Florida Stormwater Association

SEA & SHORELINE
aquatic restoration

NETWORK FOR ENGINEERING WITH NATURE

Controlling Sedimentation and Pollution with Nature-Based Systems.

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Florida Stormwater Association
Winter Conference
Dec 3-5th 2025

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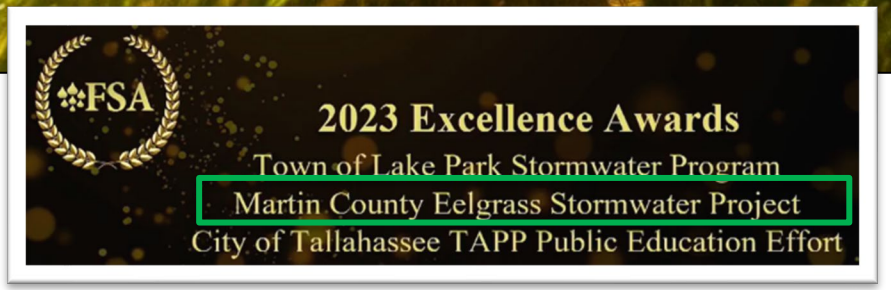
aquatic restoration

Controlling Sedimentation and Pollution with Nature-Based Systems

- Introduction to EWN & NbS definitions
- Sediment and influence on water quality
- Technical details & STEM Collaboration
- More eelgrass projects in Florida!!
- Questions



Engineering with Nature® (EWN)

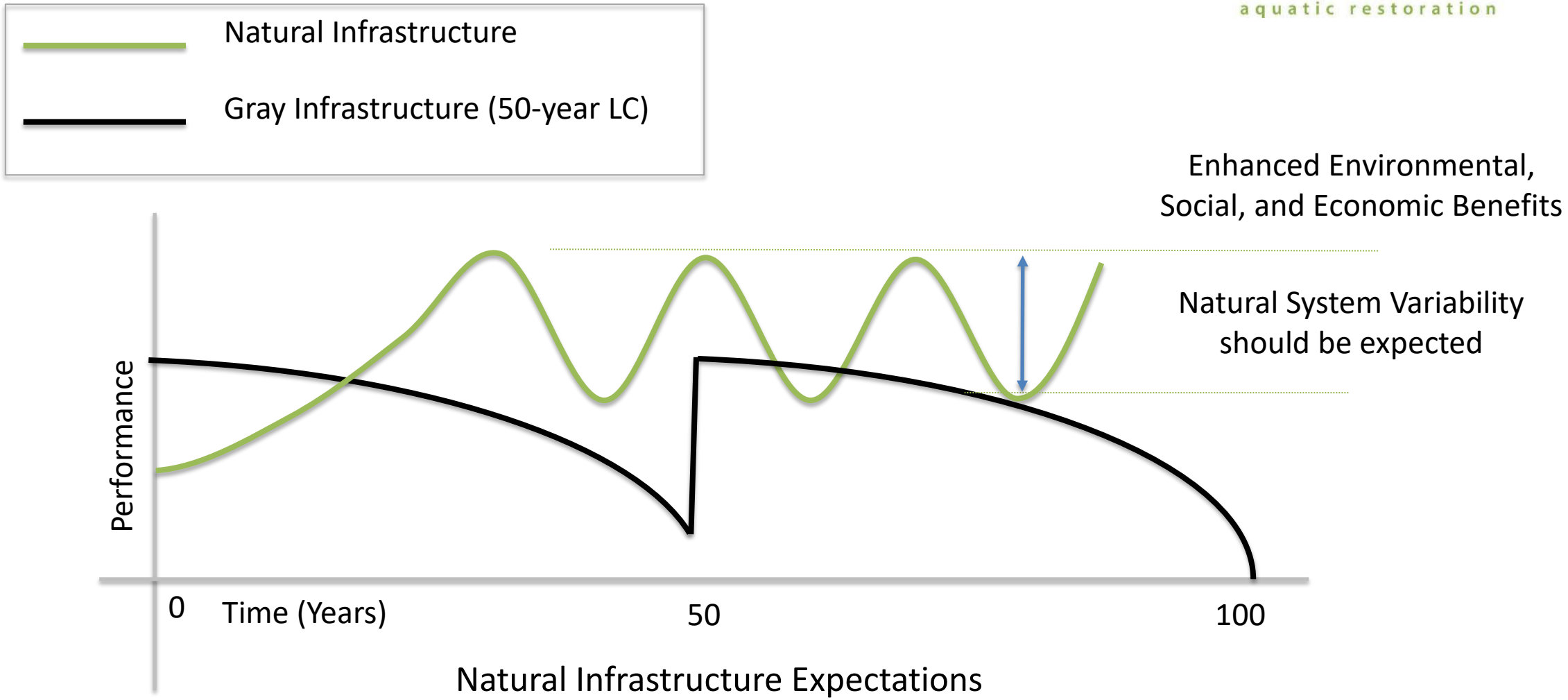
- Defined by USACE - EWN Program:
  - the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration.

Nature Based Solutions (NbS)

- Defined by TNC:
  - project solutions that are motivated and supported by nature and that may also offer environmental, economic, and social benefits, while increasing resilience. Nature-based solutions include both green and natural infrastructure.

- Defined by FEMA:
  - sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to build more resilient communities.

Natural Infrastructure (NI)



