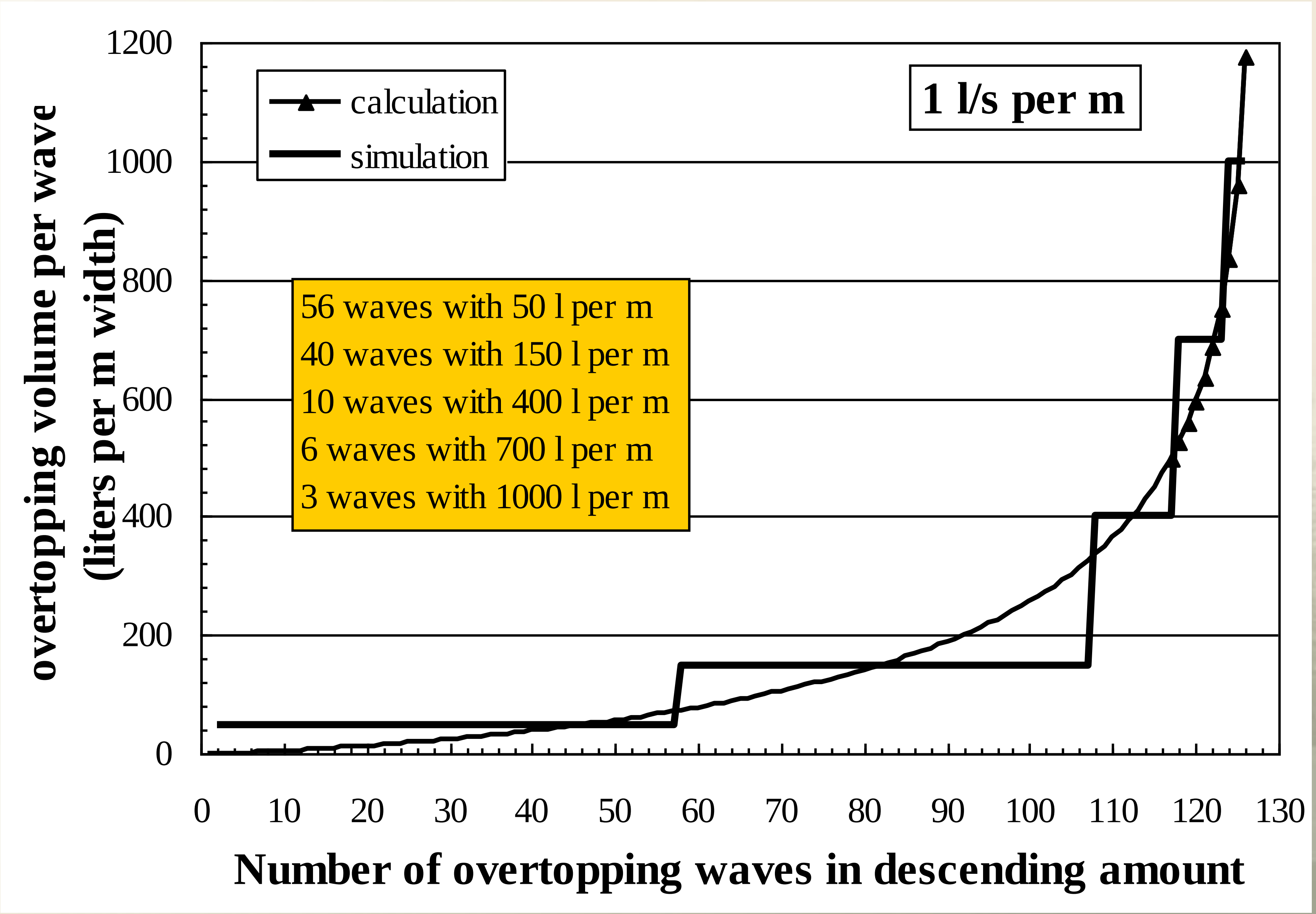
Principle of Wave Overtopping Simulation



