Natural Solutions

Designing Resiliency & Seagrass

into Stormwater

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What is a Natural Solution ?

Green/Grey Infrastructure

Public works structures consisting of man-made materials with an element of green habitat.

Bioengineering

Approach that uses natural materials and systems to mimic natural processes with the goal of reducing hazards.

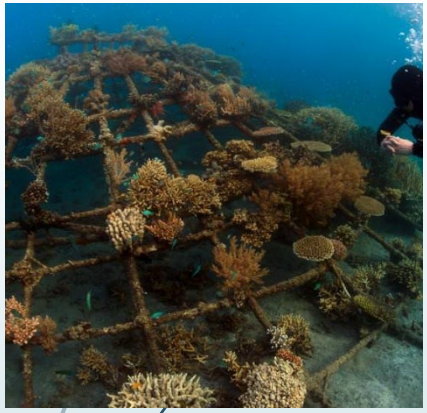
Engineering with Nature

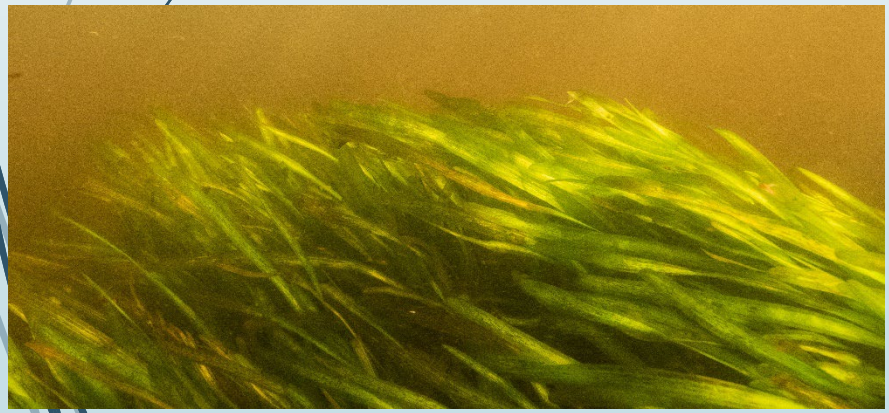
Water resources projects using natural and engineering processes to create multifunctional infrastructure.

According to FEMA

"Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience."

What is a Natural Solution ?





Gray Infrastructure consumes material

Nature-Based Solutions can create materials used to serve the function. Uses Natural Processes in an engineered capacity

Examples of true nature-based solutions

- Living shoreline or coral restoration - grows over time
- Vegetated buffers or stabilized area - Roots continue to grow and provide stabilization.
- Beneficial submerged aquatic vegetation (SAV) for Stormwater.

Not a Natural Solution

Gray Infrastructure

- Traditional Means and Methods
- Necessary in many instances.
- Used to solve the most challenging problems.

We need smarter solutions

Evaluating Resiliency for infrastructure creates a Smarter Solution.

Engineering with Nature is cost effective and adaptive.

This is a smarter way of doing things.

We need smarter solutions

Not obvious

Complex

Need the right tools!

“We can’t solve problems with the same kind of thinking we used when we created them.”

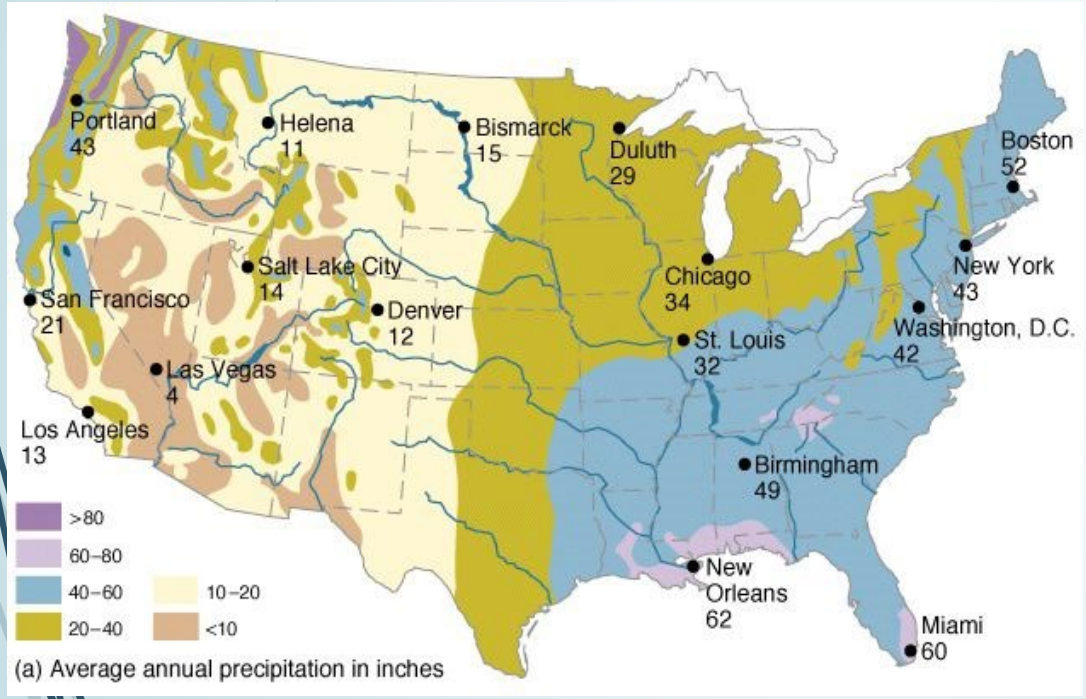
-Albert Einstein

The Struggle is Real

- State requirements and BMAP targets
- Chapter 62-304 (TMDL's)
- New Infrastructure is expensive
- Can we be more cost effective?