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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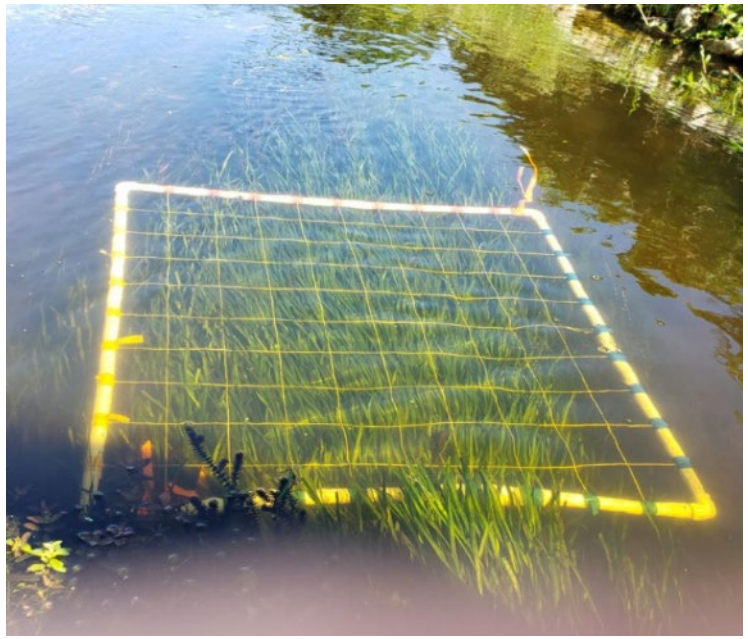
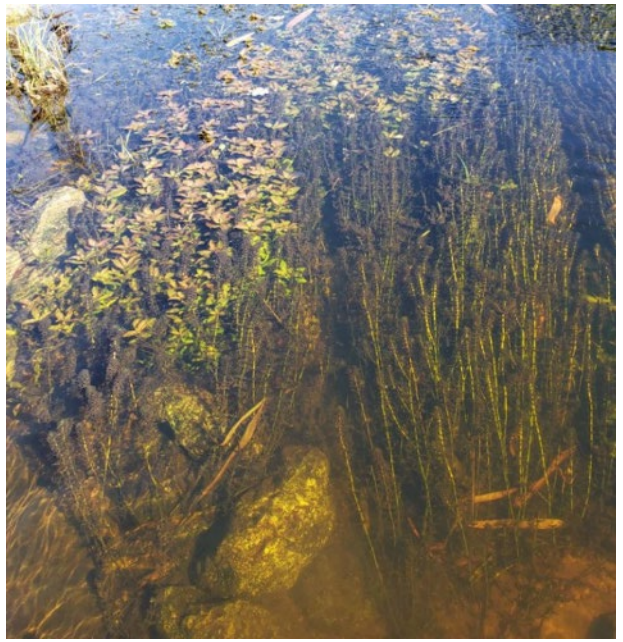
Beneficial (SAV)



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?

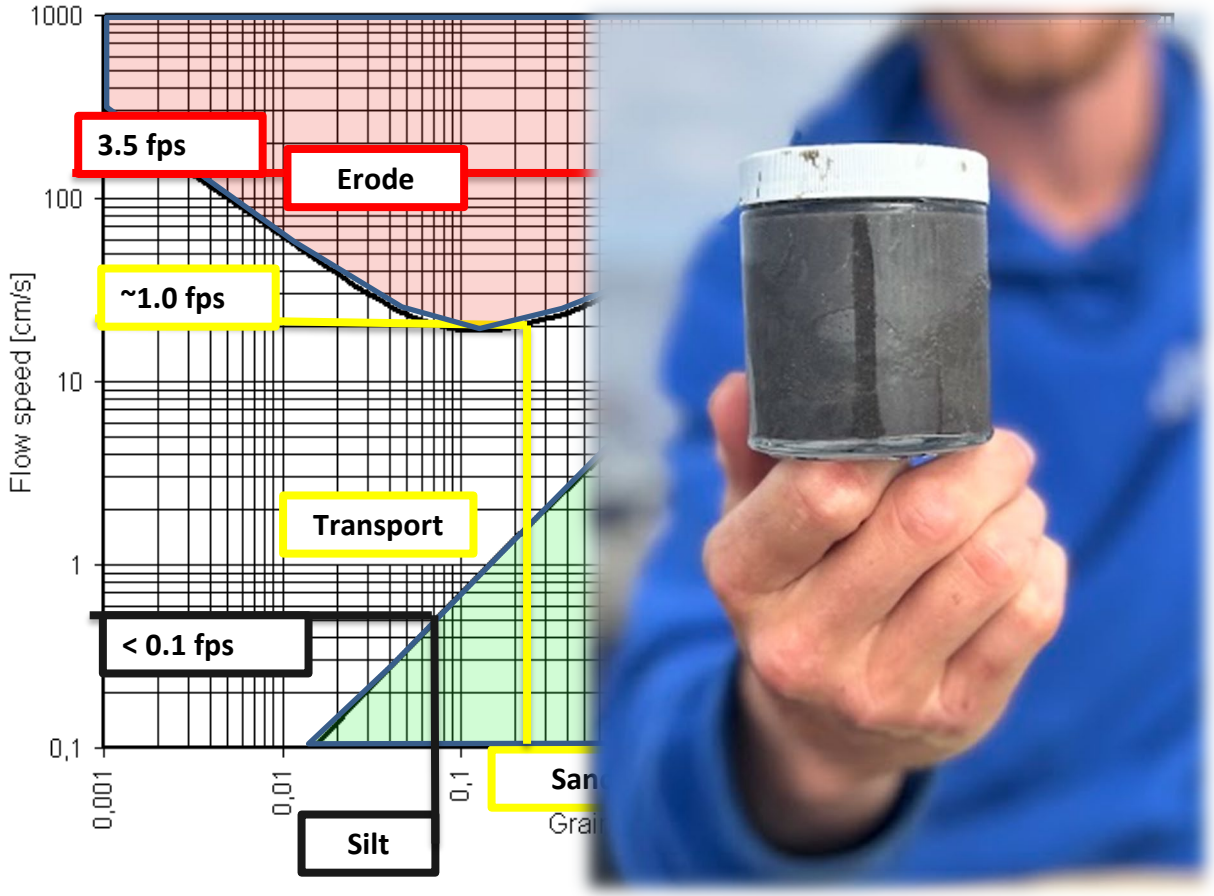
It is important to consider SAV in waterway design, as it affects:

- hydrodynamics
- sediment transport
- ecosystem health

Sediment Transport Basics

Hjulström Diagram

- Erosion
- Transport
- Deposition



Nutrient Concentrations for Water Quality

EPA guidance for Florida Ecoregion. FDEP has many watershed specific TMDL's for Florida to reference

BASED ON 25th PERCENTILE ONLY

Nutrient Parameters	Aggregate Nutrient Ecoregion XIII Reference Conditions (same as subecoregion 76)
Total phosphorus (µg/L)	**17.5**
Total nitrogen (mg/L)	**1.27**
Chlorophyll *a* (µg/L) (Trichromatic method)	**12.35**
S	

United States Environmental Protection Agency | Office of Water 4304 | EPA 822-B-00-014 December 2000