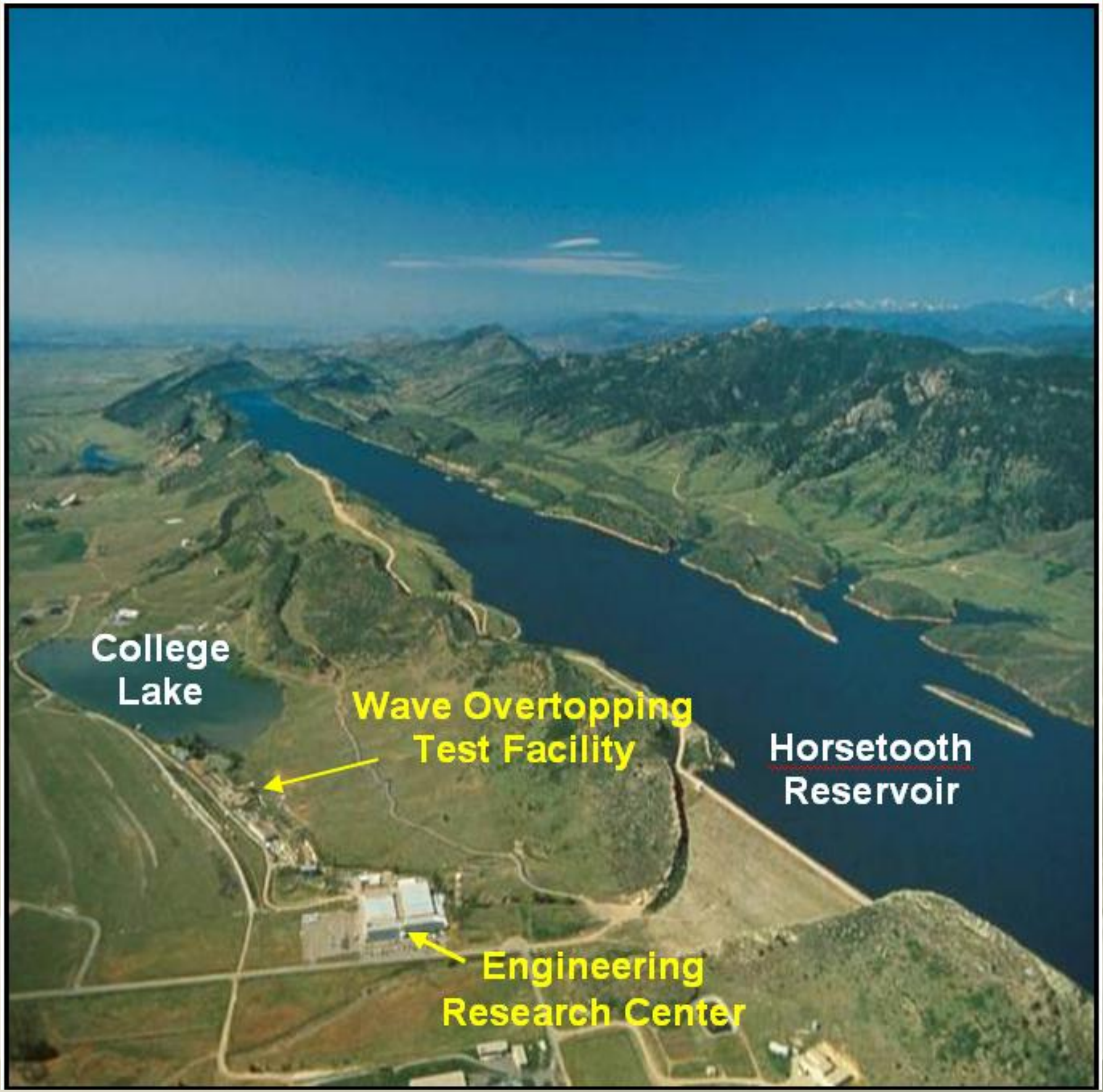
Overtopping Distribution



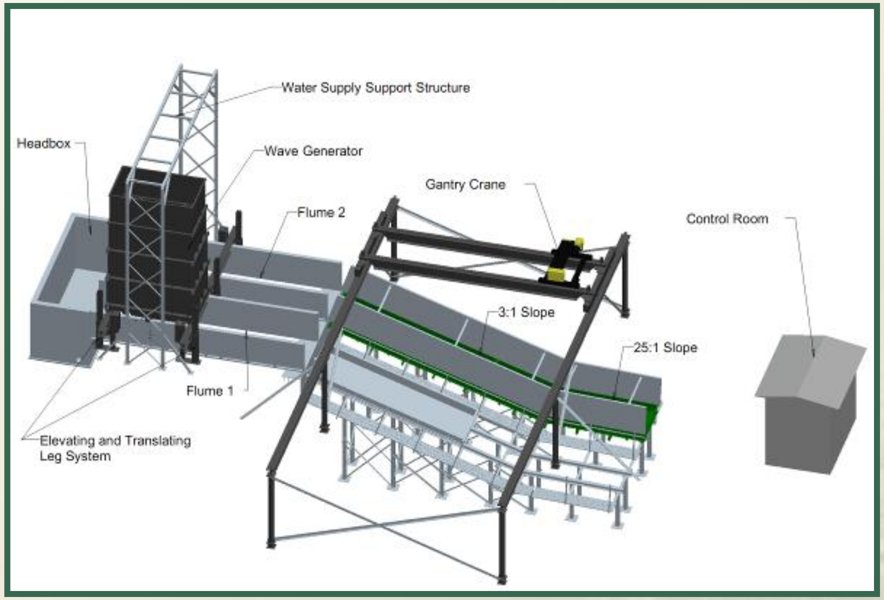
Overtopping distribution



Wave Overtopping Test Facility



Wave Overtopping Test Facility



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Wave Overtopping Test Facility