Water Quality ⟷ **Flood Control**

Precipitation in Florida



(a) Average annual precipitation in inches

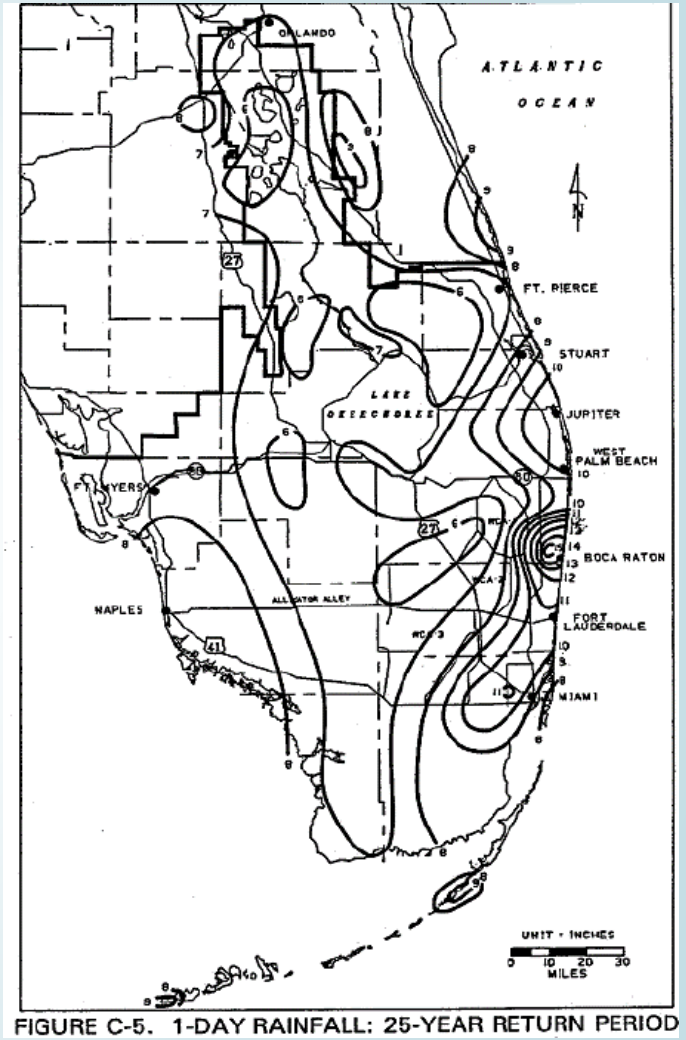
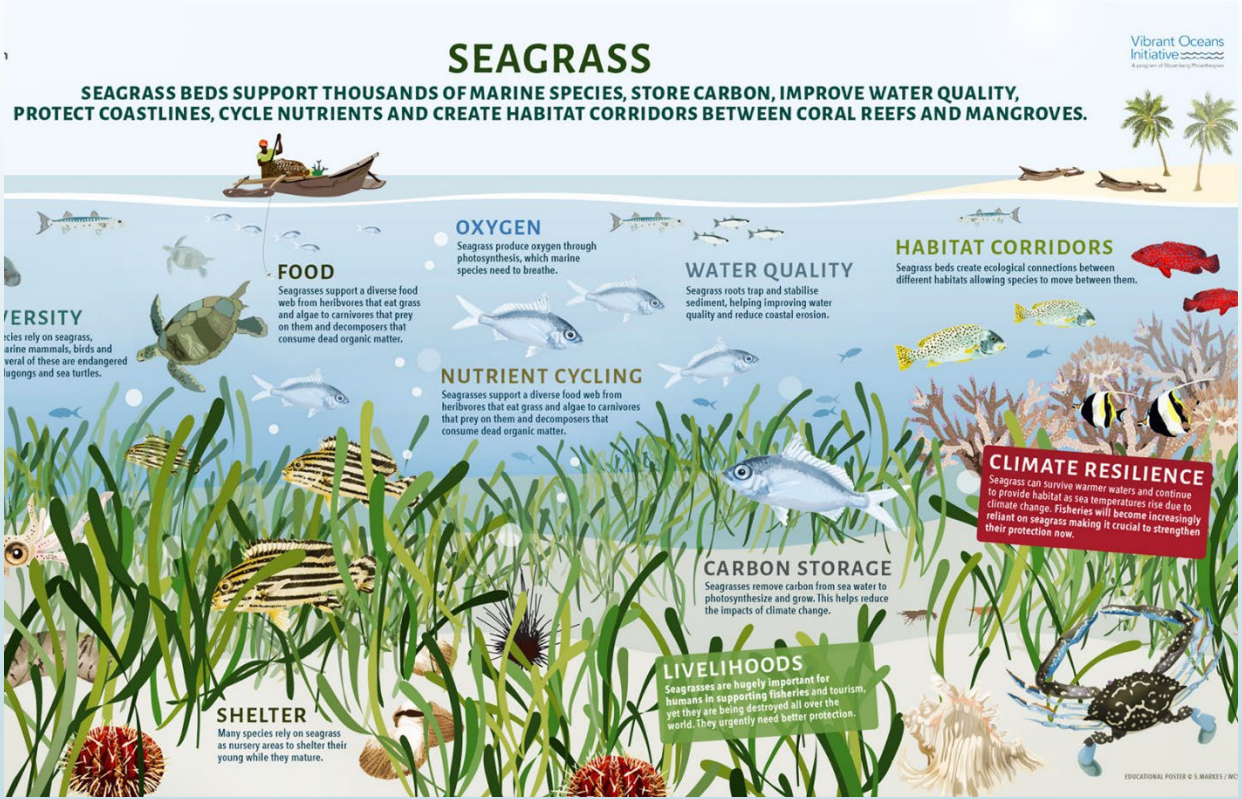