	TP	*TN*
EPA:	**0.017 mg/l**	**1.27 mg/l**

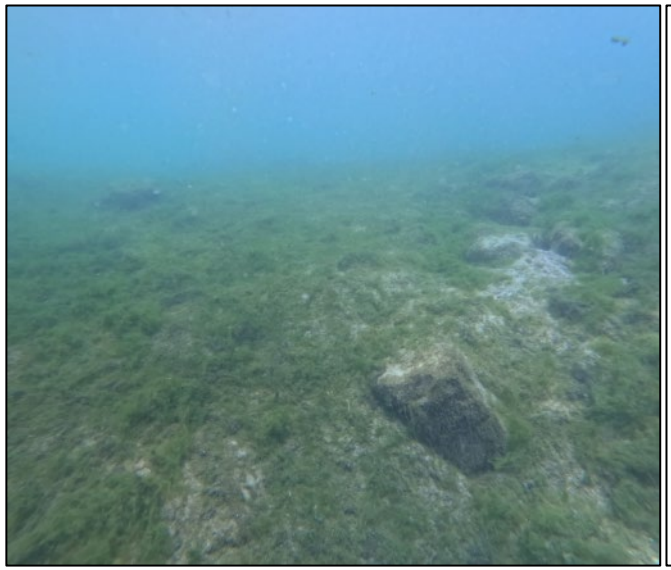
1 Liter of water = 1 kg of water

Nutrient Concentrations in Sediment

	TP	*TN*
• Sample 1:	**200 mg/kg**	**1,700 mg/kg**
• Sample 2:	**300 mg/kg**	**2,600 mg/kg**
• TMDL Conc:	**0.03 mg/l**	**0.28 mg/l**

Kings Bay – Crystal River, FL

Low Nutrient System (OFS)



Client Sample ID: Pre-Dredge CR1 — **Lab Sample ID: 660-136728-1**

Analyte	Result	Qualifier	PQL	MDL	Unit	Dil Fac	D	Method	Prep Type
Nitrogen, Kjeldahl	1700		410	210	mg/Kg	10	☼	351.2	Total/NA
Total Phosphorus as P	200		10	4.1	mg/Kg	1	☼	365.4	Total/NA
Nitrogen, Total	1700		0.41	0.21	mg/Kg	1	☼	Total Nitrogen	Total/NA
Nitrate Nitrite as N	0.92		0.41	0.21	mg/Kg	1	☼	353.2	Soluble

Client Sample ID: Pre-Dredge CR2 — **Lab Sample ID: 660-136728-2**

Analyte	Result	Qualifier	PQL	MDL	Unit	Dil Fac	D	Method	Prep Type
Nitrogen, Kjeldahl	2600		450	230	mg/Kg	10	☼	351.2	Total/NA
Total Phosphorus as P	300		11	4.5	mg/Kg	1	☼	365.4	Total/NA
Nitrogen, Total	2600		0.45	0.23	mg/Kg	1	☼	Total Nitrogen	Total/NA
Nitrate Nitrite as N	1.3		0.45	0.23	mg/Kg	1	☼	353.2	Soluble

Nutrient Concentrations in Sediment

	TP	*TN*
• Sample 5:	**1100 mg/kg**	**4,500 mg/kg**
• Sample 6:	**1000 mg/kg**	**3,900 mg/kg**
• Sample 7:	**610 mg/kg**	**1,700 mg/kg**
EPA:	**0.017 mg/l**	**1.27 mg/l**

Lake Worth Lagoon
Coastal Estuary

Sample 5

Sample 6

Sample 7

Nutrient Concentrations in Sediment

Lake Muck Nutrient Values

	TP	TN
• Sample 1:	1300 mg/kg	9,900 mg/kg
• Sample 2:	960 mg/kg	9,000 mg/kg
• Sample 3:	2200 mg/kg	20,000 mg/kg
TMDL Conc:	0.04 mg/l	1.27 mg/l

Liquid Porewater Nutrient Values

• Sample 1:	48 mg/l	390 mg/l
• Sample 2:	44 mg/l	400 mg/l
• Sample 3:	18 mg/l	56 mg/l

Figure 4: Benthic Muck Sample #1

Nutrient Concentrations in Sediment

Lake Muck Nutrient Values

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INFLOWS TO LAKE OKEECHOBEE

Description	Site	Total Phosphorus mg/L	Total Nitrogen mg/L	Chlorophyll-A µg/L
Kissimmee River	S65E	0.081	1.590	23.200
Kissimmee River	S65EX1	0.081	1.590	23.200
Harney Pond Canal (C-41)	S71	0.258	2.260	
Indian Prairie Canal (C-40)	S72	0.308	2.300	

Water Column Concentration

	TP	TN
• Kissimmee River:	0.08 mg/l	1.59 mg/l
• Indian Prairie Canal:	0.31 mg/l	2.30 mg/l
• C44 @ Port Mayaca:	0.23 mg/l	1.47 mg/l