Physical Features

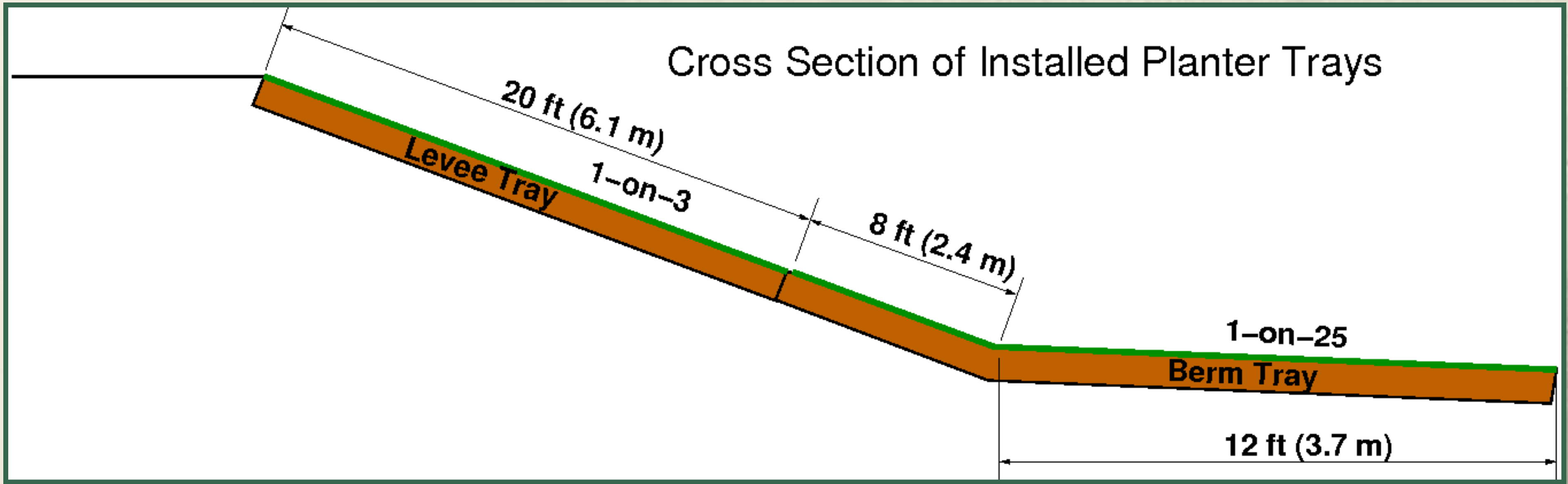
- Full-scale testing
- Dual test channels
- Steady state capabilities
- Flow measurements
- Accommodate different tray geometries

Wave Overtopping Test Facility

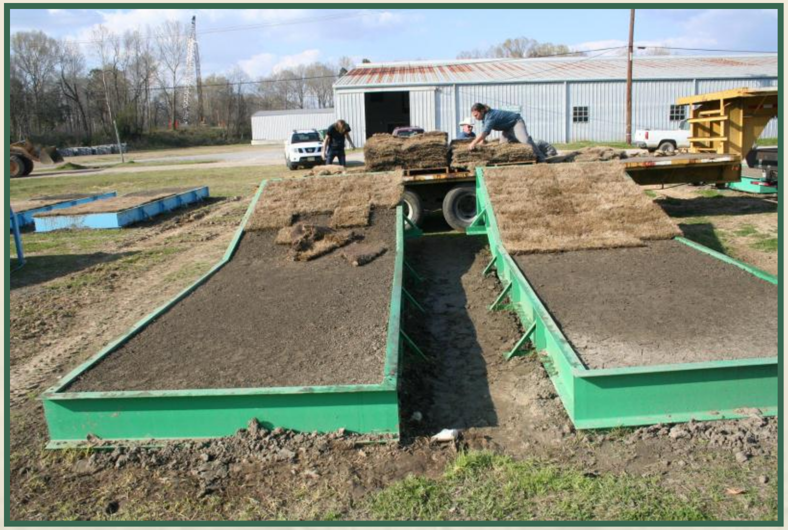
Hydraulic Features

- Total simulator capacity – 27 m^3 or 15 m^3/m
- Average wave overtopping discharge 200 – 380 l/s per m (depends on wave period)
- Corresponds to H_{m0} = 2.4 m, T_p = 9 s
- Steady overflow – 2.5 m^3/s per m (or more)

Planter Tray Dimensions



Tray Preparation



Tray Cultivation

Tray Installation

Resiliency Testing Overview

Levee Slope Surface	Hrs	Max. Ave. Discharge		End Result
		l/s per m	ft^3/s per ft	
Sponsored Tests				
Bare Clay	1.3	19	0.2	Severe Erosion
Bermuda Grass	24	370	4.0	No Damage
Bahia Grass	17	280	3.0	No Damage
Bermuda w/TRM	9	370	4.0	No Damage
Bermuda w/HPTRM	9	370	4.0	No Damage
Bermuda w/Ruts	9	370	4.0	Minor Erosion
Lime-Stabilized Clay	2	370	4.0	Severe Erosion
Articulated Concrete Block	3	370	4.0	Minor Erosion
Dormant Bermuda Grass	3	230	2.5	Significant Erosion
Additional Tests				
Dormant Bermuda w/TRM	5	140	1.5	Significant Erosion
Dormant Bermuda w/HPTRM	6	370	4.0	No Damage