FIGURE C-5. 1-DAY RAINFALL: 25-YEAR RETURN PERIOD

Erosion Control

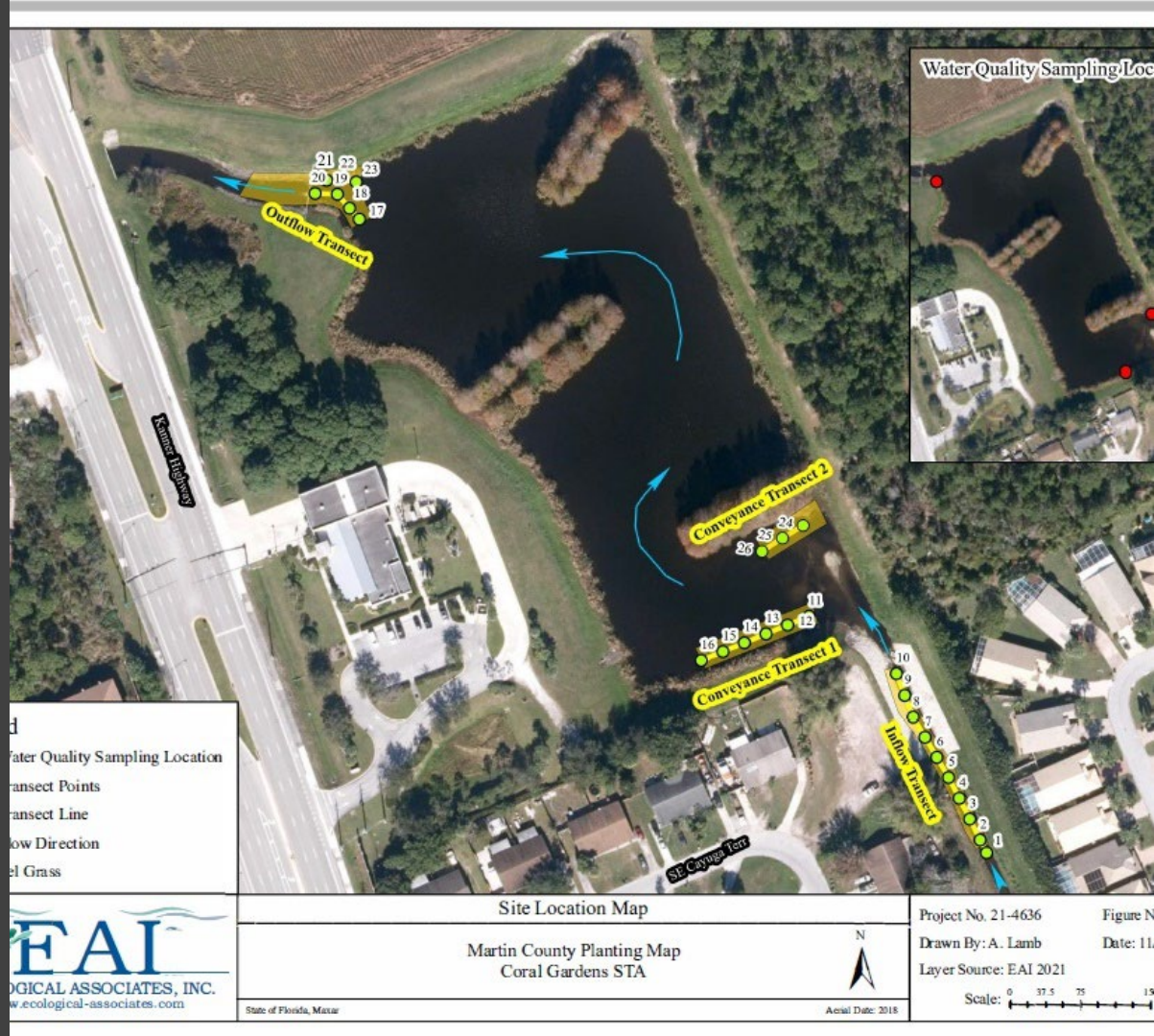
- Impacts water quality
- Negative impacts to flood control
- Costly to fix

What Tools has Mother Nature Provided ?



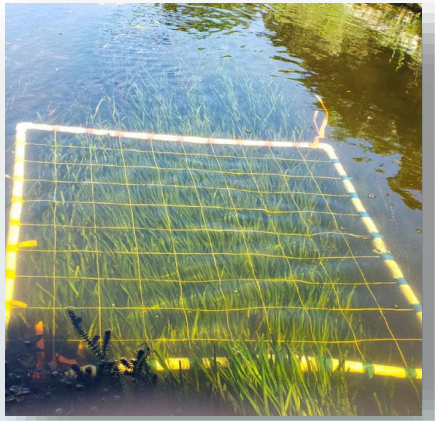
2020 Test Project

- Test ability to out complete nuisance vegetation.
- Stabilize the bottom to reduce sediment transport.
- Improve Water Quality.
- Restore a Natural Ecosystem.
- Provide Coastal Resilience.
- Potential for Blue Carbon Sequestration and/or Credits



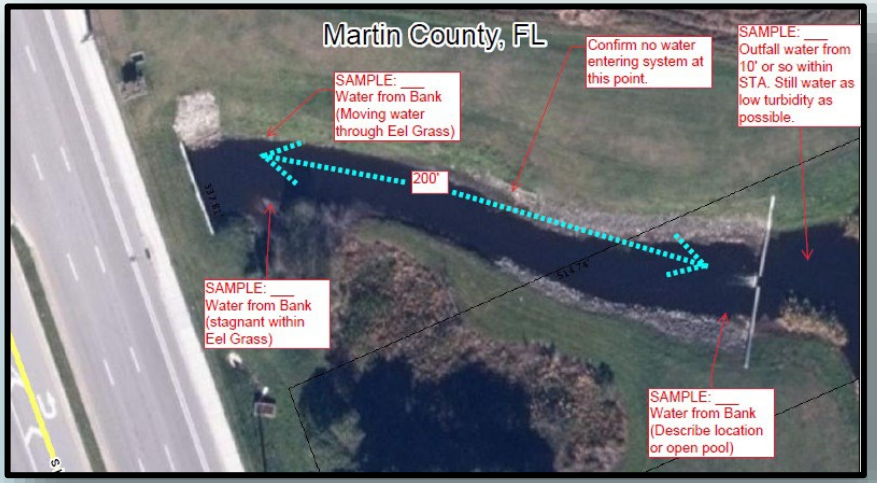
How

- Vallisneria Americana & Ruppia Maritima Grasses in strategic locations within the municipal stormwater system.
- Planted over 5000 plugs throughout Stormwater system specifically within the outfall canal.
- Monitoring and Changing Maintenance Practices to help establishment
- Waited about 1 year



What we learned

- Establishes very well in moving water (~ 0.5 fps to 1.5 fps)
- Lots of animals eat it.
- Great for Water Quality!



