The N-EWN Knowledge Series

A Continuing Education Series about Engineering with Nature

Nicholas Muzia, PE
Principal Engineer and Design Build Manager
Sea & Shoreline

Harnessing Submerged Aquatic Vegetation (SAV) as a Natural Infrastructure Tool for Water Quality & Biodiversity

Submerged aquatic vegetation (SAV), including freshwater macrophytes and saltwater seagrasses, is a valuable natural infrastructure tool for improving water quality and biodiversity. This presentation examines how SAV can be integrated into hybrid green/gray infrastructure and restoration projects to stabilize sediment, reduce wave energy, and enhance water clarity, fostering resilient habitats for aquatic species. Examples span constructed wetlands, resilient coastal systems, and urban waterfront restorations in both freshwater and saltwater settings. By combining SAV plantings with structural elements like breakwaters, these systems optimize ecological and engineering benefits. The session will outline SAV's biomechanical and ecological functions, offer implementation guidance, and highlight its role in the Engineering With Nature (EWN) framework to address climate-driven challenges such as flooding and habitat loss.

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Oct. 16
12:30pm ET

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Stantec
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Register here: https://bit.ly/3gR9ADL or scan:

1 Continuing Education Credit (CEC) is available to attendees

Recorded webinars will be posted online at: https://n-ewn.org/resources/n-ewn-knowledge-seminars/

Presented by:

NETWORK FOR ENGINEERING WITH NATURE · LimnoTech · University of Georgia · ERDC

Questions? Please contact:
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SEA & SHORELINE
aquatic restoration

NETWORK FOR ENGINEERING WITH NATURE

Harnessing Submerged Aquatic Vegetation (SAV)

A Natural Infrastructure Tool for Water Quality & Biodiversity

Nicholas Muzia, PE

Principle Engineer & Design Build Project Manager

Nick@seaandshoreline.com

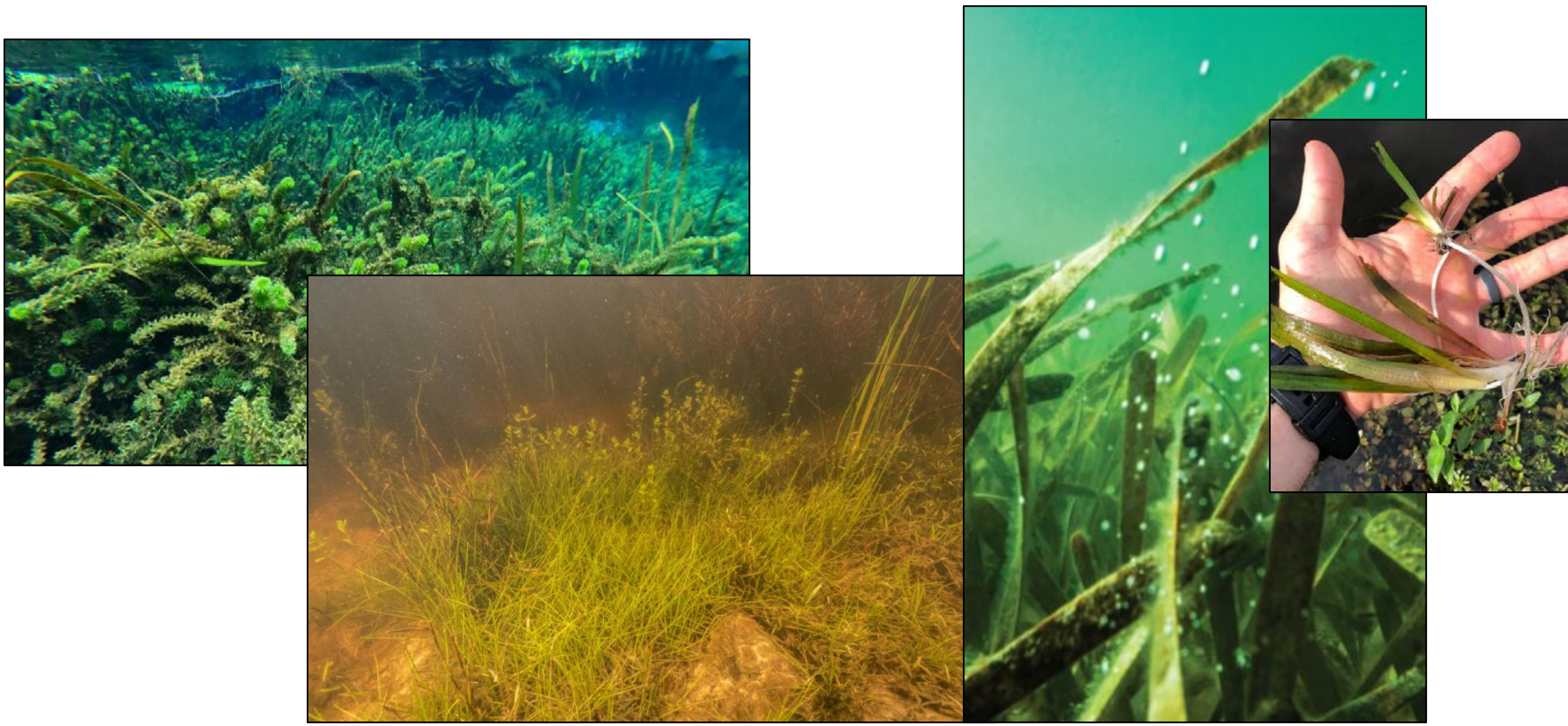
Agenda

- Introduce Submerged Aquatic Vegetation (SAV) and how it can function as natural infrastructure

- How SAV can influence sediment transport, improve water quality, and improve biodiversity as a component to water resource infrastructure projects.

- What a project may look like.

Submerged Aquatic Vegetation (SAV) refers to plants that grow fully or partially submerged in shallow aquatic environments. SAV is crucial for water quality, sediment stabilization, and aquatic habitat.



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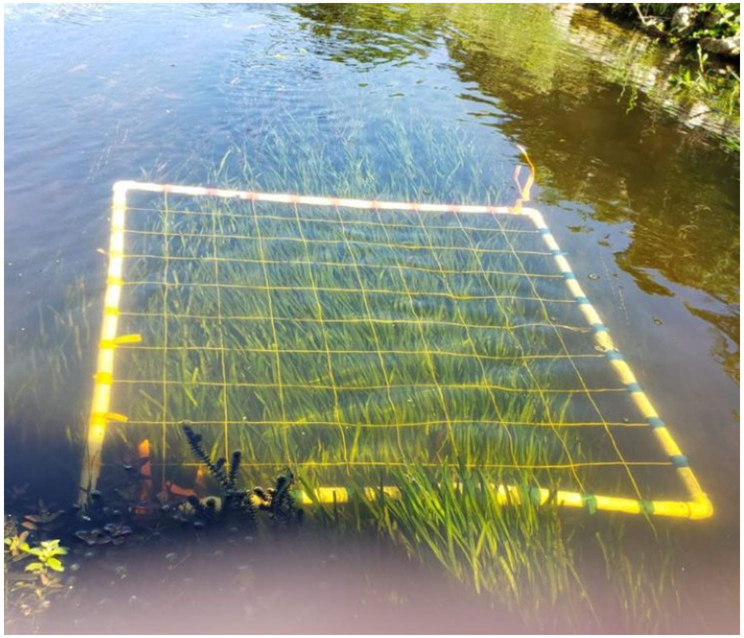
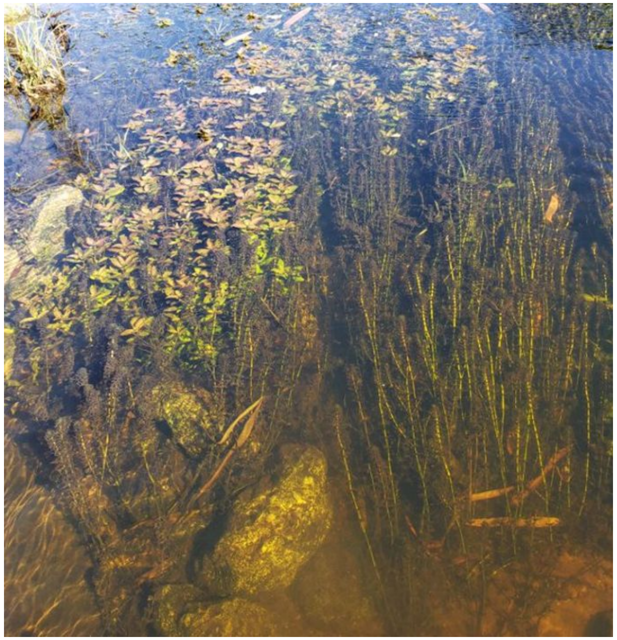
Beneficial



Nuisance & Invasive Plants (SAV)



Submerged Aquatic Vegetation (SAV) refers to plants that grow fully or partially submerged in shallow aquatic environments. SAV is crucial for water quality, sediment stabilization, and aquatic habitat.

What does this mean to engineers?

It's important to consider SAV in waterway design, as it affects hydrodynamics, sediment transport, and ecosystem health.

What is SAV used for?

- Restore natural ecosystems
  - Florida springs restoration projects
- Improve water quality in engineered systems
  - Florida Everglades stormwater treatment areas
- Prevent erosion and wave attenuation
  - Lines of defense for coastal & estuary systems
- Ecosystem services & food security
- Much more…

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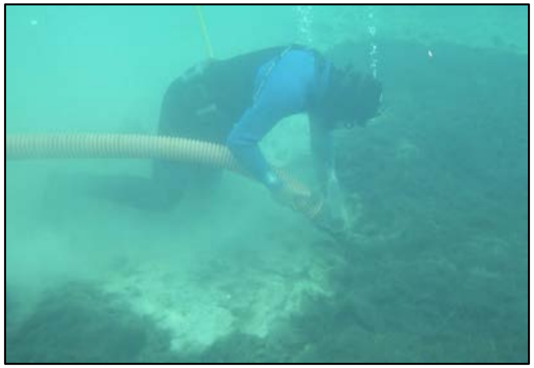
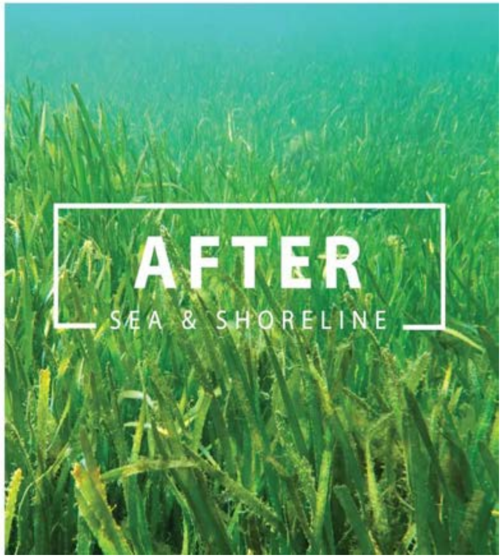
aquatic restoration