Overtopping Simulator in Action

Video

Bare Clay Slope Test

Before

Upper Tray

Lower Tray

After 1 hour at 9.3 l/s per m

Total failure after 20 min at 18.3 l/s per m

Lime-Stabilized Bare Clay Test

Before

After 20 min at 370 l/s per m

ACB Slope Protection Tests

New Orleans Clay

Before

After test at 370 l/s per m

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ACB Slope Protection Tests

Golden Soil

Failure at 370 l/s per m

Grass Slope Resiliency Tests

After 12 hrs of testing

Bermuda Grass Slope

No damage after 370 l/s per m

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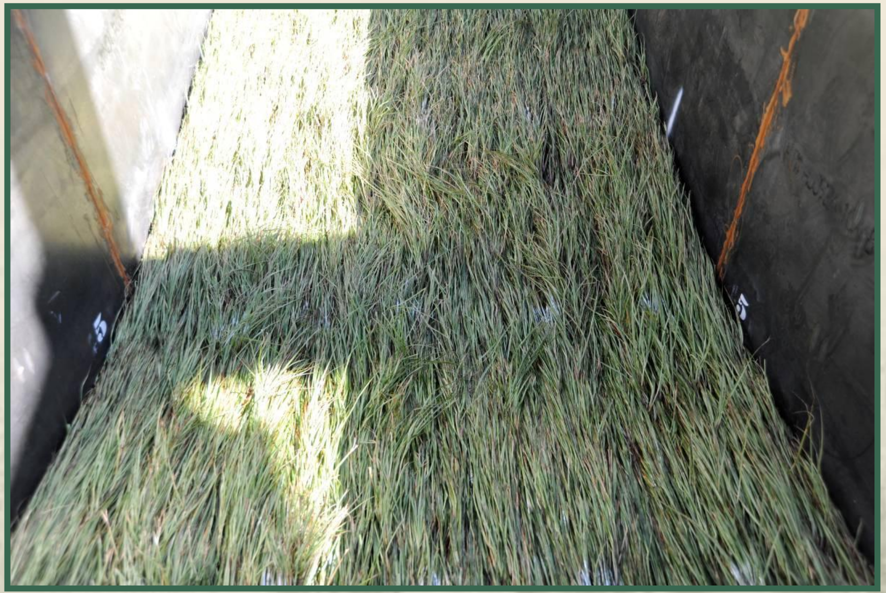
Grass Slope Resiliency Tests

Bahia Grass Slope

Before



No damage after 280 l/s per m

Grass Slope Resiliency Tests

Bermuda Grass with TRM

Before

No damage after 370 l/s per m

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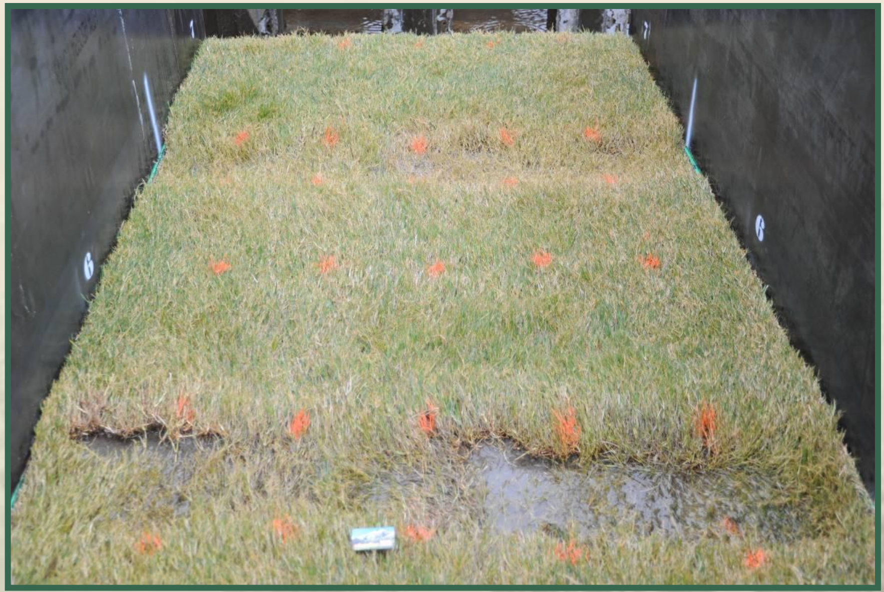
Grass with Wheel Ruts