Controlled Testing

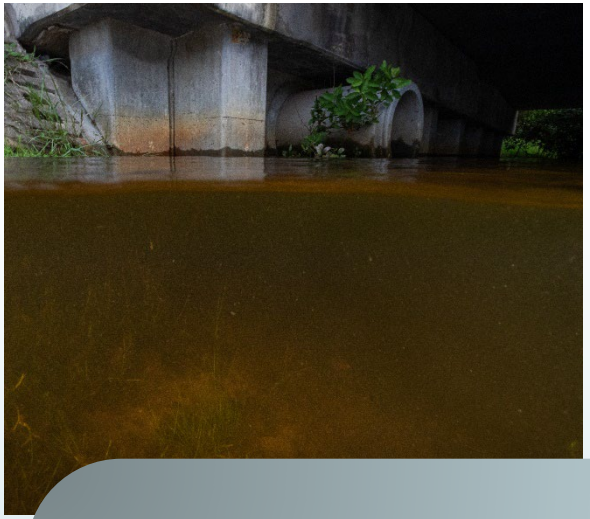
- Tested in March and April 2022

- Extremely low $20,000 project cost
- ~ 1% of new infrastructure cost

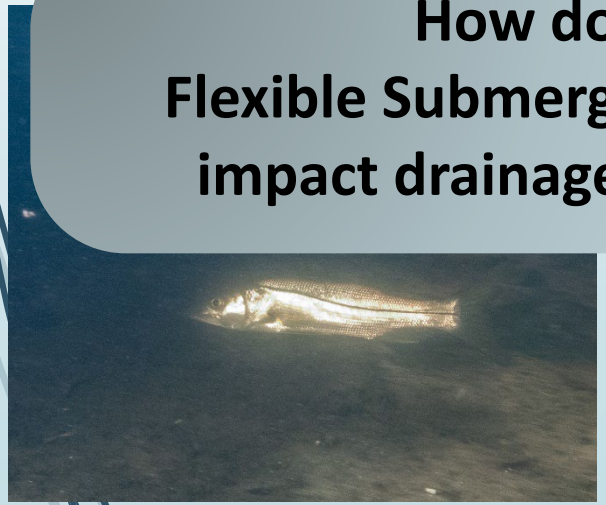
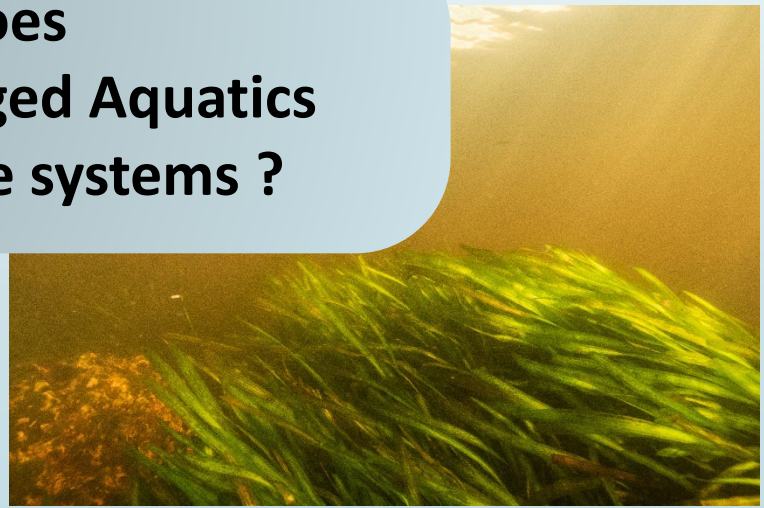
- Treats every drop of water
- Simple retrofit for stormwater, scalable for large or small sites

Pollutant Reductions

	TSS	*TN*	*TKN*	*TP*	*OrthoP*
March Reductions	-38%	-44%	-50%	-47%	-55%
April Reductions	-72%	-20%	-27%	-41%	-30%