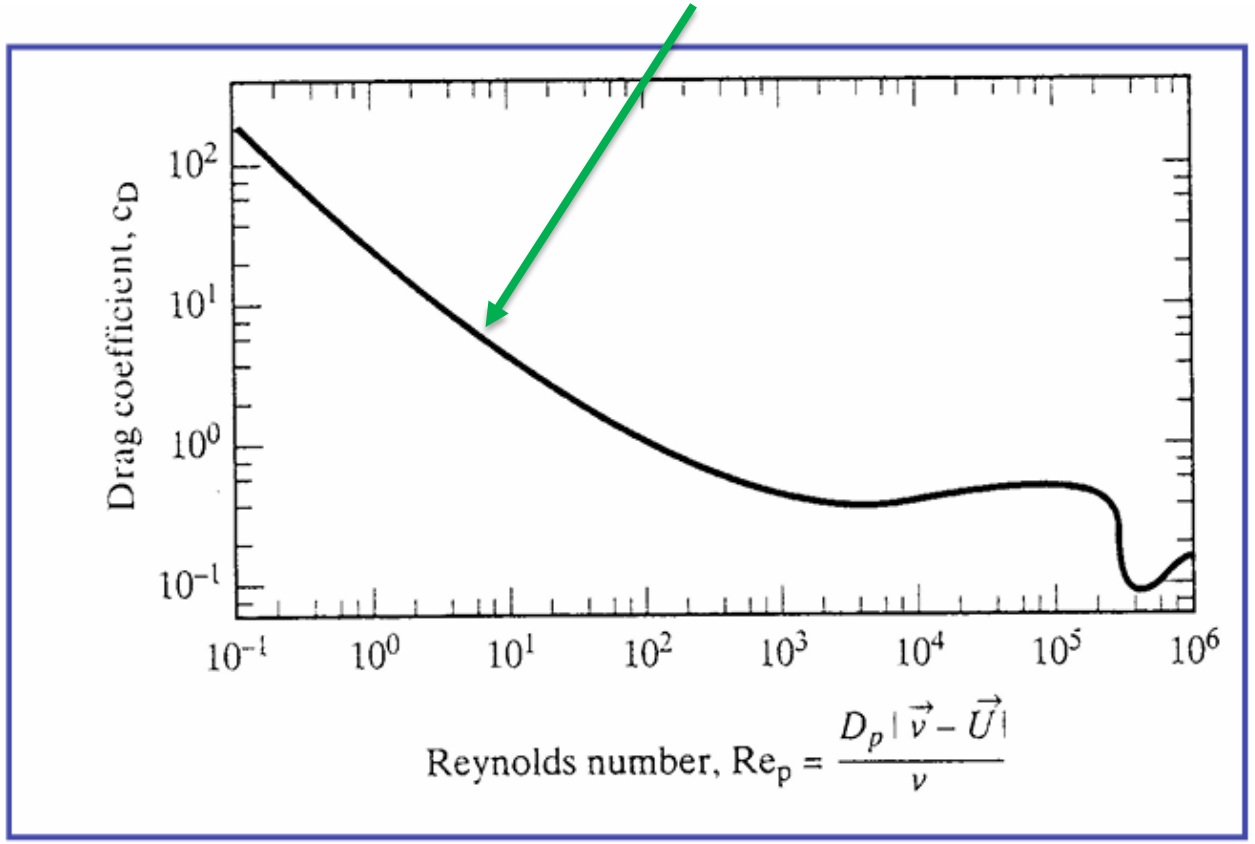
C-44 Canal at Port Mayaca	S308	0.230	1.470	15.900
L-65 Canal	S153	0.551	1.670	
C-44 Canal at St Lucie Estuary	S80	0.273	1.080	10.200

Source: SFWMD Site Status Sampling Database Lake O

Evaluate Soil & Site Conditions

- EPA 365.4 (Phosphorus) or EPA 351.2 + 353.2 (TN) to evaluate nutrient concentration in soils (NELAC)
- Fine sediments (passing #200 Sieve) greater than 60% can negatively impact SAV.
- Perform a sediment gradation by grain size
  ASTM C117, ASTM D422, & ASTM D2487
- SAV needs at least 6” of good sediment.

Particle Settling

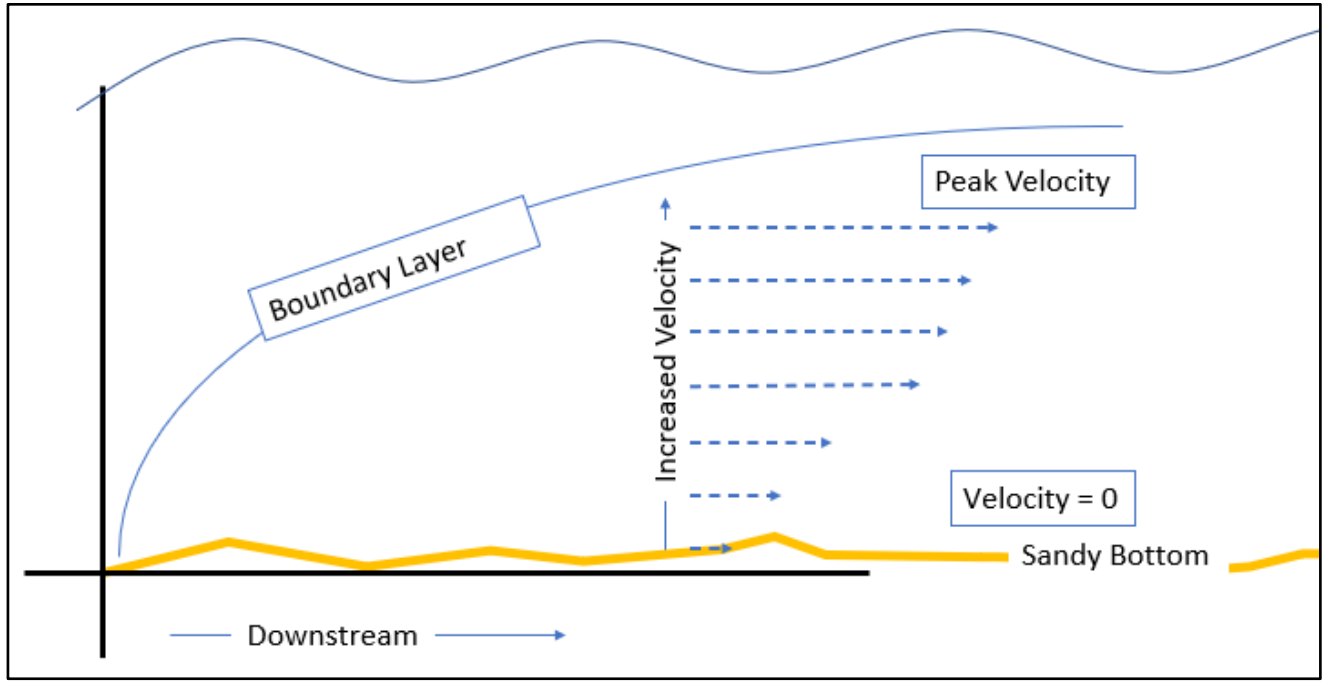


Stokes law:

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

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

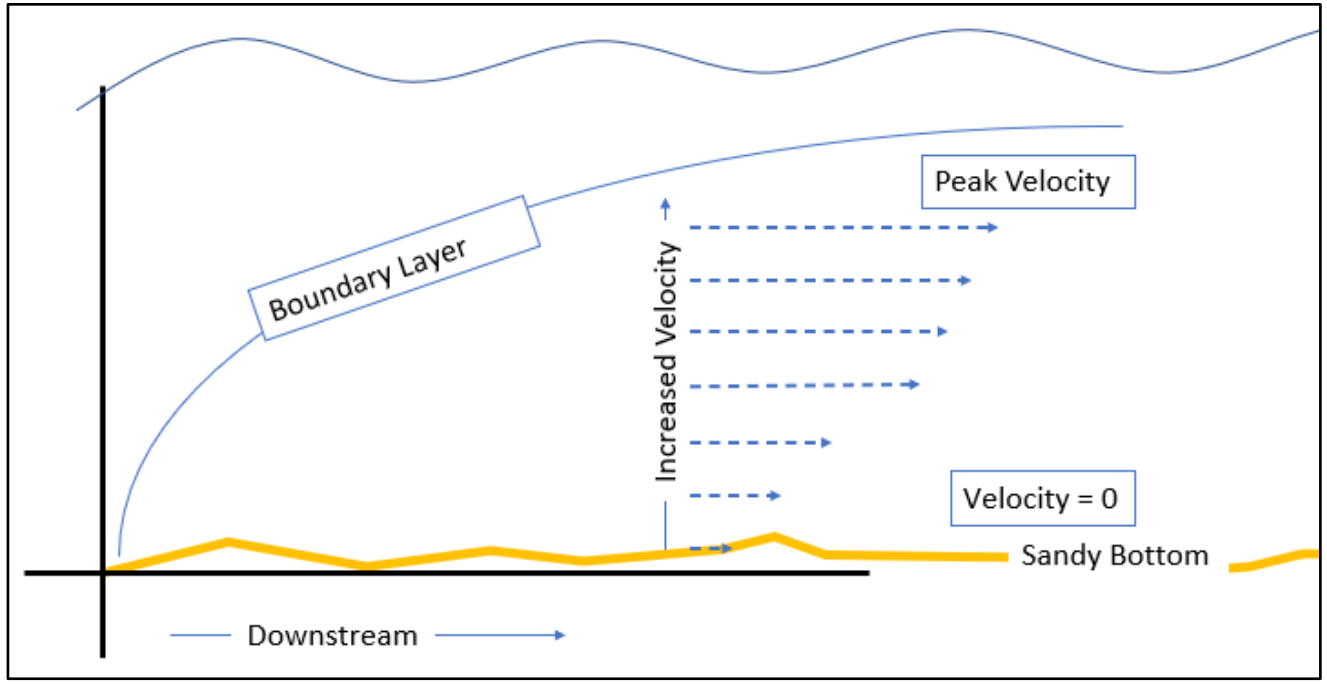
Boundary Layer Theory



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.

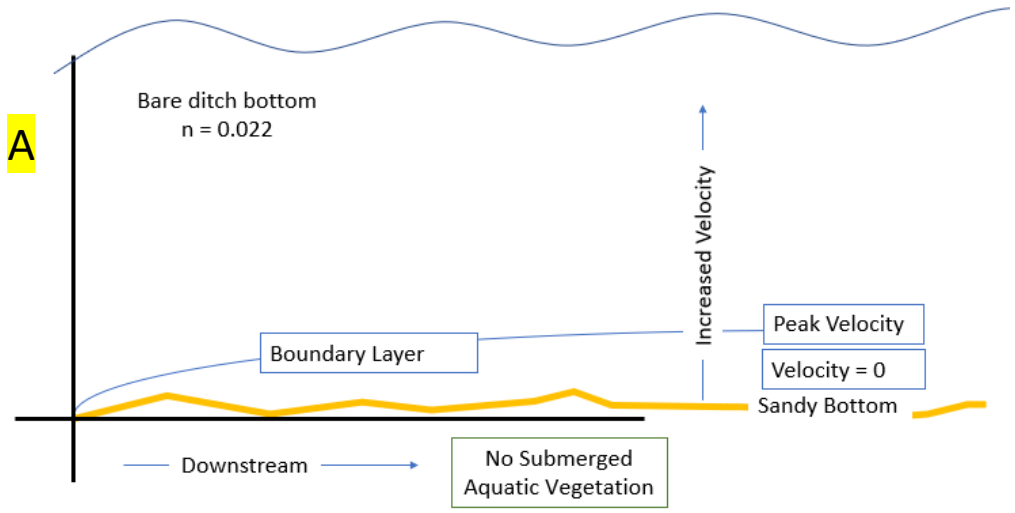
Boundary Layer Theory

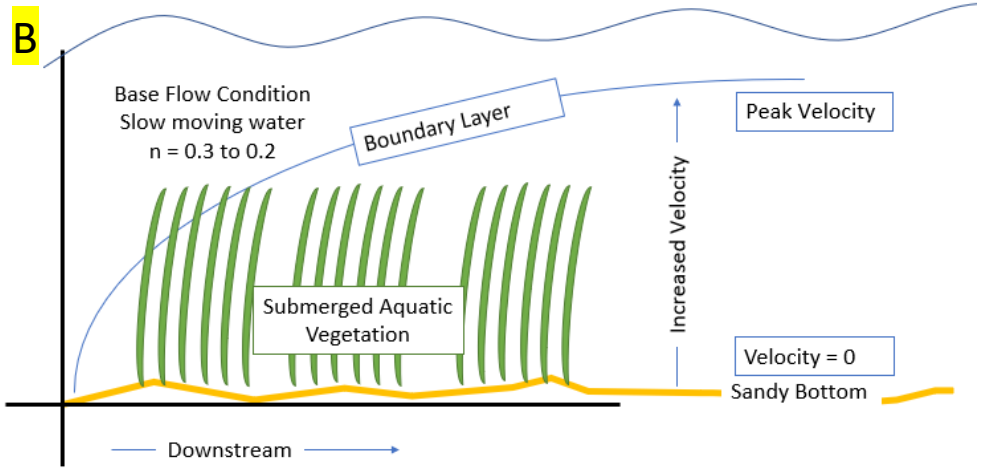


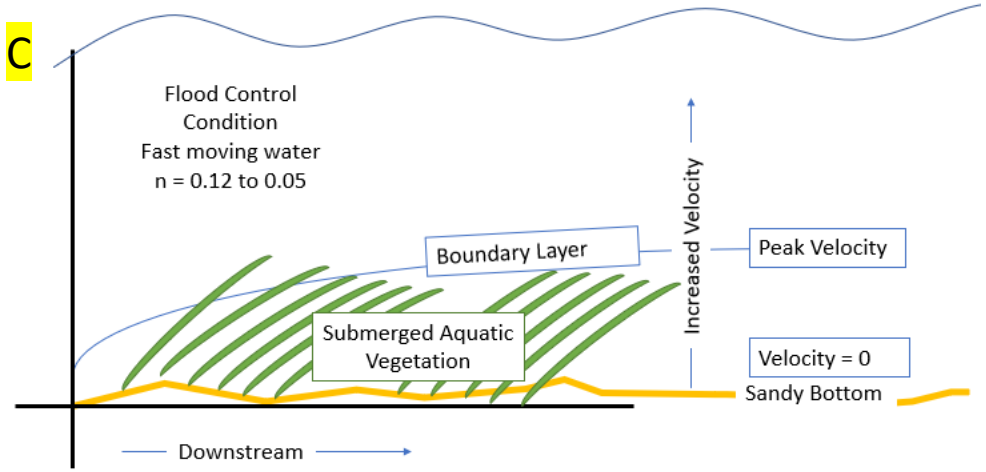
Expansion of the Boundary Layer

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

Boundary Layer with SAV







The Boundary Layer Effect
(fluid mechanics)