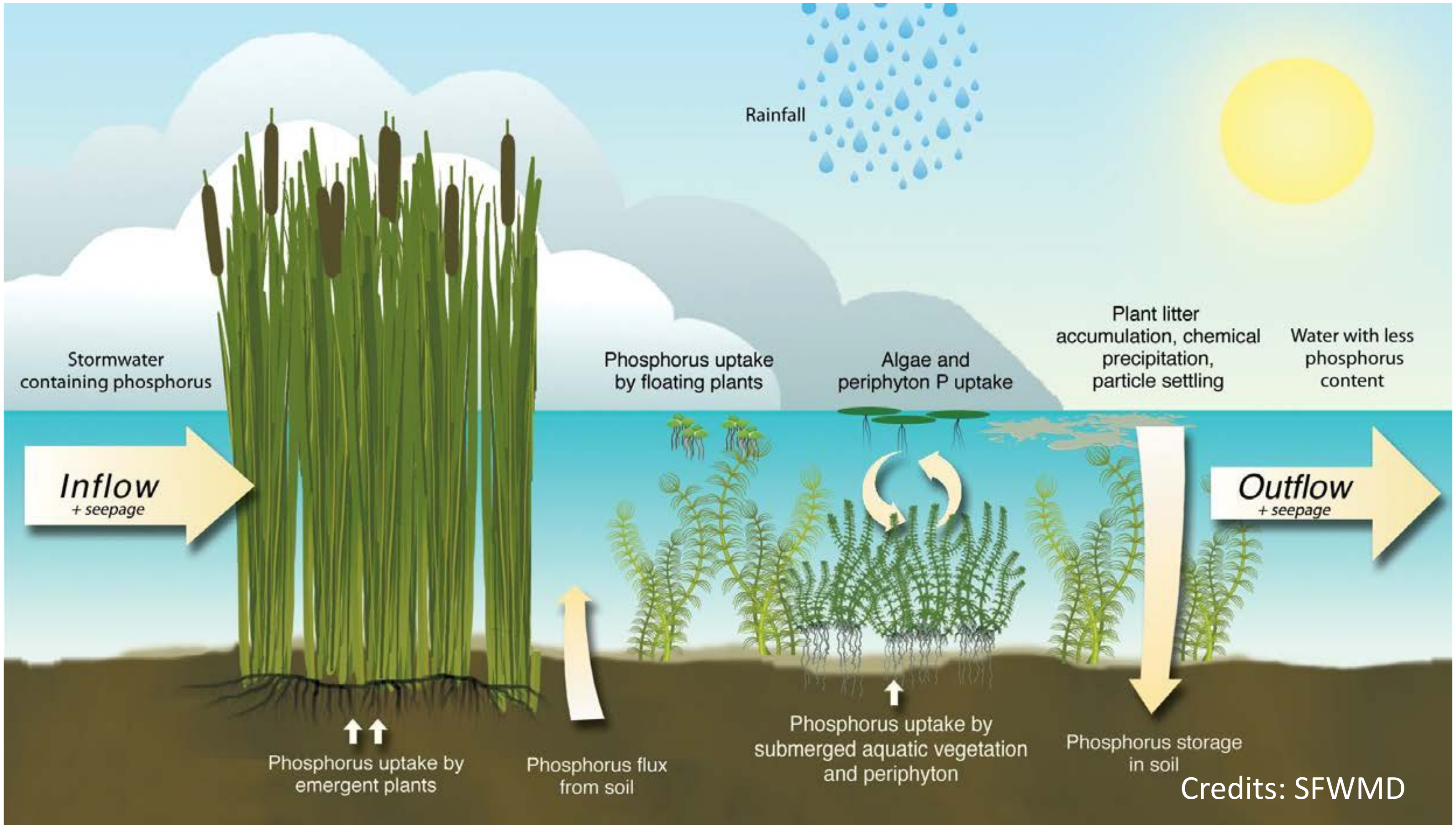
Restore Natural Systems





According to St. John’s River Water Management District (SJRWMD) , just two and a half acres of seagrass can support up to 100,000 fish and 100 million invertebrates.

Improved Water Quality in Engineered Systems

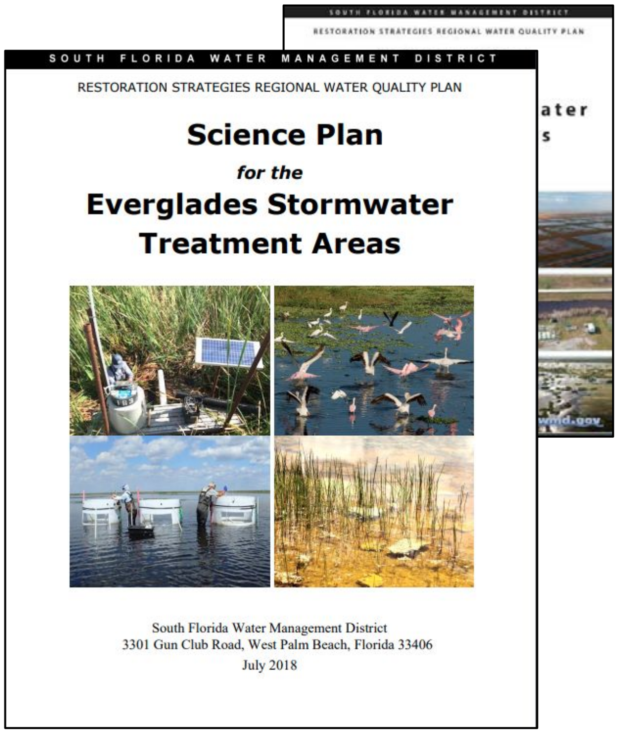


Credits: SFWMD

Improved Water Quality in Engineered Systems

"Photosynthesis within dense beds of SAV elevates the water column pH, which facilitates co-precipitation of P with cationic minerals such as Ca (Brix, 1997; Reddy and DeLaune 2008; Kadlec and Wallace, 2009). Macrophytes also provide contact surface for microbes and periphyton, which can reduce soluble reactive phosphorus (SRP) from the water column by storing it as cellular organic P and/or through extracellular processes of metal-phosphate deposition, co-precipitation with Ca and magnesium (Mg), and adsorption to inorganic compounds like calcium carbonate (CaCO3; Hagerthey et al., 2011). "

“Beyond their role as attachment surfaces for periphyton and microbes, vegetation communities in wetlands can also lower P concentrations in the water column by pervasive changes they cause in the physical environment. **Macrophytes reduce current velocities greatly near the sediment-water interface and thereby stabilize the sediment surface and minimize the movement of superficial sediments and floc. The underwater plant canopy forms a fiber bed that reduces water movement; decreases sediment and floc resuspension and transport; and provides a large surface area for particle impaction, interception, and settling** (Kadlec and Wallace, 2009, Ch. 10).”



SOUTH FLORIDA WATER MANAGEMENT DISTRICT

RESTORATION STRATEGIES REGIONAL WATER QUALITY PLAN

Science Plan

for the

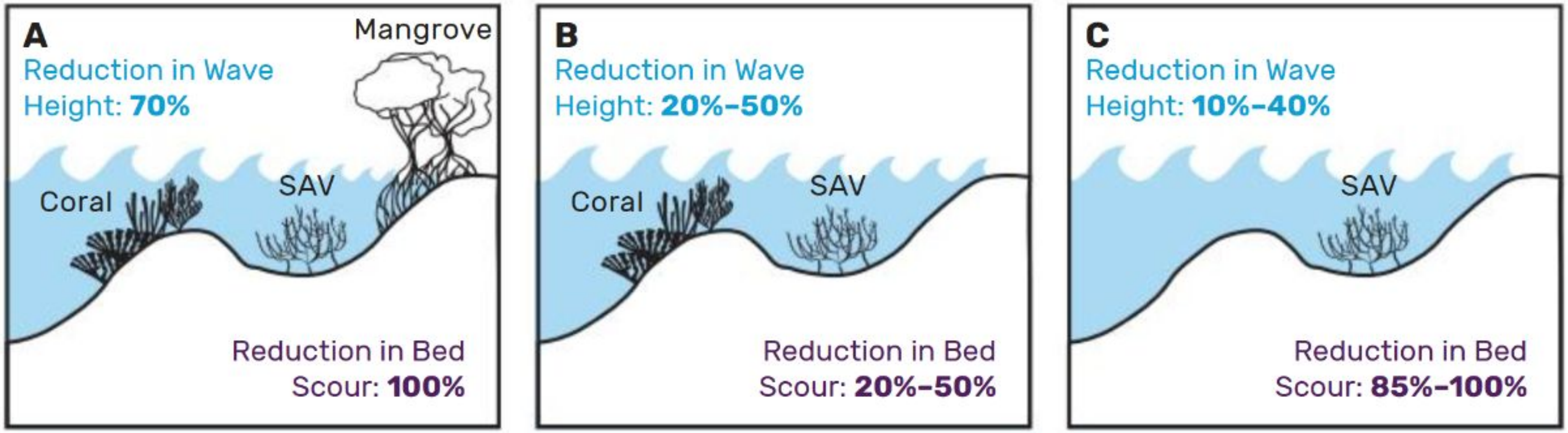
Everglades Stormwater Treatment Areas

South Florida Water Management District
3301 Gun Club Road, West Palm Beach, Florida 33406
July 2018