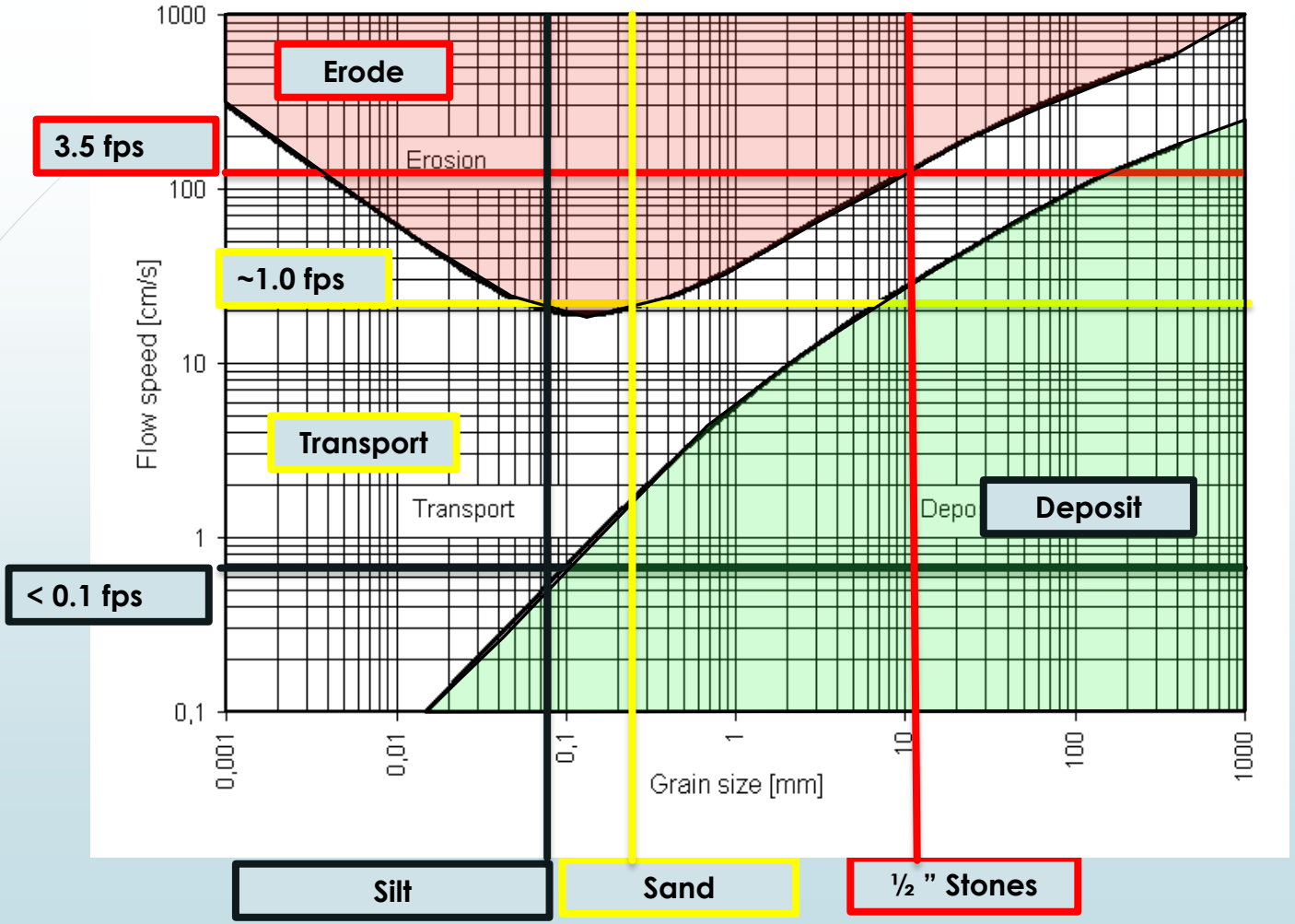
How does
Flexible Submerged Aquatics
impact drainage systems ?

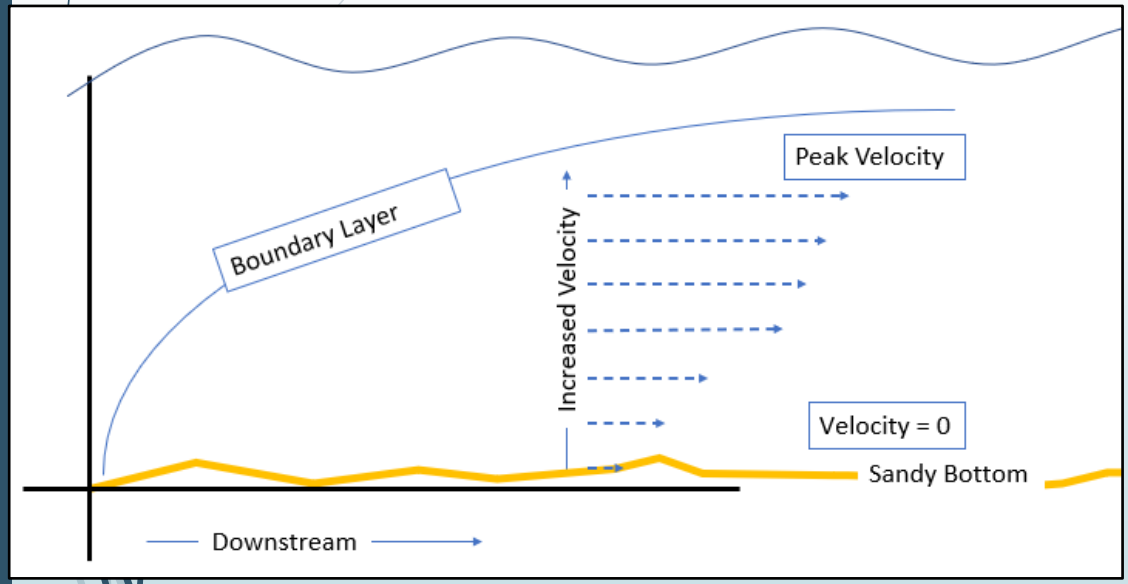

Sediment Transport

Sediment Transport

- Size of Sediment vs. Velocity
- Erode, Transport, or Deposit
- Hjulström Curve / Shields Diagram
- Sediment impacts water quality


Erode
3.5 fps
Erosion
~1.0 fps
Transport
Transport
Depo
Deposit
< 0.1 fps
Flow speed [cm/s]
1000
100
10
1
0,1
0,001
0,01
0,1
1
10
100
1000
Grain size [mm]
Silt
Sand
½ " Stones