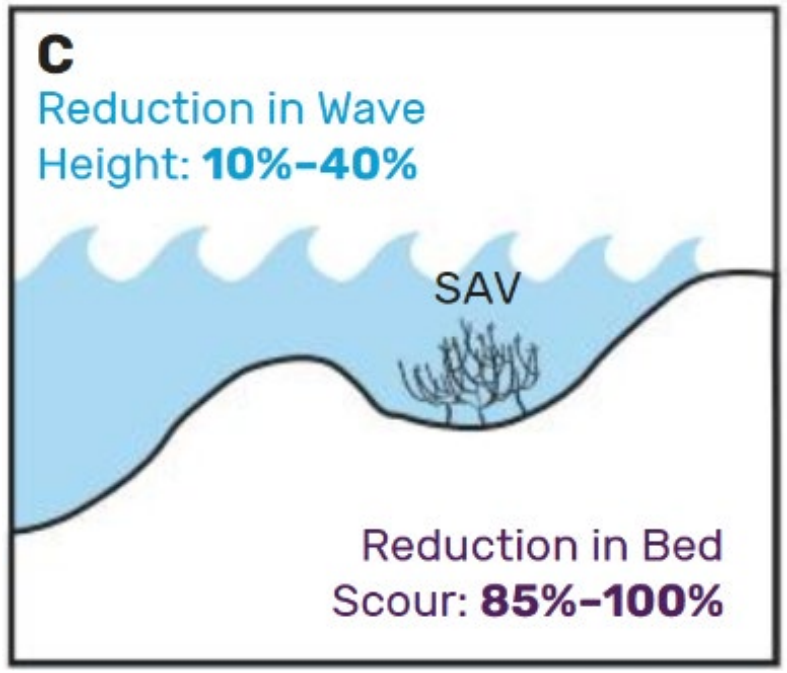
Schügerl, R. et al.: Effect of aquatic vegetation on Manning´s roughness coefficient value – Acta Hydrologica Slovaca, Volume 21, No. 1, 2020, 123–129

USACE Nature Based Solutions Guidelines

SAV meadows provide ecosystem services that benefit the community

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

Entire Chapter dedicated to Submerged Aquatic Vegetation



Reference Source:
International Guidelines on Natural and Nature-Based Features for Flood Risk Management - Engineering With Nature
https://ewn.erdc.dren.mil/international-guidelines-on-natural-and-nature-based-features-for-flood-risk-management/

What about Flood Control and Manning Coefficient?

Manning's Equation:

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

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

Where:

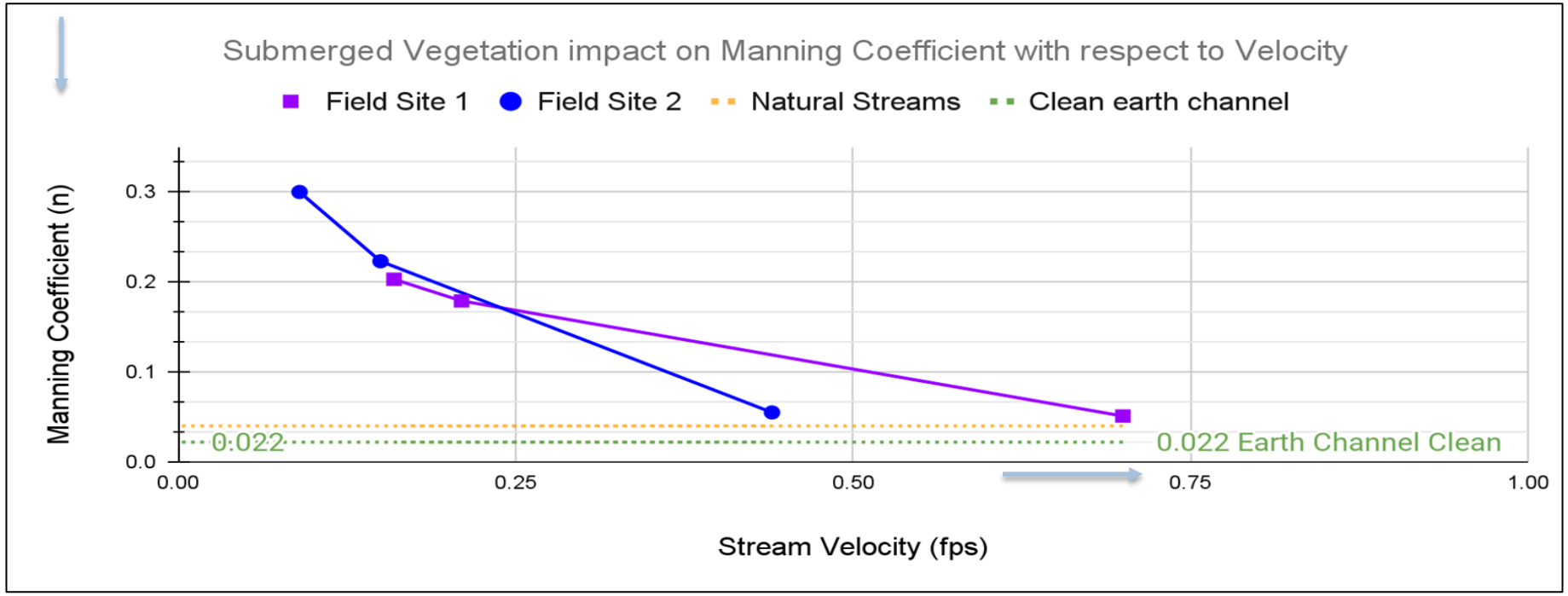
Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