Prevent Erosion & Wave Attenuation

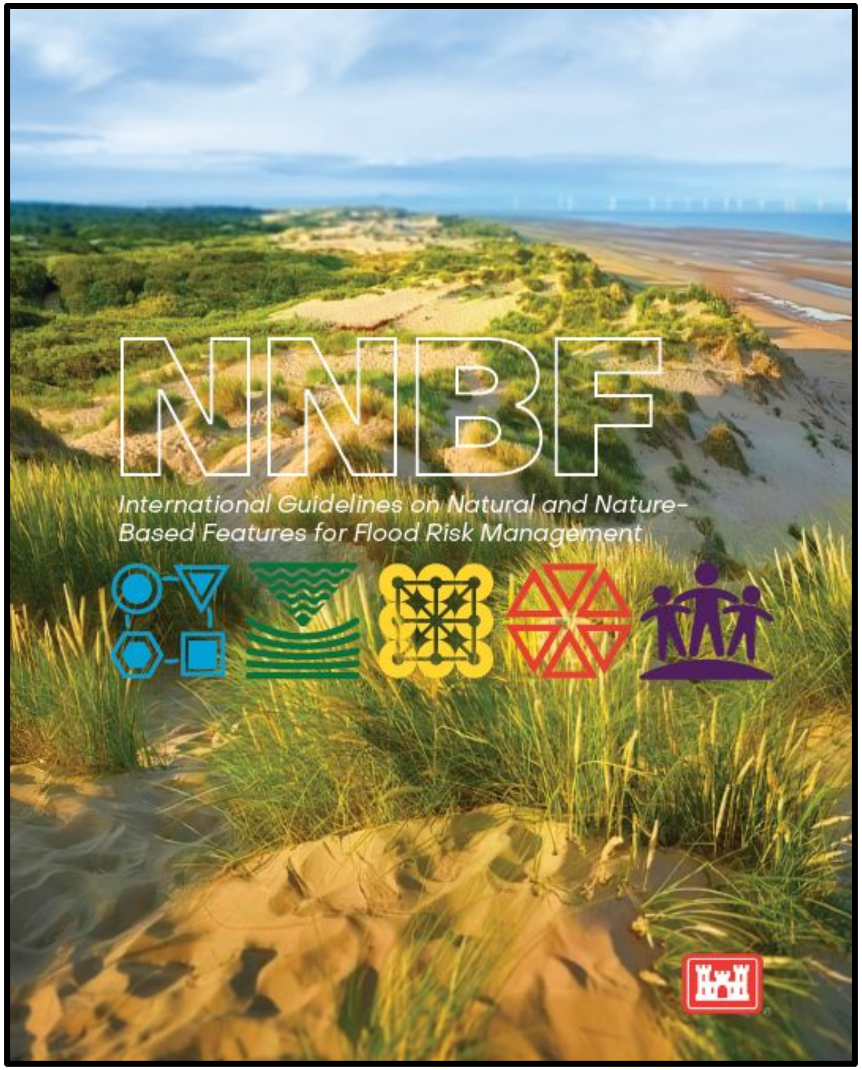
According to the International Guidelines for Natural and Nature Based Features for Flood Risk Mitigation; seagrass meadows can reduce wave energy by up to 40% and reduce sediment sour by 85-100%.

Figure 13.4. *Multiple Lines of Defense Strategies*



Note: Strategies that incorporate multiple NNBF measures provide more effective shoreline and storm protection.

Prevent Erosion & Wave Attenuation

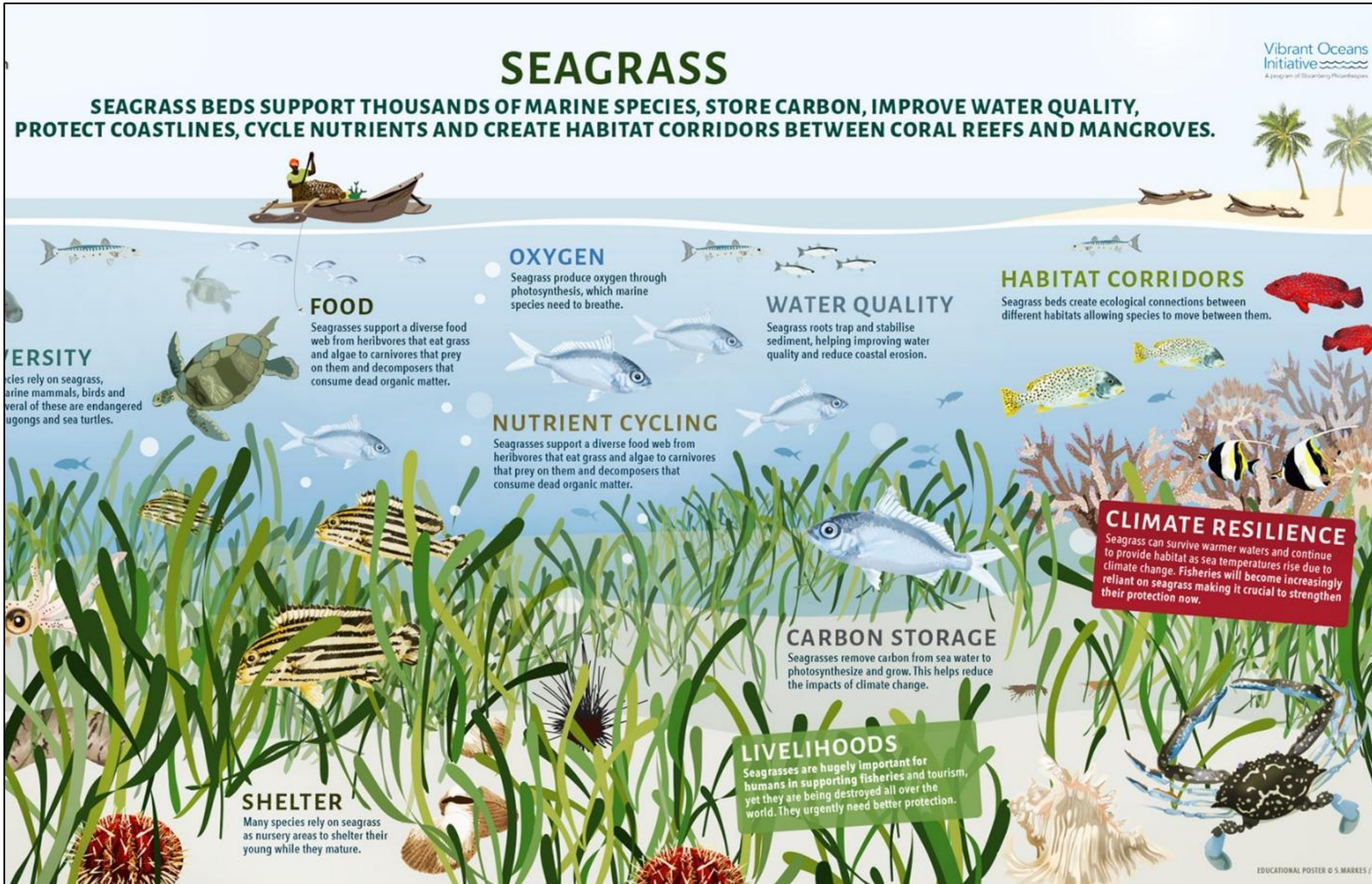


International Guidelines for Natural and Nature Based Features, published by the US Army Corp in 2021.

Chapter 13 – Submerged Aquatic Vegetation & Kelp

Altman, S., C. Cairns, P. Whitfield, J. Davis, M. Finkbeiner, and B. McFall. 2021. "Chapter 13: Plant Systems: Submerged Aquatic Vegetation and Kelp." In *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*. Edited by T. S. Bridges, J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, and R. K. Mohan. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Ecosystem Services



Nuisance vegetation control

- State & Federal funds expended in Florida during FY 2021-2022 to control aquatic plants in public waters $18,238,006 (does not include municipal SW treatments)
- Aquatic plants are generally 1-2% Nitrogen and 0.25% Phosphorus
- Let the manatees help for free!
- Plants systems can be self sustaining when nutrient limited, but that is not the current condition.

Natural Infrastructure Expectations

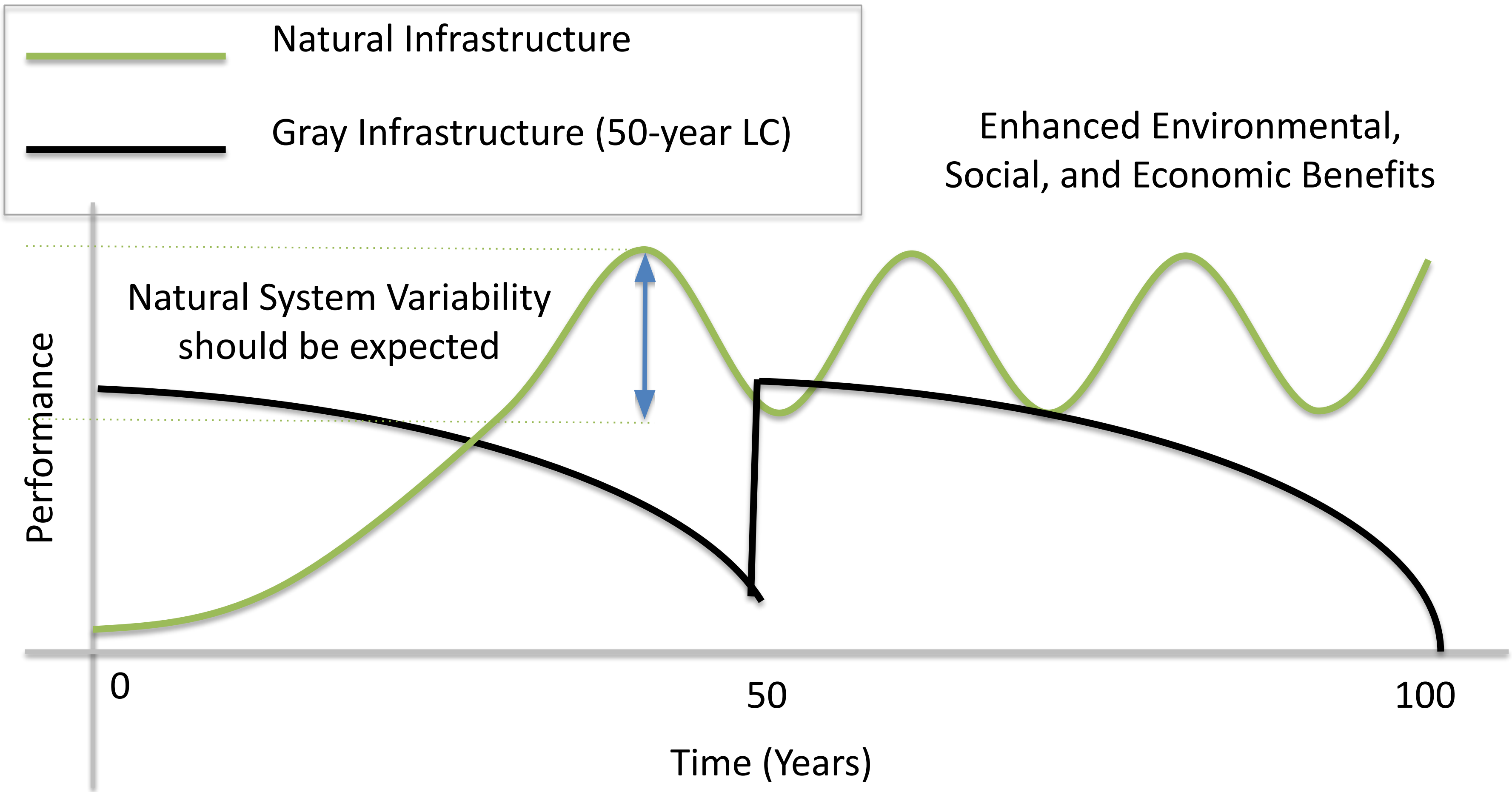
- **Gray Infrastructure** consumes material

- **Nature-Based Solutions** can create materials used to serve the function. Utilizes natural processes in an engineered capacity to provide the environmental, social, and economic benefits.