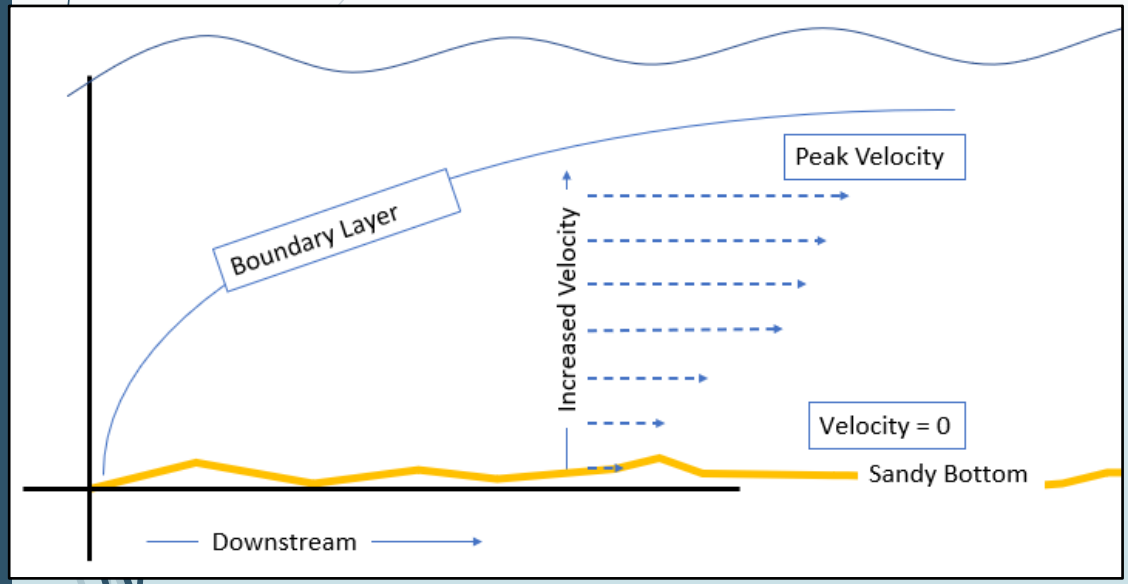
Boundary Layer Theory



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



Stabilizing the Boundary Layer

- Reduces sediment transport
- Reduces erosion
- Improves water quality
- limits nuisance SAV (e.g., hydrilla)

Flood Control - Manning

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)