<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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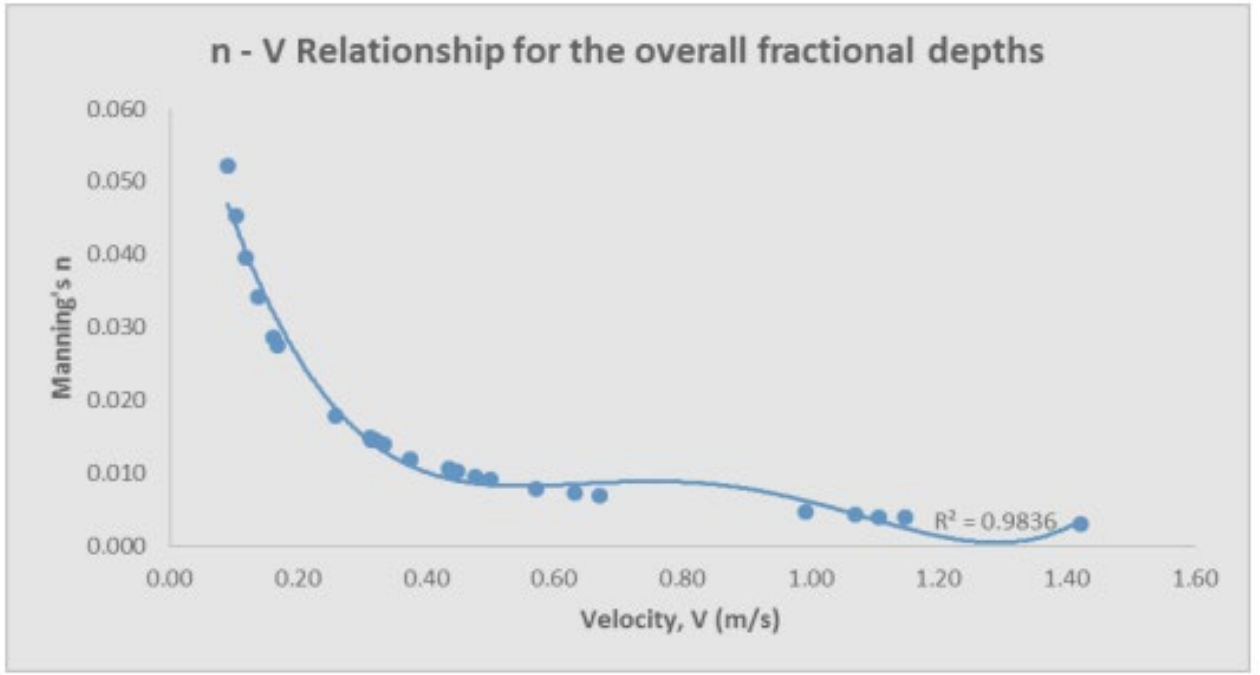


Figure 4. Relationship between manning's and velocity

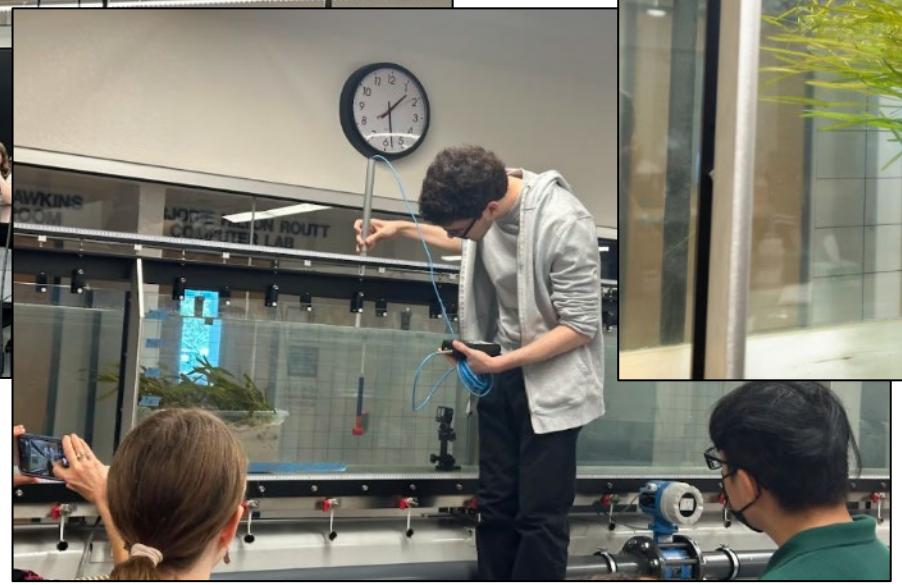
Khamaruzaman Wan Yusof et al 2017 IOP Conf. Ser.: Mater. Sci. Eng. 216 . 012046

STEM – Community Involvement

A partnership with Indian River State College Science & Mathematics department.