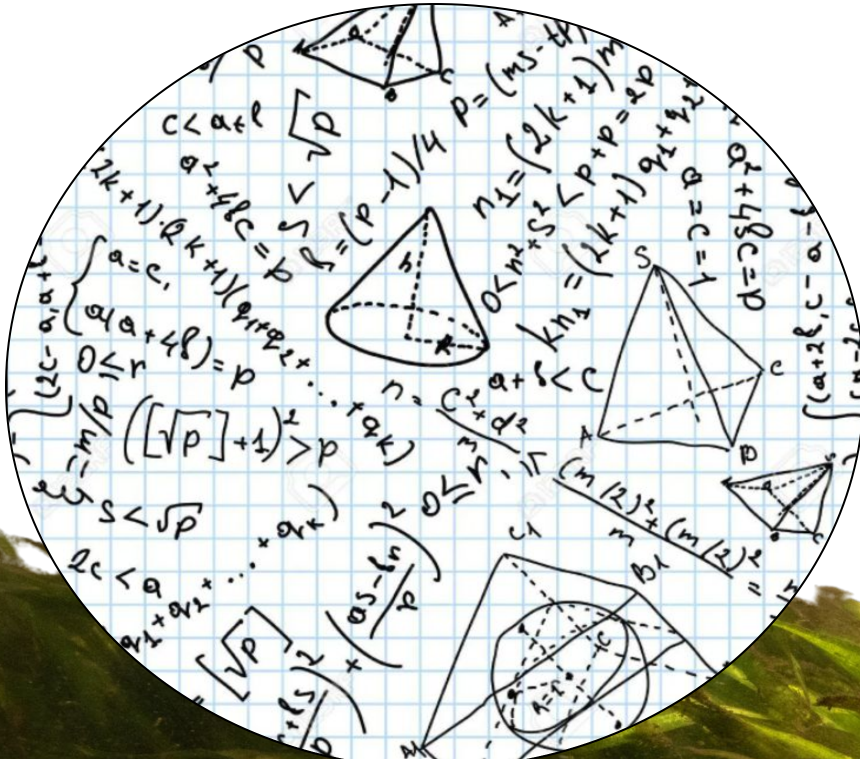
Examples of true nature-based solutions

- Living shoreline or coral restoration
- Vegetated buffers or stabilized area
- Flexible submerged aquatic vegetation (FlexSAV) for Stormwater.