The Manning's Equation

- 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

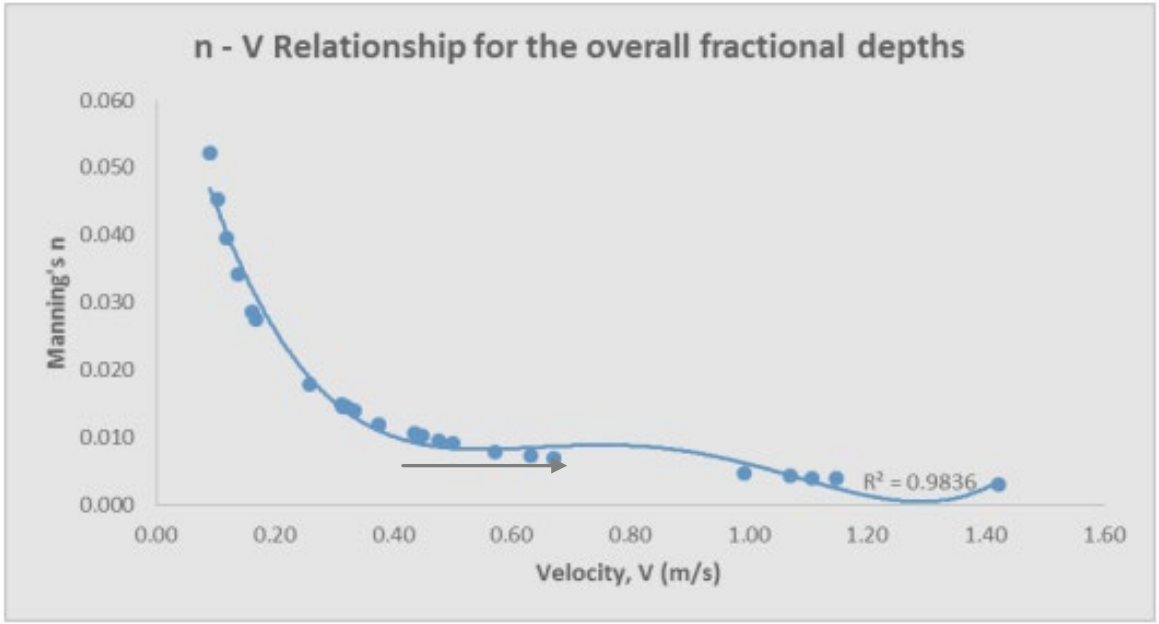


Figure 4. Relationship between manning's and velocity

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

Natures Smart Solution

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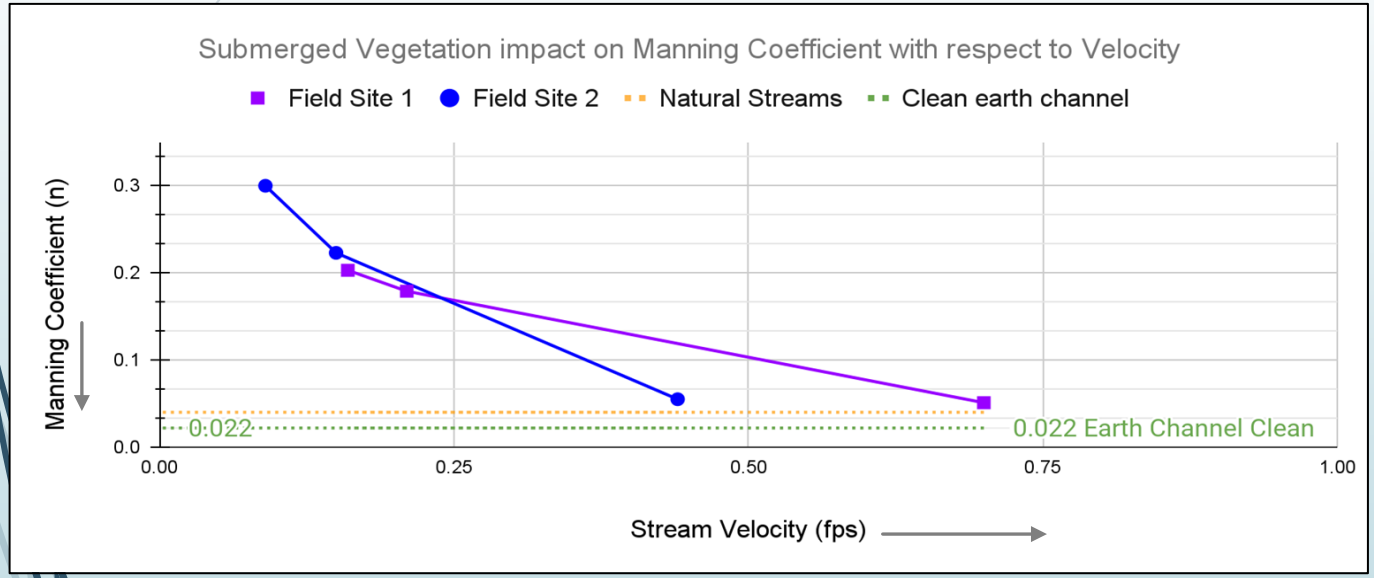
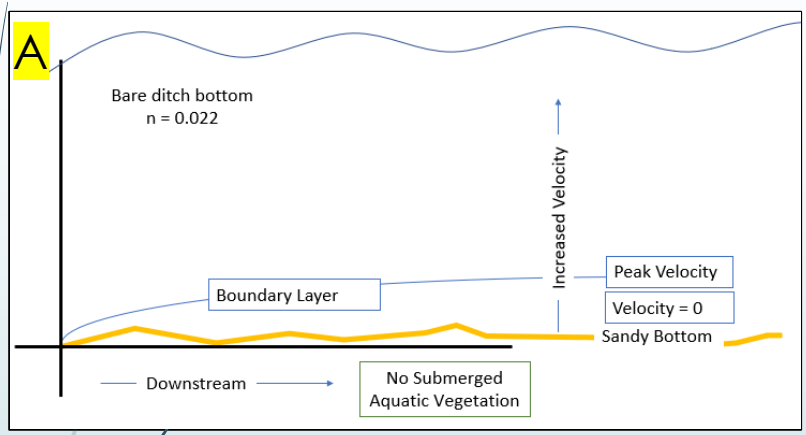
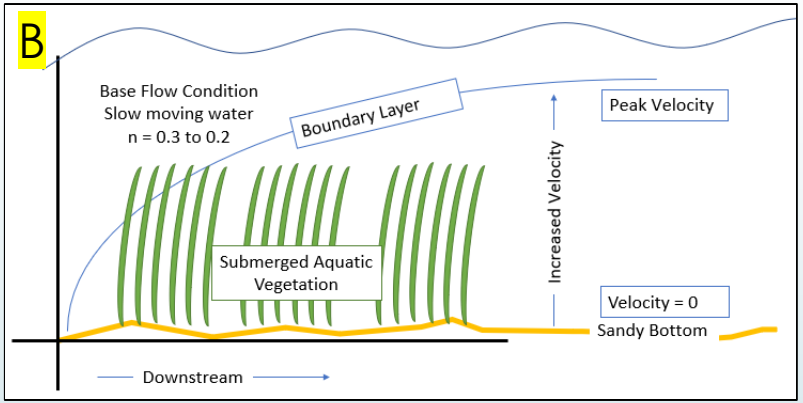
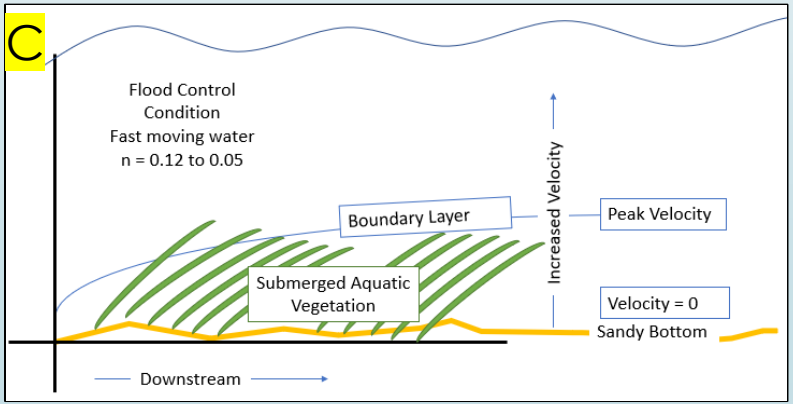


Schügerl, R. et al.: Effect of aquatic vegetation on Manning´s roughness coefficient value – Acta Hydrologica Slovaca, Volume 21, No. 1, 2020, 123–129

Natures Smart Solution







Residence Time

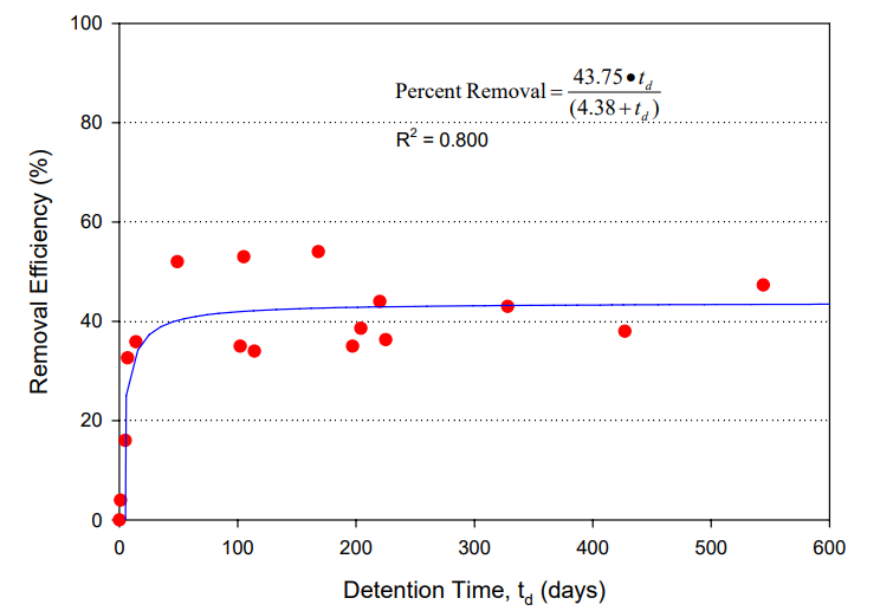


Figure 5-10. Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

Increased Residence Time

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

(Harvey Harper Ph.D, P.E. David Baker, P.E., 2007) - Evaluation of Current Stormwater Design Criteria within the State of Florida – Final Report for Florida Department of Environmental Protection;