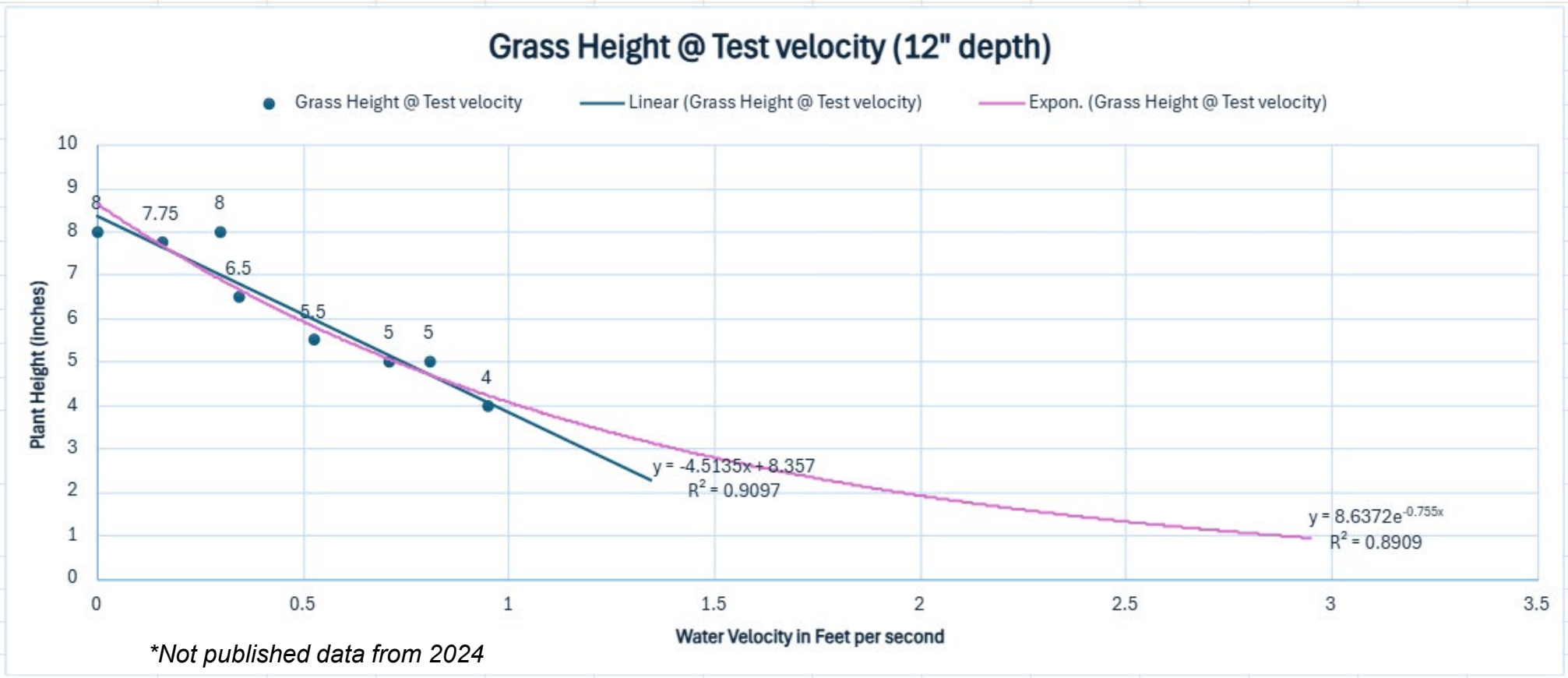
STEM – Community Involvement

Involved students in physical performance experimentation as a STEM experience. After calibration with the students, actual data was collected!!



STEM – Community Involvement

Data collected found that the vegetation height for Eelgrass (*Vallisneria sp.*) reduced canopy height by 50% in as little as 1 fps



**Not published data from 2024*

Reduce Nutrients

Increased Residence Time

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

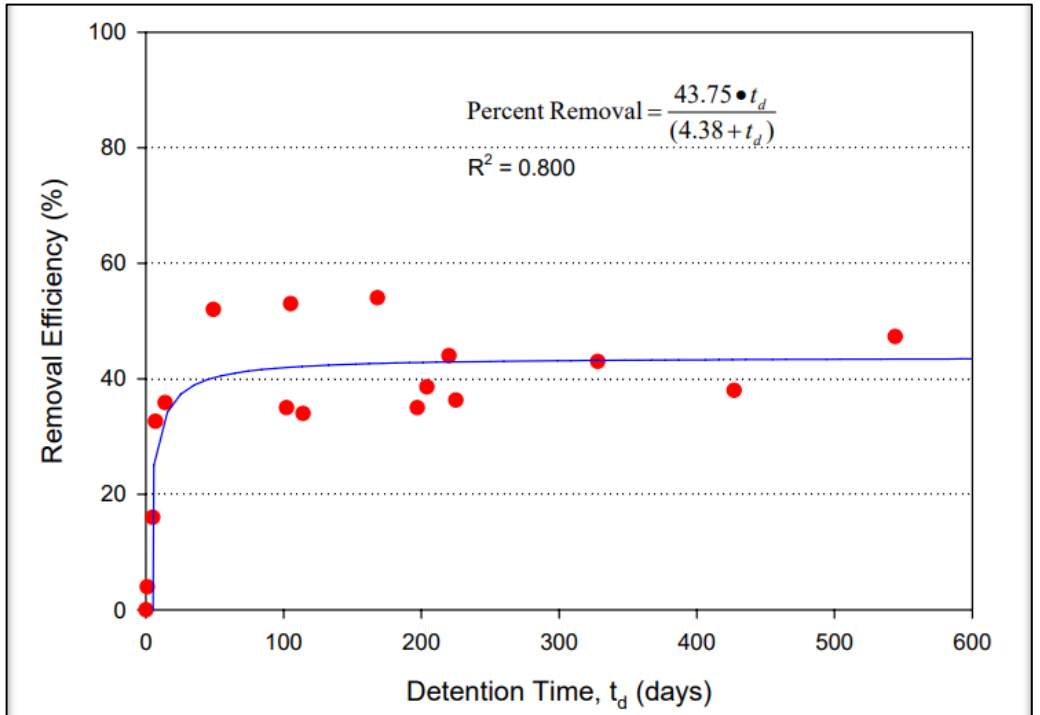
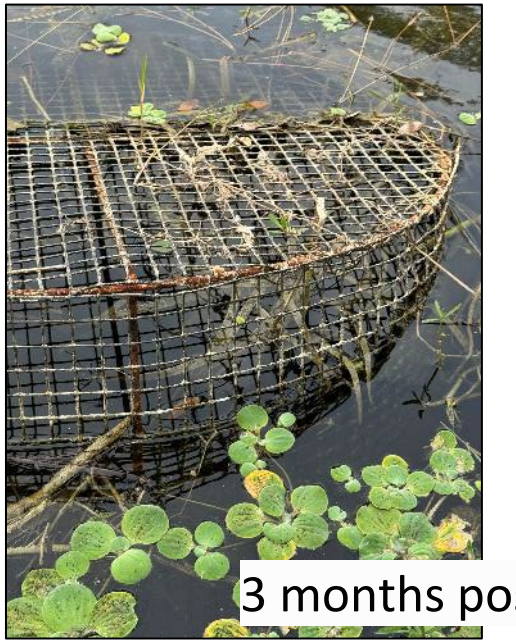


Figure 5-10. Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

Charlotte County – Stormwater Quality Pilot Project



3 months post planting

Planted in 2025

Hillsborough County – Reed Park Stormwater Outfall

Beneficial SAV (Vallisneria sp.)

Martin County – The Eelgrass Project

Beneficial submerged aquatic vegetation (SAV) supporting muck sediment sequestration

<u>Lessons learned</u>

Adaptive management and maintenance contractor education is critical for long term success as an engineered system.

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