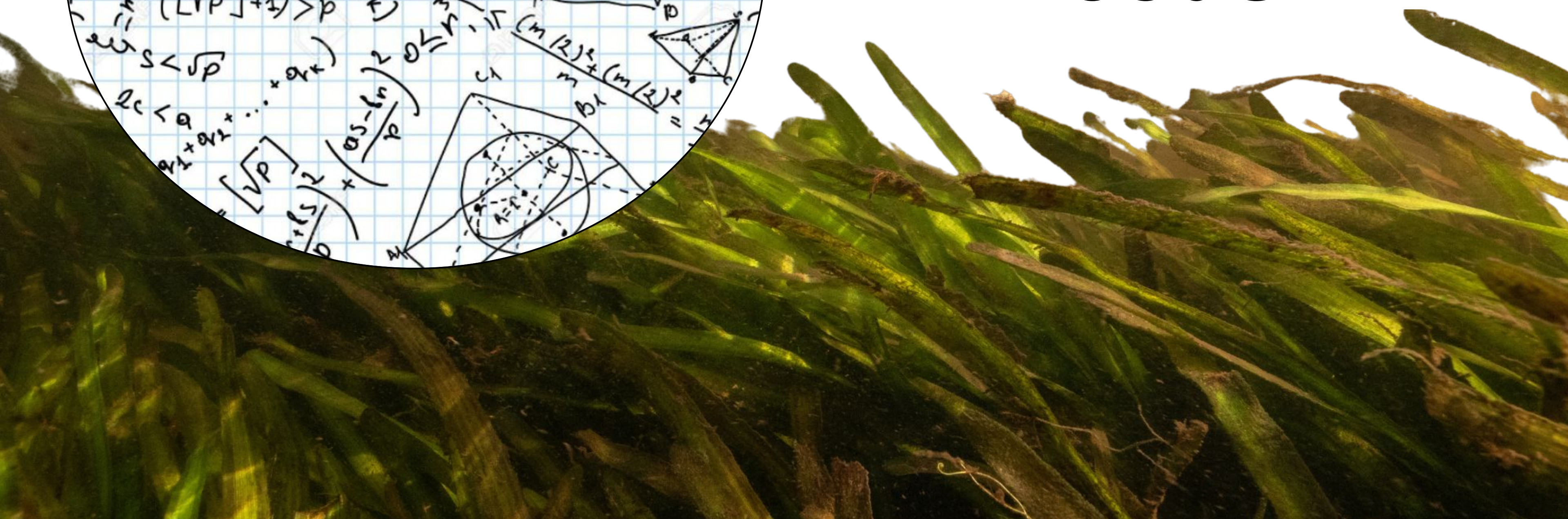
Natural Infrastructure Expectations



How does this really work ? …



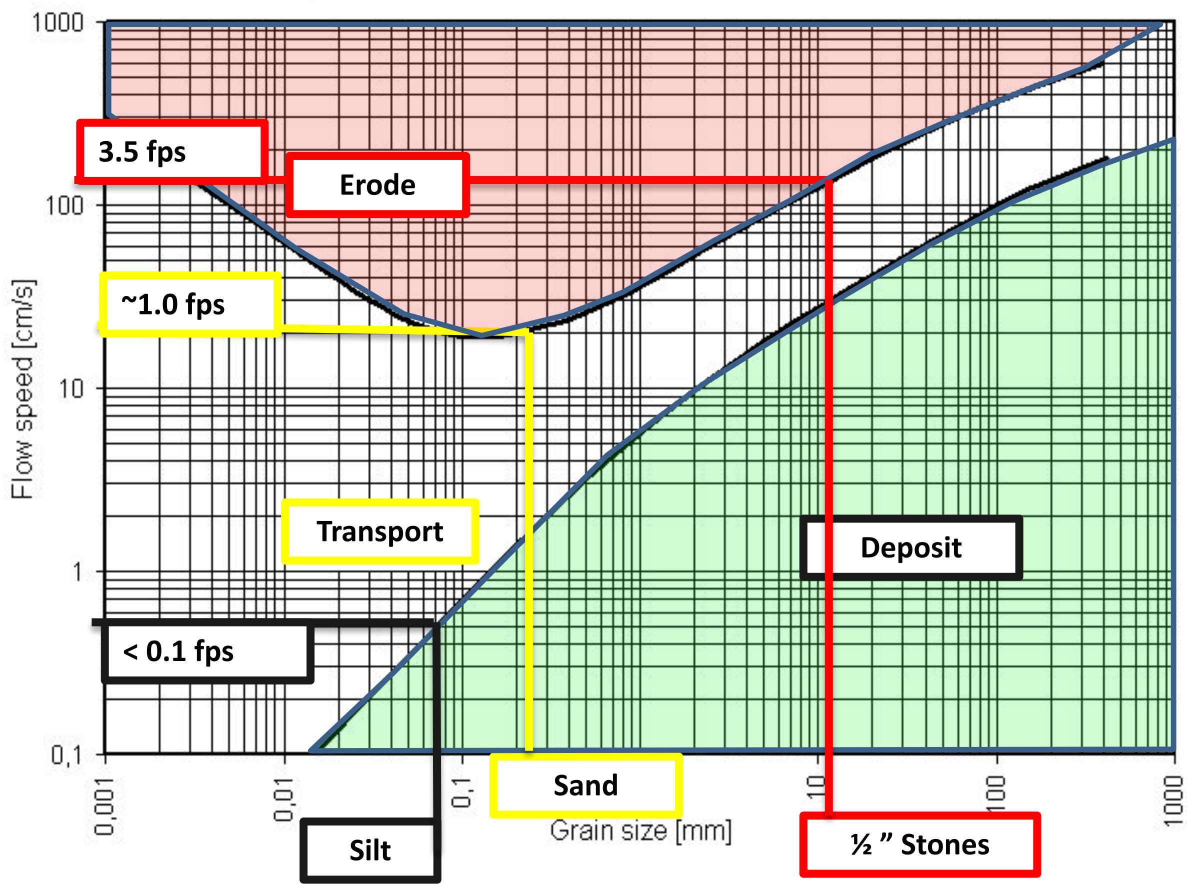
Let’s get into the weeds



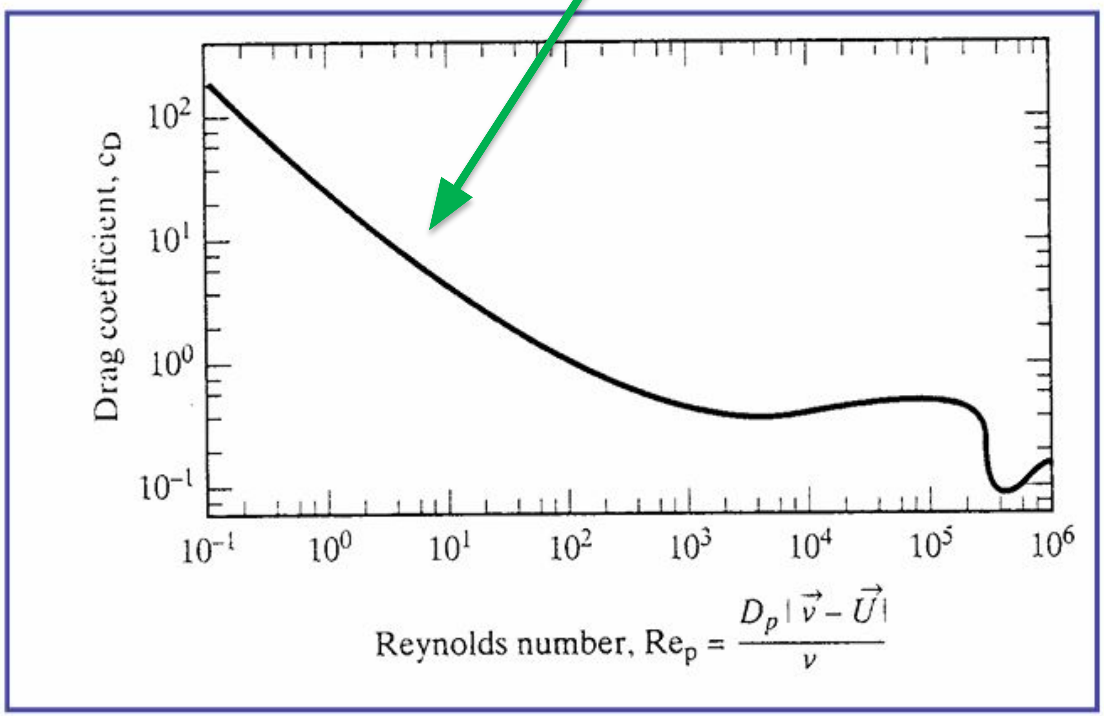
Sediment Transport Basics

Hjulström Diagram

- **Erosion**
- **Transport**
- **Deposition**



Particle Settling

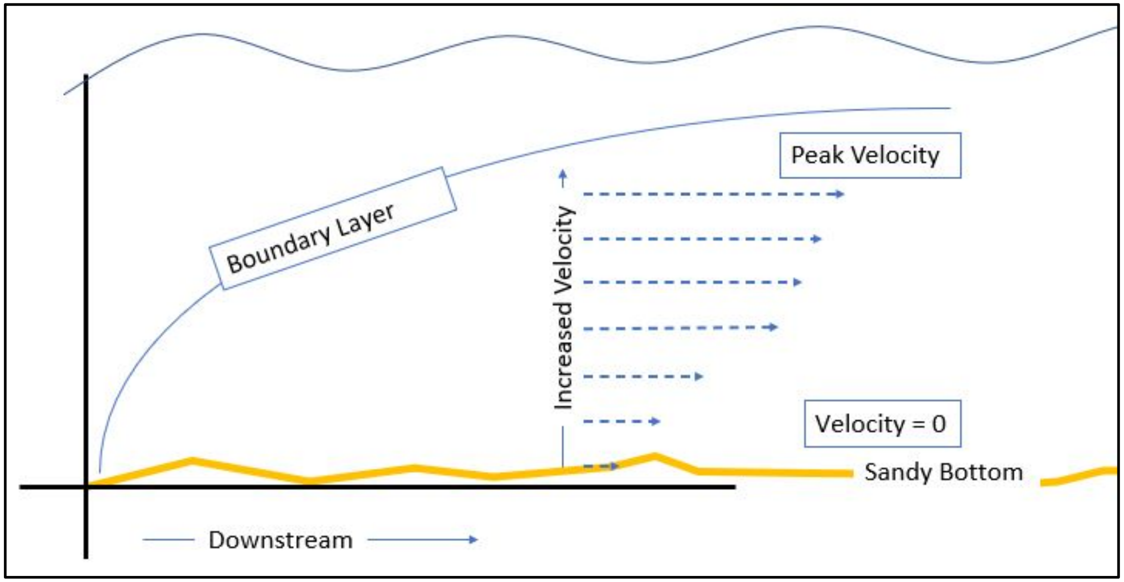


- Size of Sediment vs. Velocity
- Defined by Stokes Law
- Sediment impacts water quality

Stokes law:

$$V = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g R^2$$

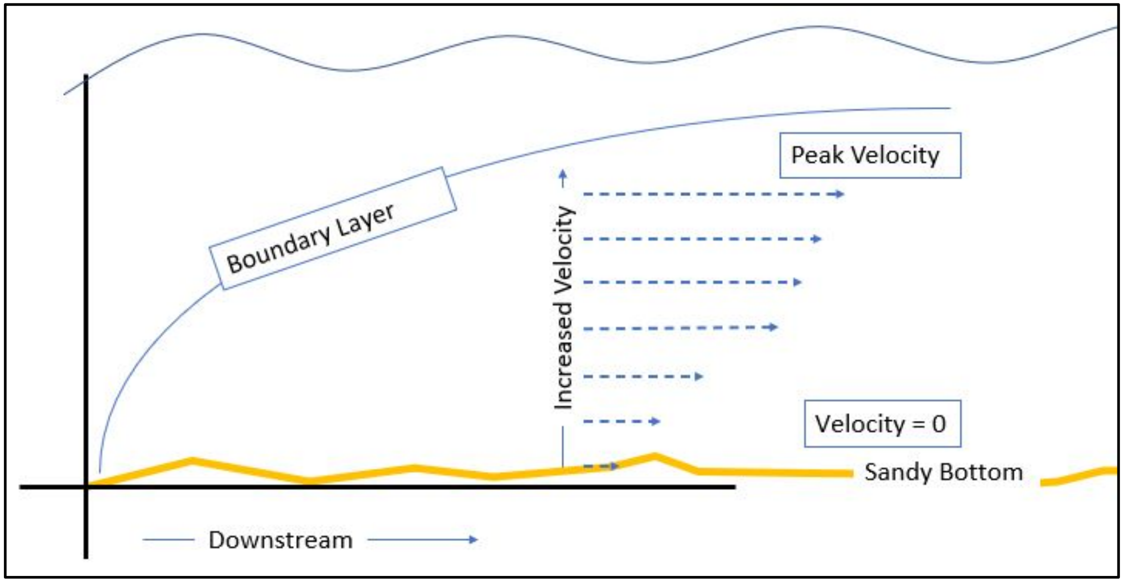
Boundary Layer Theory



Boundary Layer Theory

- Thin layer of fluid
- Affected by surface roughness and fluid velocity (speed)
- Where speed changes from zero on the surface to the speed of moving water.

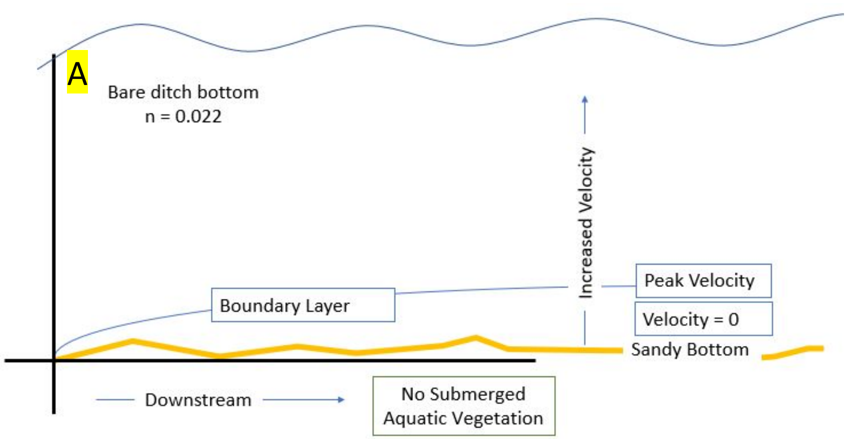
Boundary Layer Theory

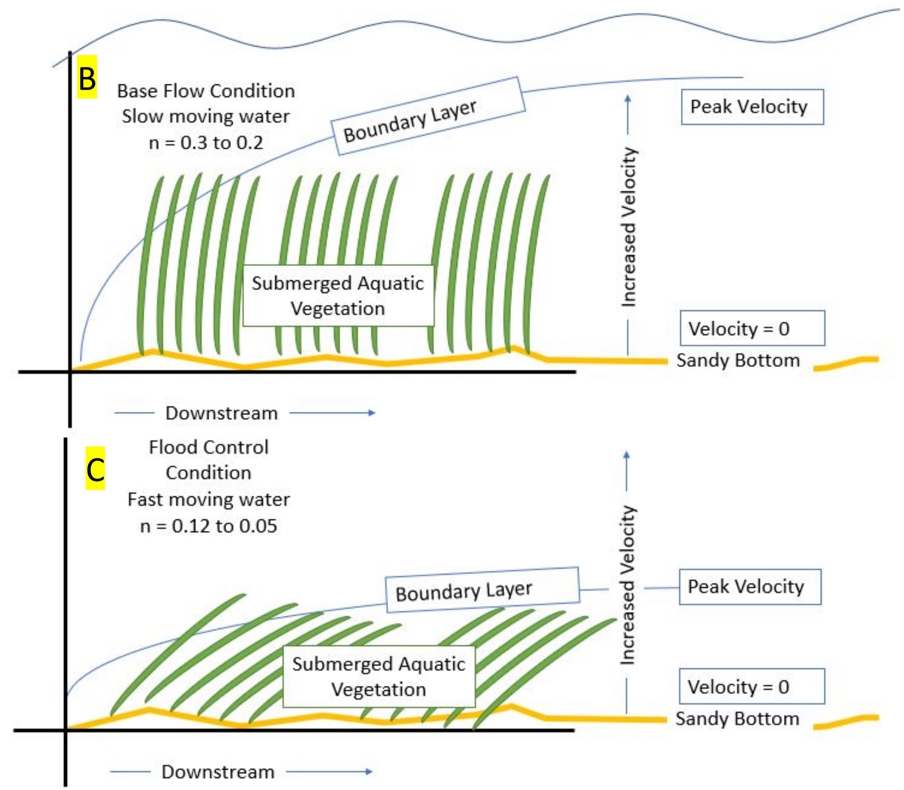


<u>Expansion of the Boundary Layer</u>

- Reduces sediment transport
- Reduces scour & erosion
- Improves water quality

Boundary Layer with SAV





The Boundary Layer Effect
(fluid mechanics)

Schügerl, R. et al.: Effect of aquatic vegetation on Manning ́s roughness coefficient value – Acta Hydrologica Slovaca, Volume 21, No. 1, 2020, 123–129

What about Flood Control and Manning Coef. ?

Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n}\right) A R^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) A R^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

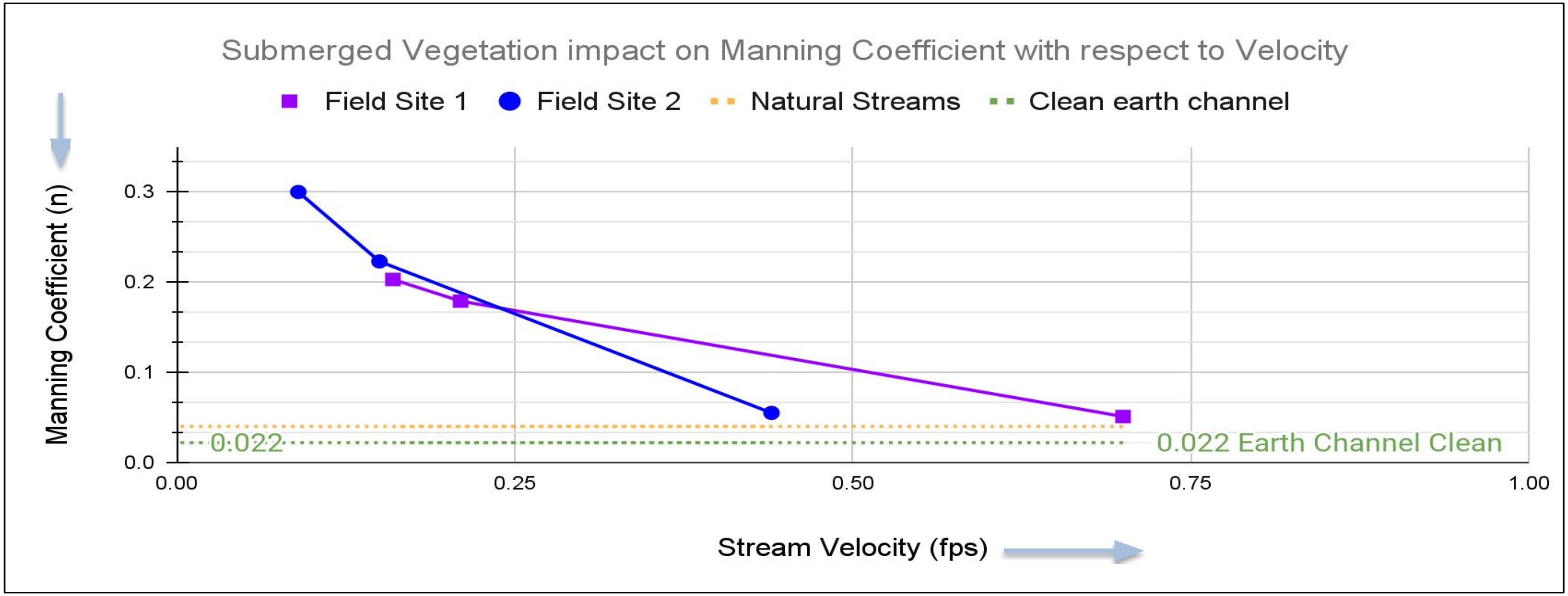
Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

<u>The Manning's Equation</u>

- Open Channel Flow
- Modelling Parameter
- Manning's Roughness Coef.
- Determines Flow Rate

Natures Smart Solution

- For flexible vegetation, vegetation height decreases with increased flow velocity, and hence the flow resistance decreases with flow velocity



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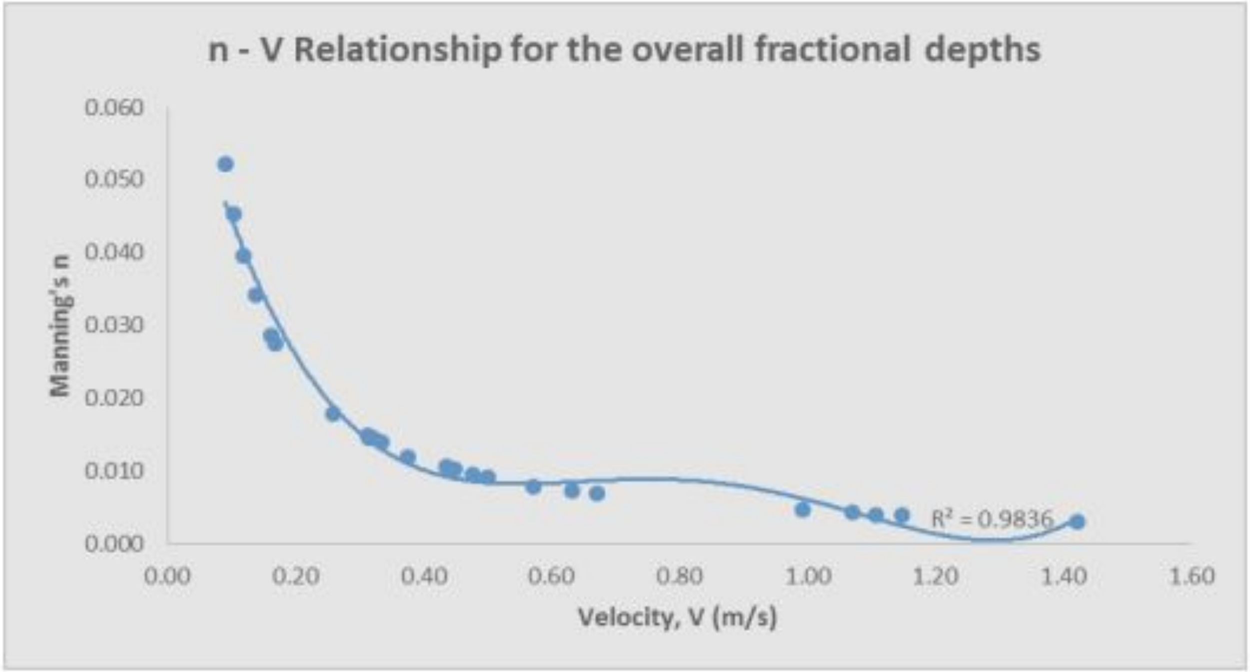


Figure 4. Relationship between manning's and velocity

Khamaruzaman Wan Yusof et al 2017 IOP Conf. Ser.: Mater. Sci. Eng. 216 . 012046

Reduce Nutrients

Increased Residence Time

- Significantly increases residence time during base flow condition
- Improves water quality
- Most important factor for water quality performance (Harper, 2007)

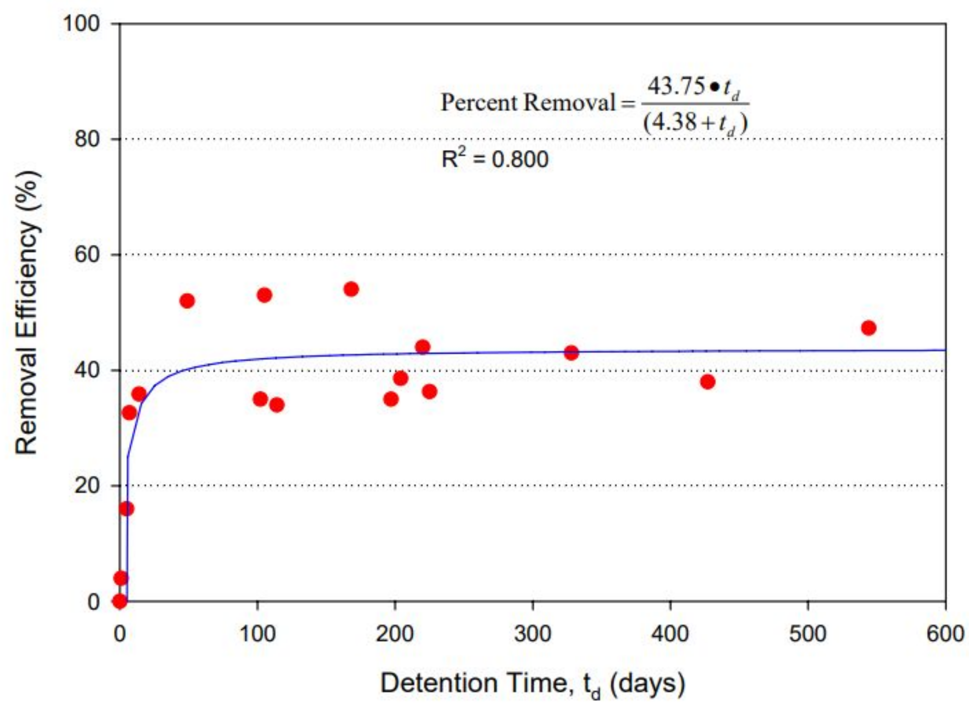
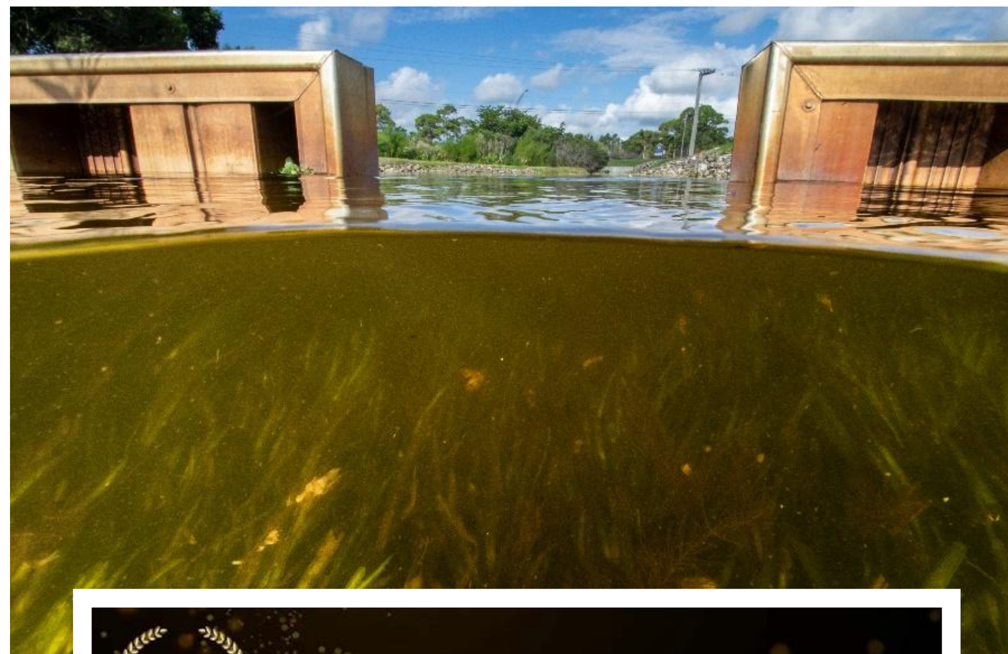


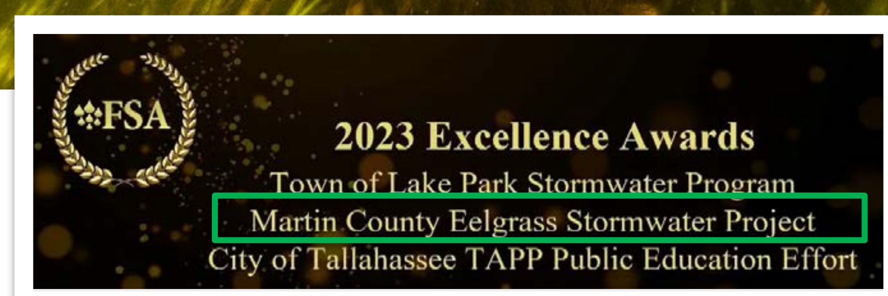
Figure 5-10. Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

Challenges for SAV in Stormwater Systems

- Expect seasonal variability in cooler temperatures.
- SAV needs typical water velocities below ~2 feet per second
- Stormwater managers have typically viewed SAV as problematic in stormwater systems due to public option and potential clogging of small diameter infrastructure.
- Invasive species such as Hydrilla or Eurasian Milfoil have given SAV a bad reputation. These nuisance species require expensive removal or environmentally damaging treatments.