Before



After test at 370 l/s per m

Dormant Grass Slope Resiliency Test


Before


After 1st hour at 230 l/s per m


After 2nd hour at 185 l/s per m


At end of 3rd hour

Dormant Grass + Tight Weave TRM

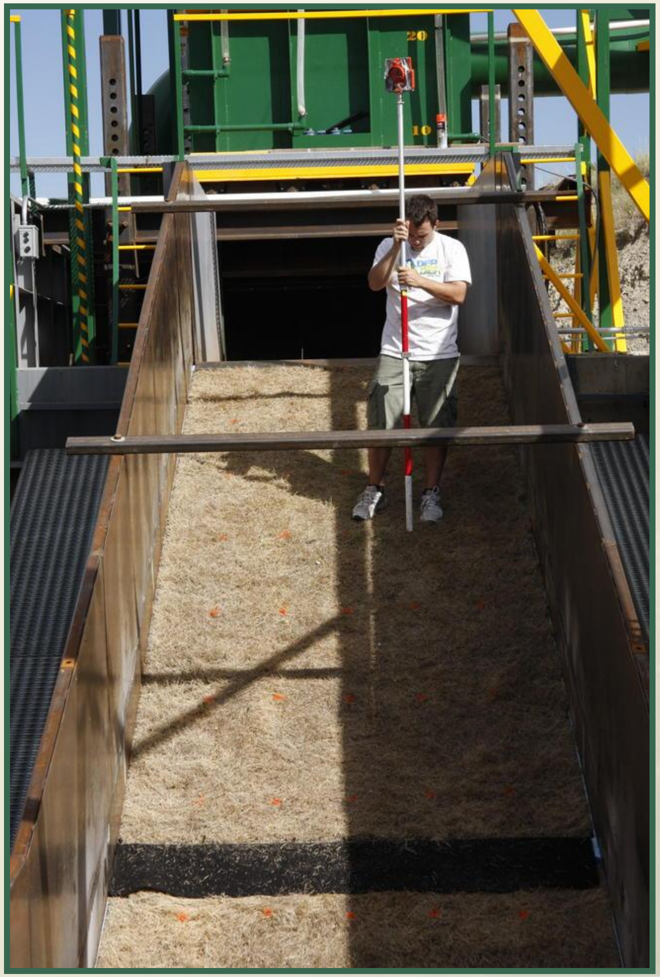
Before

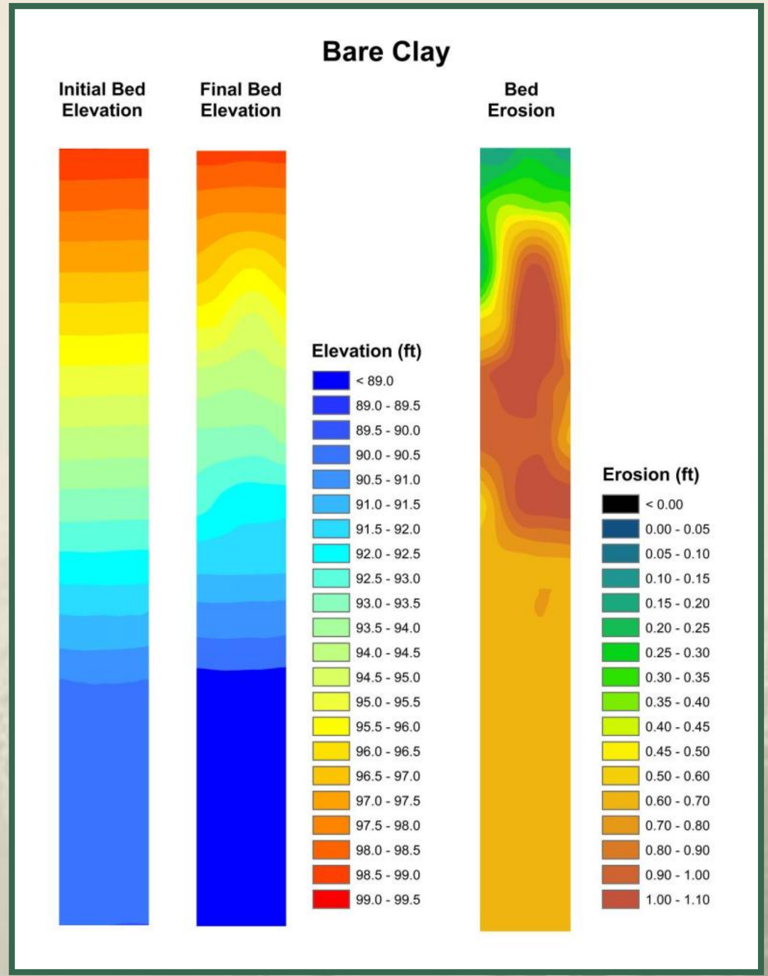
After 3rd test at 370 l/s per m

Dormant Grass + Open-Weave TRM

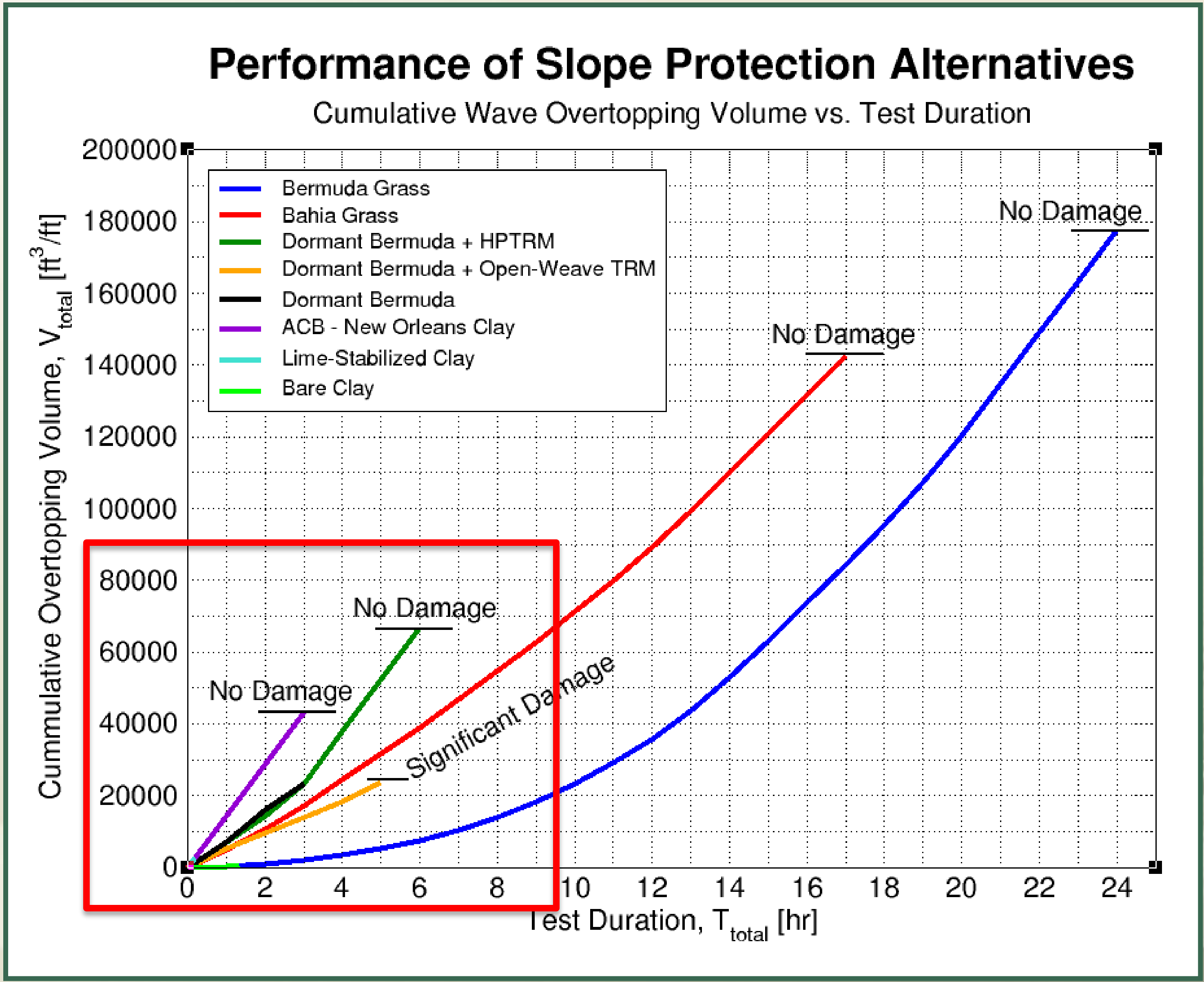
After 3rd hour at max. of 140 l/s per m

Damage Quantification

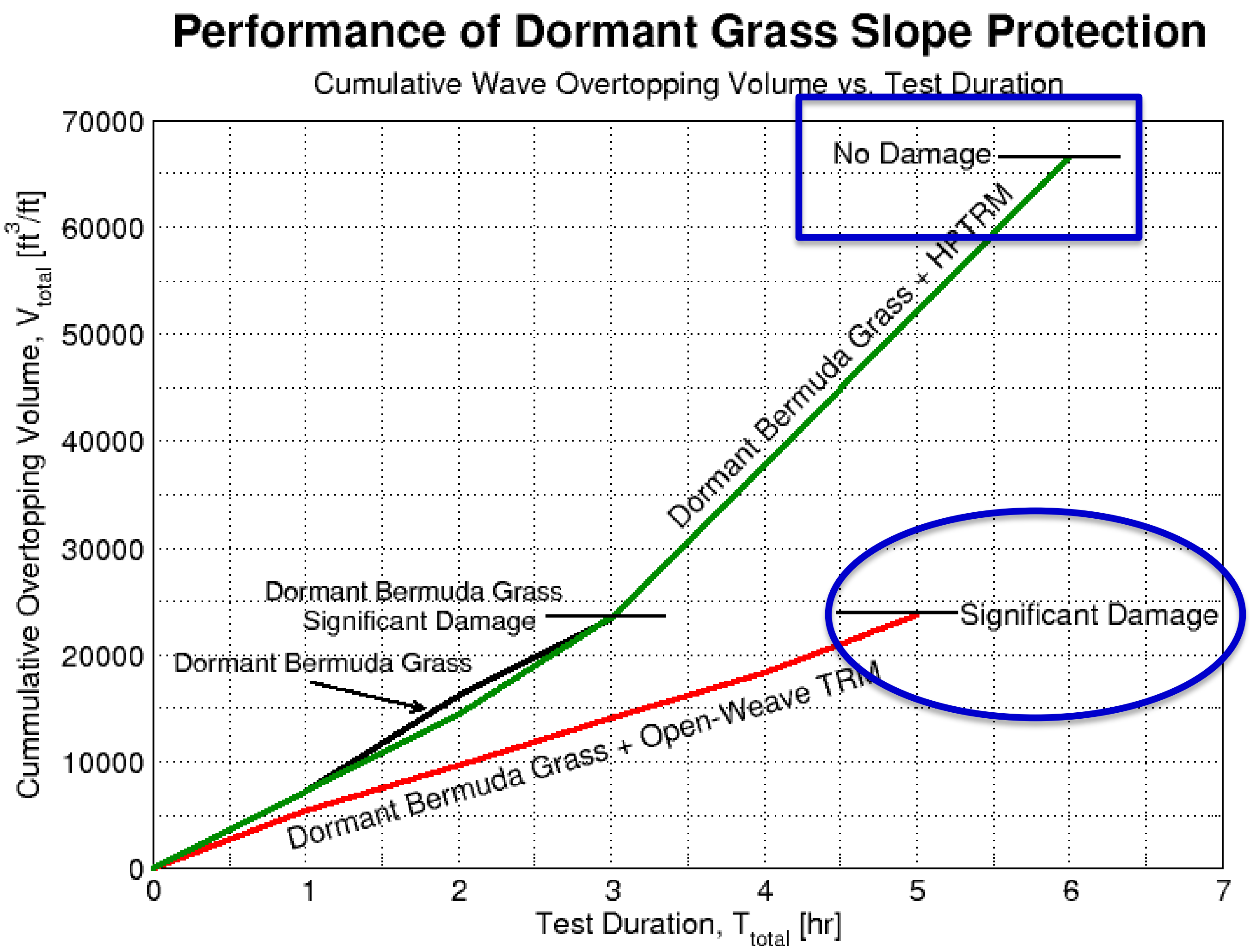




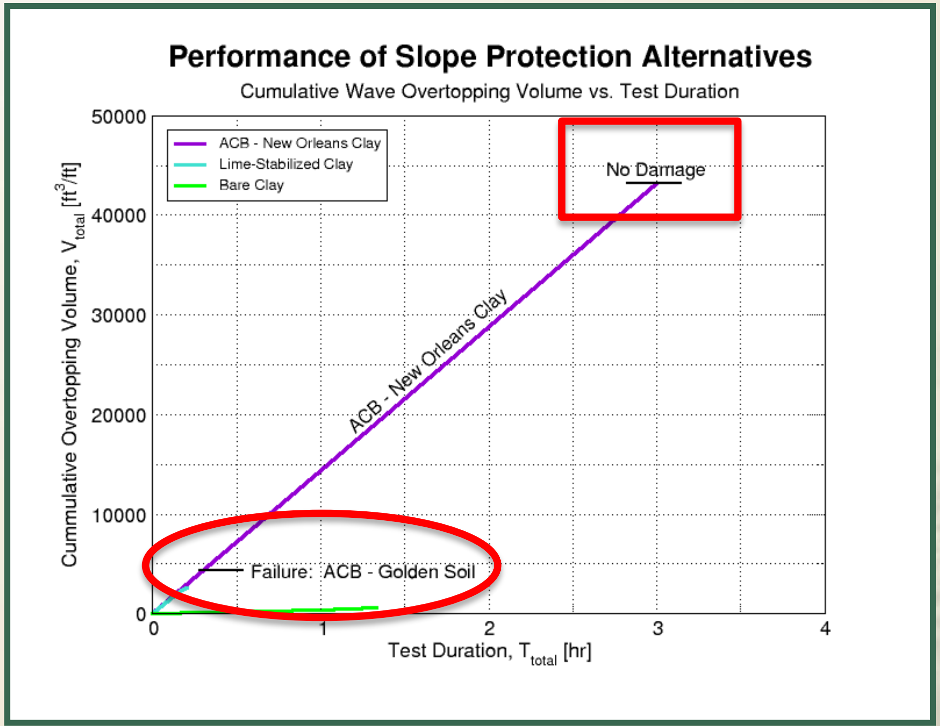