Residence Time

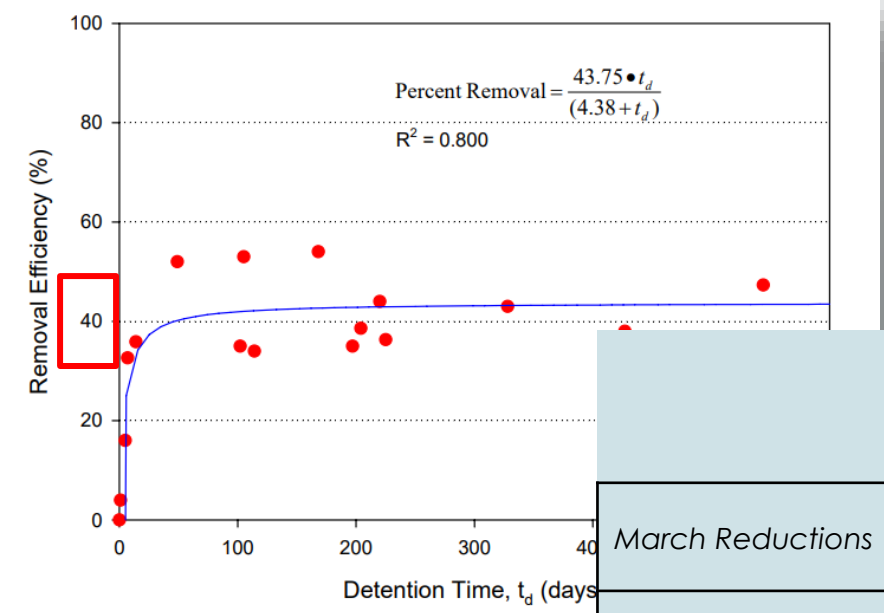


Figure 5-10. Removal Efficiency of Total Nitrogen in W
Function of Residence Time.

Wet Detention ponds cap out at ~ 40 % TN Removal

Pollutant Reductions

	TSS	*TN*	*TKN*	*TP*	*OrthoP*
March Reductions	-38%	-44%	-50%	-47%	-55%
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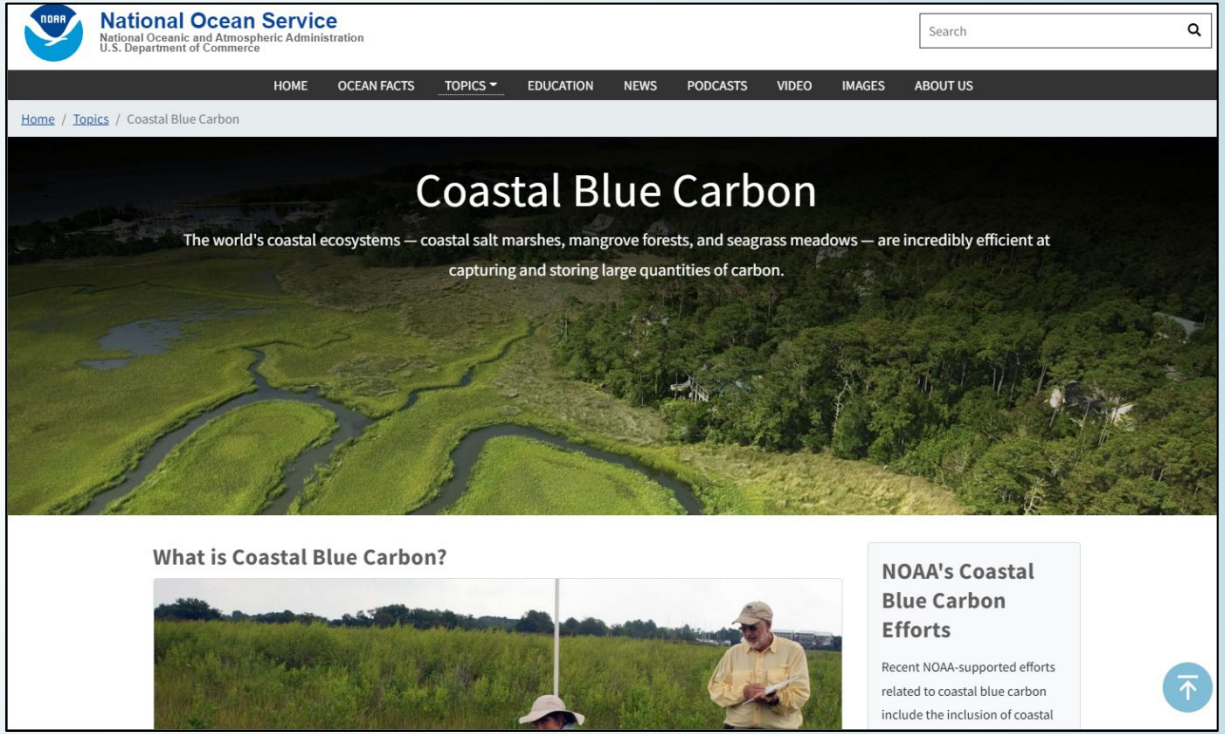
Blue Carbon

- Studies suggest that coastal wetlands annually sequester carbon at a rate 10x greater than mature tropical forests.
- This is possible by simply making your dirty drainage ditch look better and function better.



https://oceanservice.noaa.gov/ecosystems/coastal-blue-carbon/

Conclusion

- Shown ability to out complete nuisance vegetation.
- Stabilized the bottom to reduce sediment transport.
- Improves Water Quality.
- Improved a Natural Ecosystem.
- Provides Coastal Resilience.
- Potential for Blue Carbon Sequestration and/or Credits

Questions?

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