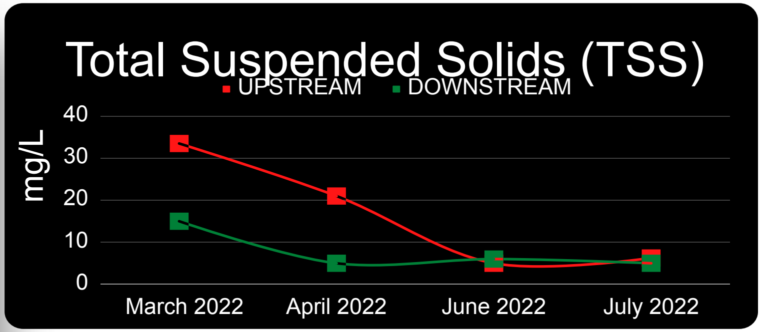
Can we add submerged aquatic vegetation to your stormwater infrastructure?

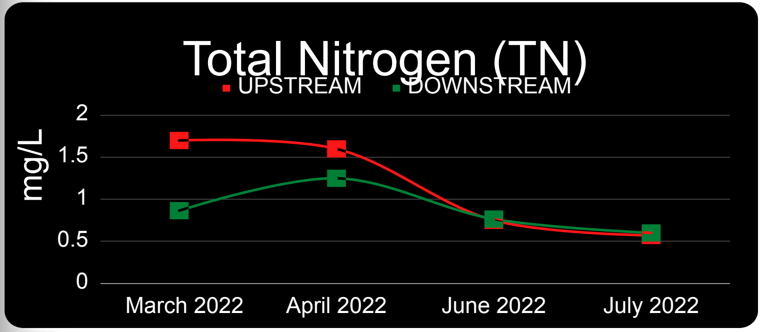


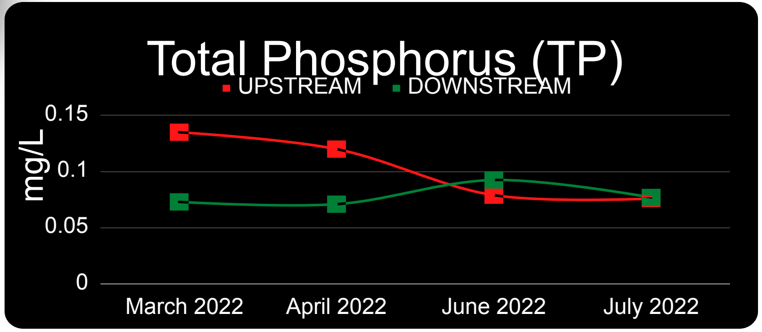


Preliminary Controlled

Testing 2022





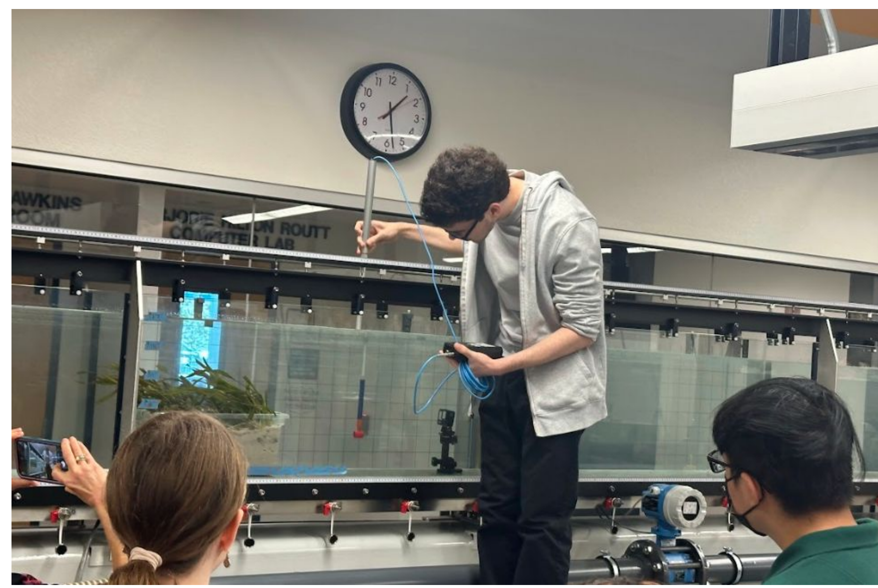


STEM – Community Involvement

SEA & SHORELINE
aquatic restoration

Partnership with Indian River State College Science & Mathematics department.

Physical performance experimentation with students as a STEM experience.



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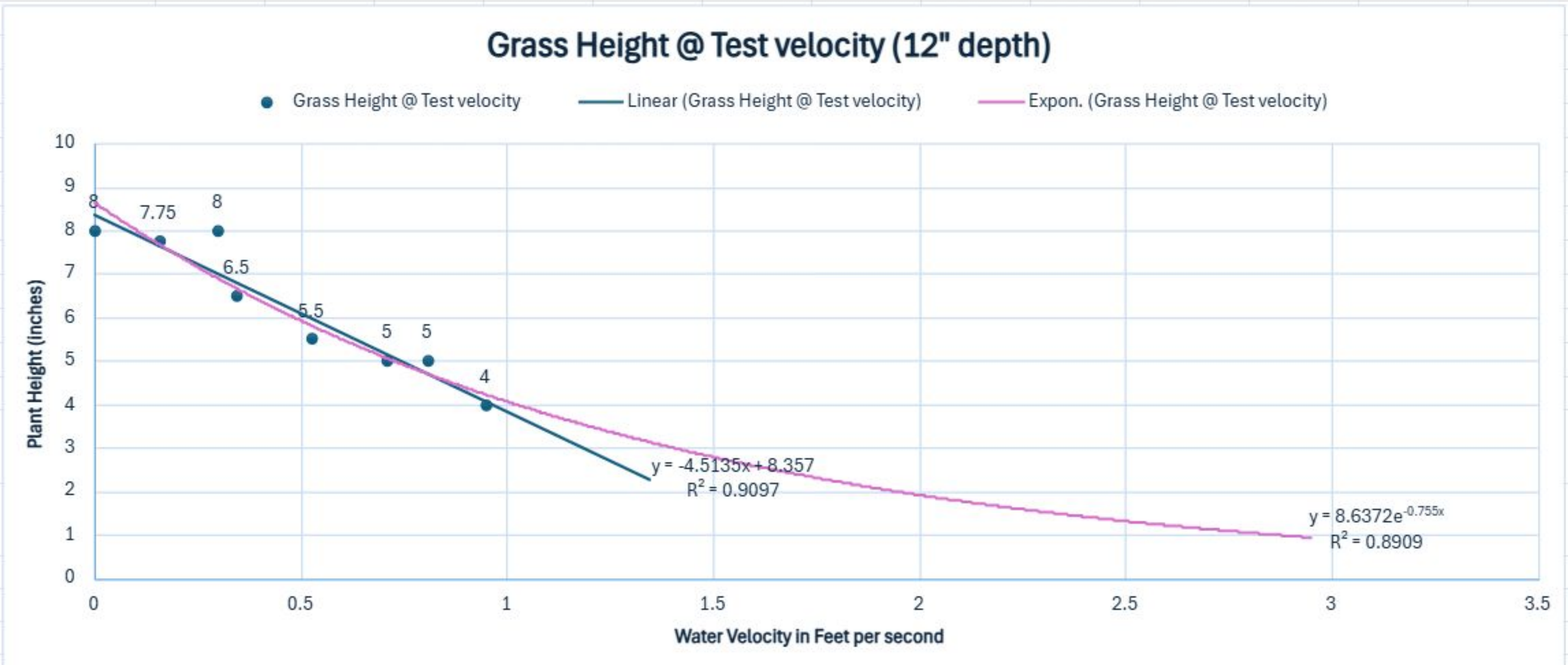


Not published data from 2023/24

What to expect

SEA & SHORELINE aquatic restoration

How SAV can be incorporated into a project

- Evaluate soil & site conditions
- Plant selection & planning
- Planting & Installation
- Maintenance
- Monitoring

Evaluate Soil & Site Condition

Fine sediments (passing #200 Sieve) greater than 60% can negatively impact plantings.

SAV needs at least 6” of sediment

Perform a sediment gradation by grain size

- ASTM C117
- ASTM D422
- ASTM D2487

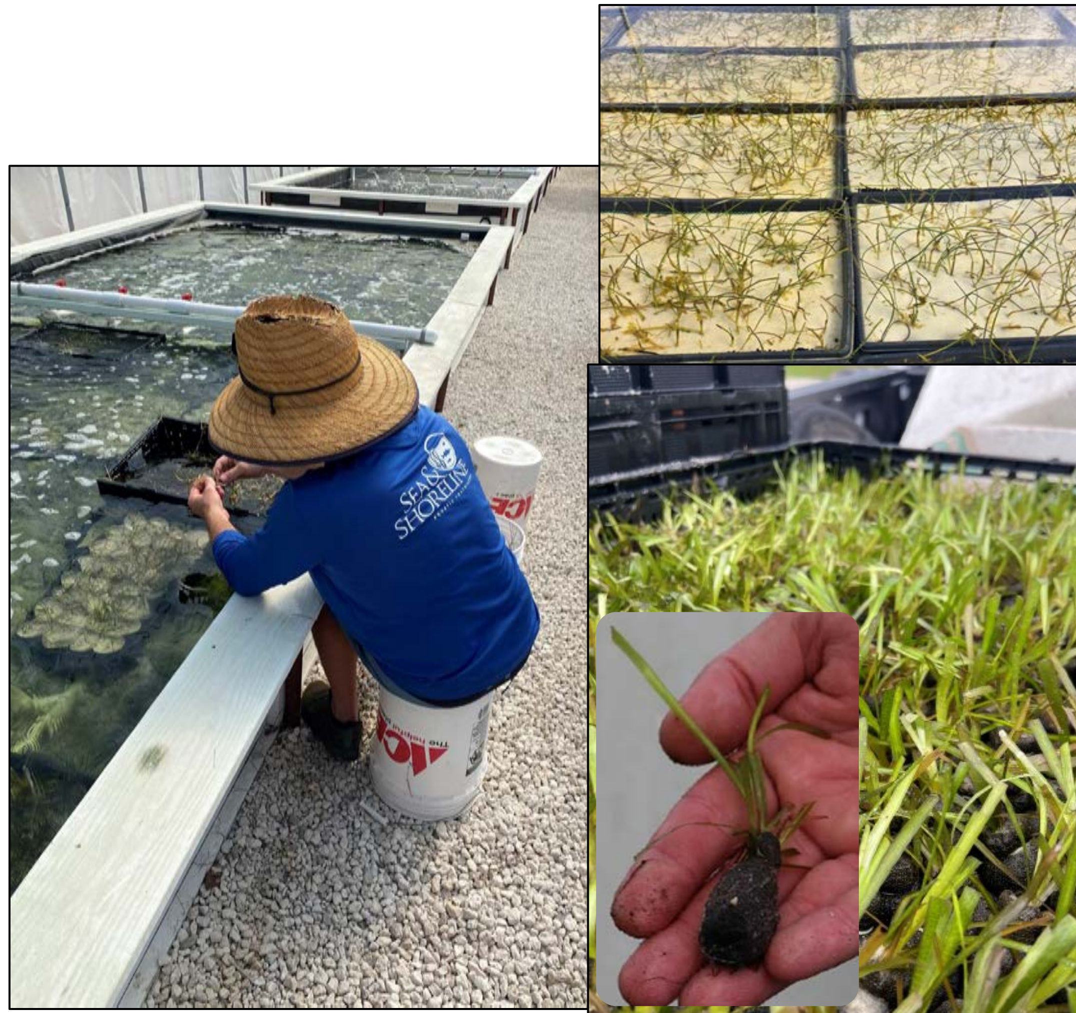
Evaluate potential for predation and physical stream conditions.