Cumulative Loading vs. Duration



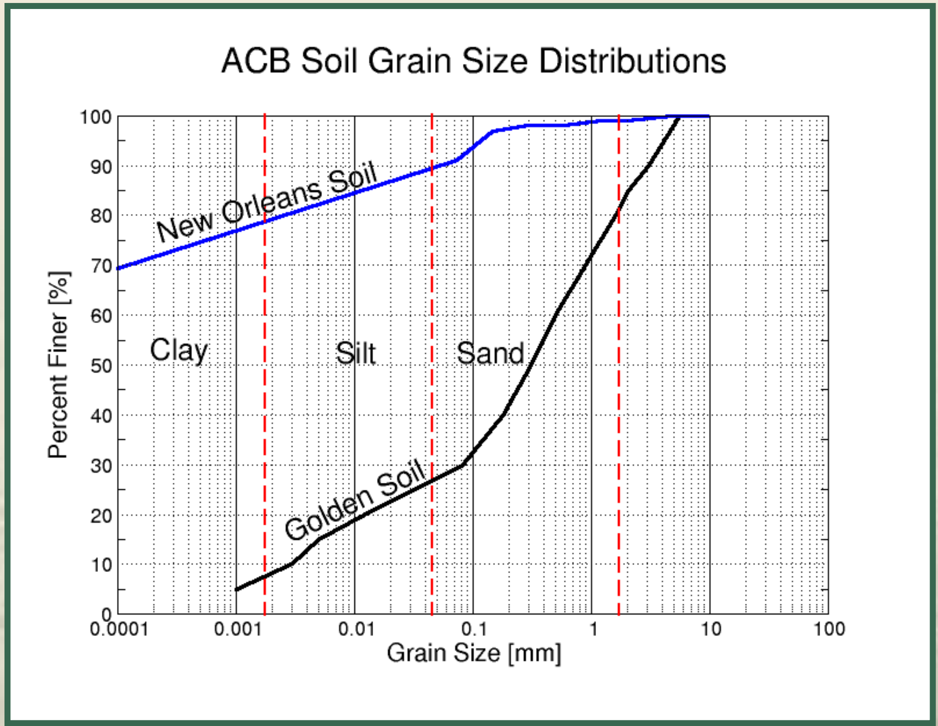
Dormant Grass Performance



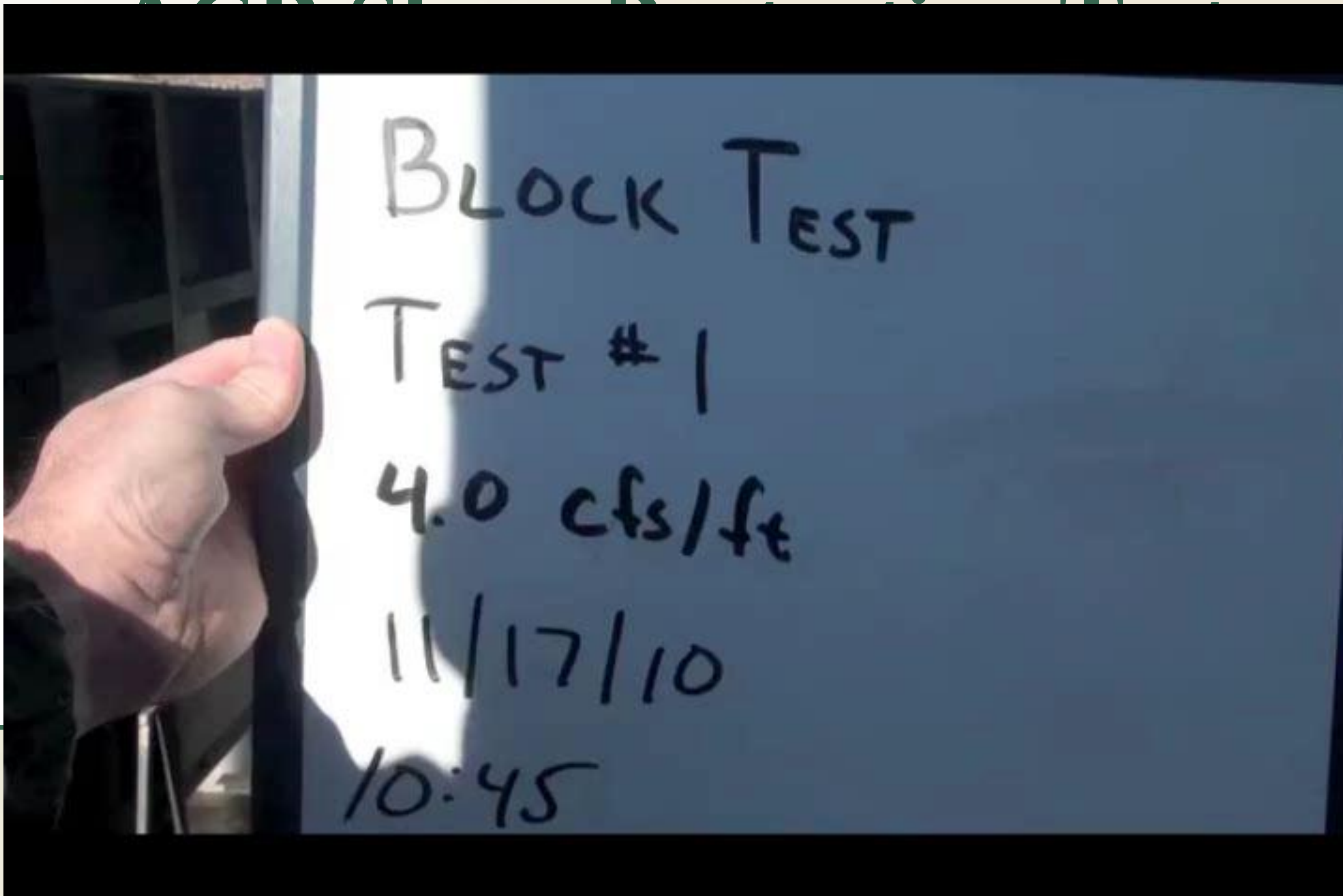
ACB Slope Protection Tests



Cumulative Loading



ACB Soil Quality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TEST #1
4.0 cfs/ft
11/17/10
10:45

Levee Slope Resiliency Testing

Results

- Healthy sodded grass surfaces did not fail
- Damaged healthy grass surfaces survived at high loads
- Dormant grass failed at reduced loads
- HPTRM provided significant protection for dormant grass
- Open-weave TRM provided little protection for dormant grass
- Bare clay and lime-reinforced clay fail rapidly
- ACBs effectively protected the underlying clay, but performance dependent on soil type

Levee Slope Resiliency Testing

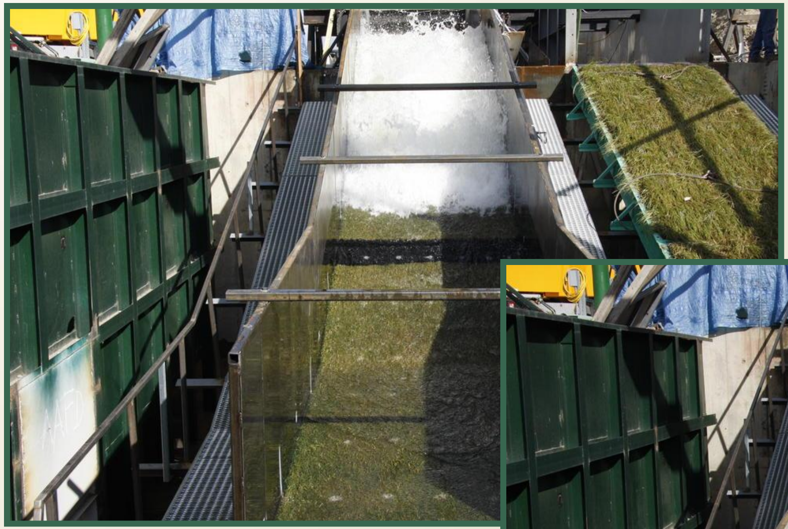
Lessons Learned

- Dense roots and thatching are critical at high overtopping rates
- Grass in planter trays was very good and most likely not representative of typical grass slopes
- Robust test protocol has been developed and vetted
- Soil type may be key to performance
- Steady state loading results applied to wave overwash most likely very non-conservative

Lessons Still to Learn

- Effect of variations in soil type
- Correlation between steady and un-steady loading
- Quantification of dynamic hydraulic forces
- Significance of:
  - Wave conditions
  - Levee geometry
  - Vegetation species
  - Resiliency of grass reinforcement
- Implementing cumulative excess work and hydraulic loading methodologies

Comments or Questions?



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