Plant Selection & Planning

SAV restoration has historically had relatively low success rates. Often resulting from disturbing the roots during 'transplant' efforts.

Improved success come from nursery grown SAV utilizing planting units to reduce stress to the roots when planting.

There are significant differences between freshwater and saltwater SAV (e.g. seagrass)



Plant Selection & Planning

There are permitting tools available:

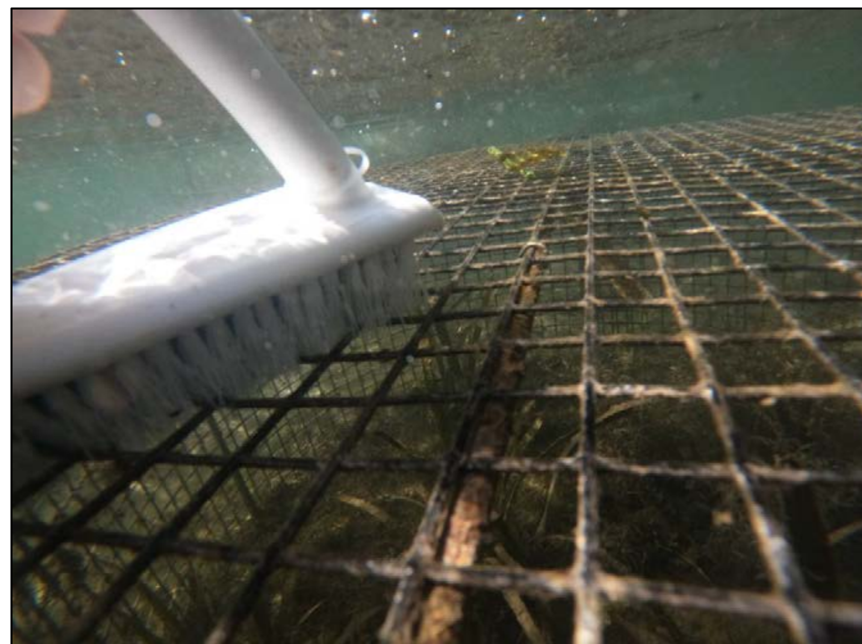
- USACE NWP 27 Aquatic Habitat Enhancement
- State Environmental Resource Permits generally include vegetation as ‘maintenance’ for established stormwater treatment wet ponds.
- Always confirm with state wildlife commission for species specific regulations.

Initial Planting (with cages)

(Typical) 3 months after planting

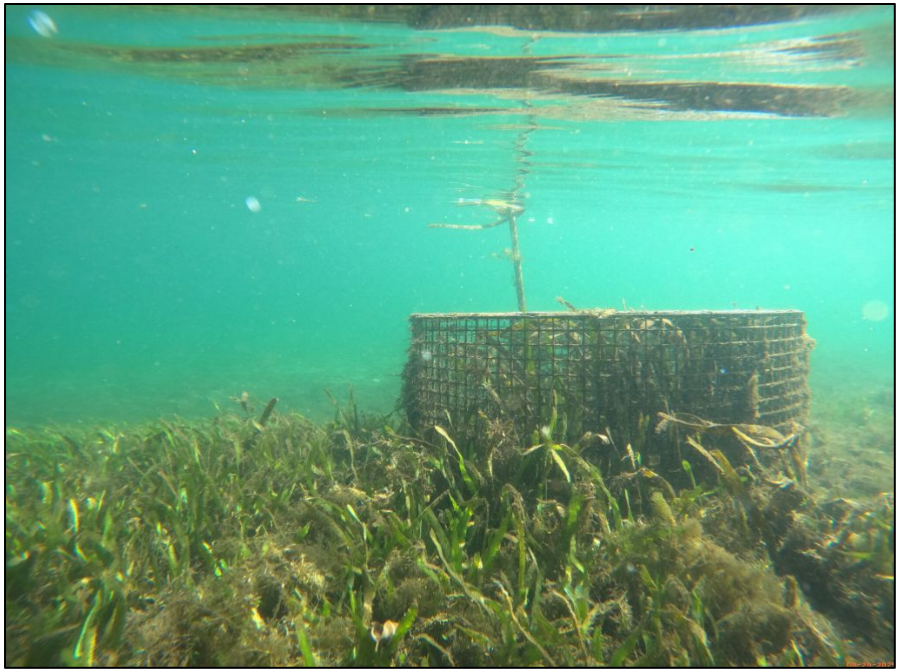
Maintenance – Monthly or as needed

Herbivory exclusion cages require maintenance to remove biofouling and maximize available sunlight. This is critical to success.



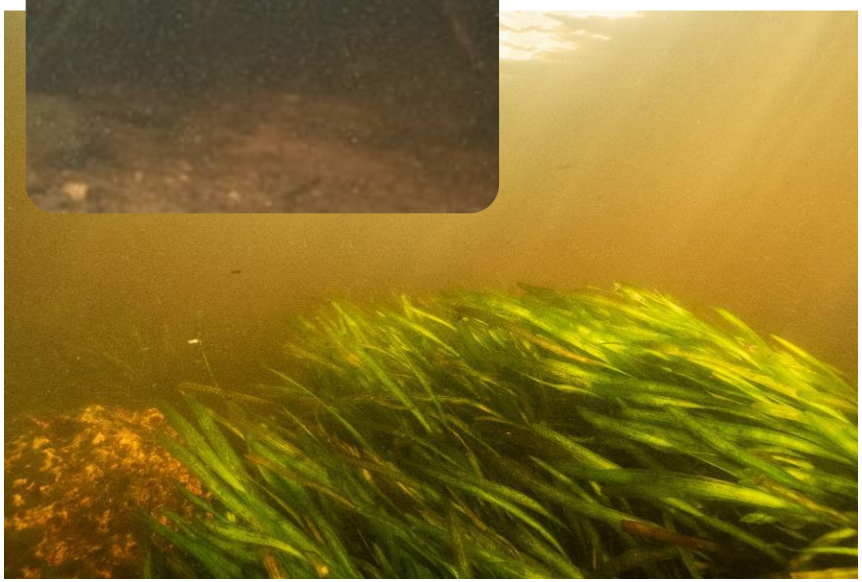
(Typical) 9 months after planting

Can be see expanding beyond the cages
Once roots are established the plant can sustain predation



What to expect

Native Pipefish in Stormwater Ditch



Martin County Stormwater Ditch

Submerged aquatic vegetation (SAV) coverage may change seasonally.

Lots of wildlife will eat it. Cages are used to allow the roots to establish.

It may take up to 2 years for the beneficial SAV to sustain predation.

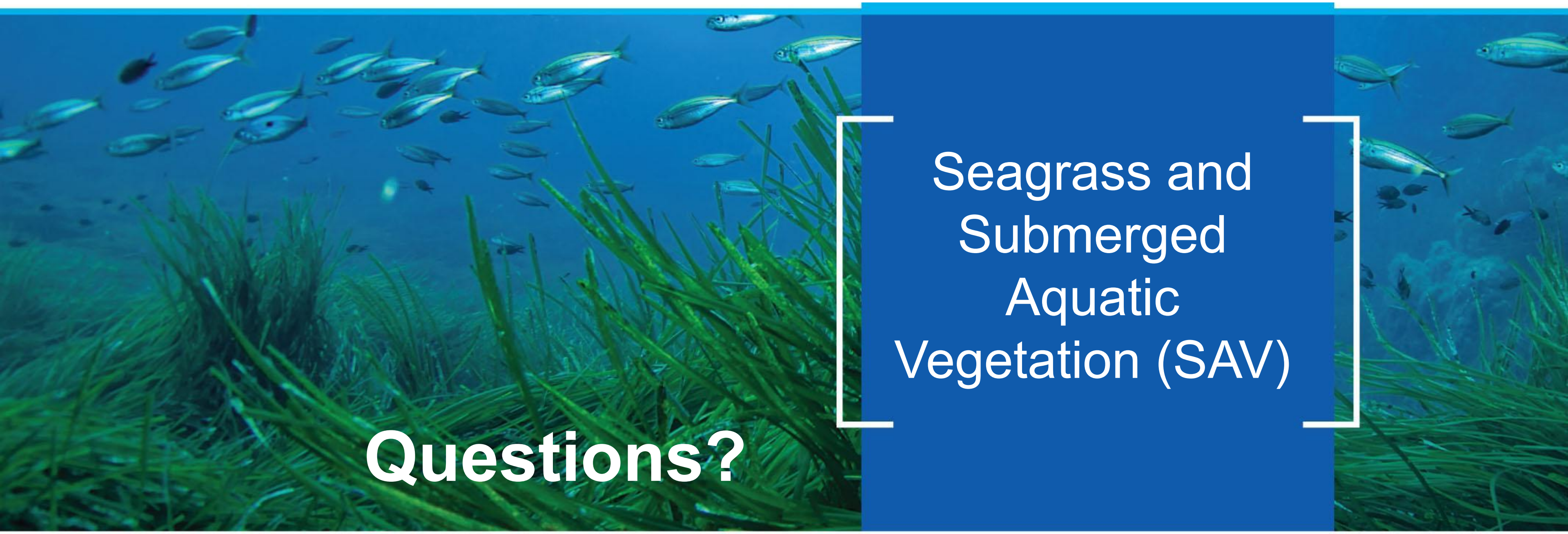
Establish a seed bank for SAV to expand as a resilient water quality solution.

Plan to monitor and maintain any cages for up to 1-year, supplemental plantings may be necessary due to weather and site conditions.

Collaborations

We are excited and interested in supporting collaboration and sharing lessons learned.

Contact us if you're interested in joining forces!



Questions?

Seagrass and Submerged Aquatic Vegetation (SAV)

Nicholas Muzia, PE

Principle Engineer & Design Build Manager

Nick@seaandshoreline.com

Strategies for Water Quality, Shoreline Protection, and Sediment Control

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