Subaqueous Soils and Rhode Island's Coastal Zone Soil Survey

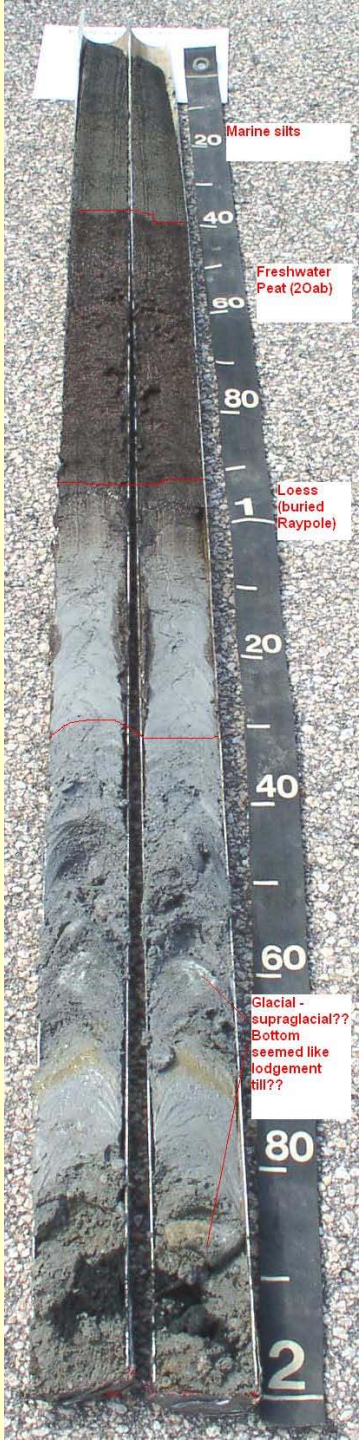
James D. Turenne

State Soil Scientist

Rhode Island (The Ocean State)

USDA-NRCS

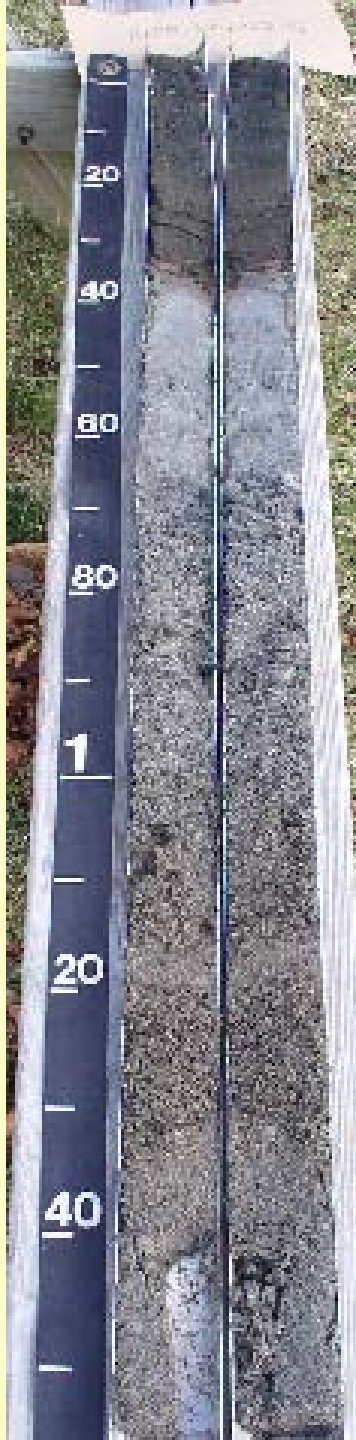
www.mapcoast.org or www.nesoil.com/sas *@SoilSNE*



Billington - COARSE-SILTY, MIXED, ACTIVE, NONACID, MESIC THAPTO-HISTIC SULFIWASSENTS

Outline

- Brief Introduction and History to Subaqueous Soils.
- Rhode Island Coastal Zone Soil Survey and the MapCoast Partnership.
- Research, Mapping, and Interpretations.
- Reason why needed and uses.
- Freshwater SAS mapping/research.
- Data examples.
- Questions and Answers.
- Check out some soil cores!



Fort Neck - Fine-loamy over sandy or sandy-skeletal, mixed, nonacid Typic Sulfiwassents

USDA-NRCS and the NCSS

USDA-Natural Resources Conservation Service

- Began as Soil Conservation Service in 1935 to address soil erosion problems.
- Provide technical assistance to private land owners to address soil, water, air, plant/animal concerns.

www.vt.nrcs.usda.gov

National Cooperative Soil Survey

http://soils.usda.gov/partnerships/ncss/

- nationwide partnership of federal, regional, state and local agencies; and private entities and institutions.
- works together to cooperatively investigate, inventory, document, classify, interpret, disseminate, and publish information about soils of the U.S.
- The activities of the NCSS are carried out on national, regional, and state levels.

http://soils.usda.gov/partnerships/ncss/conferences/2011_national/

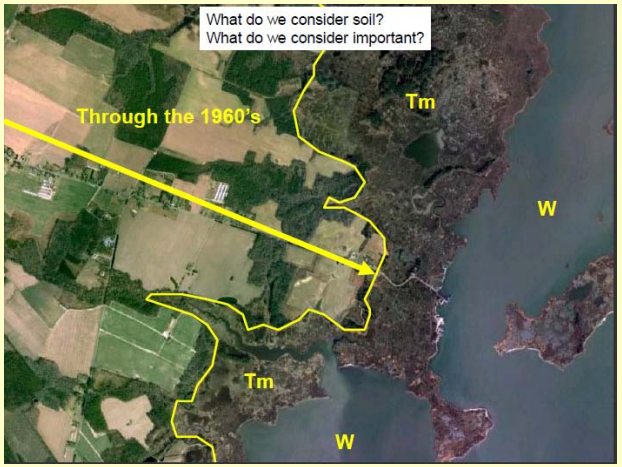
Historical Background on SAS

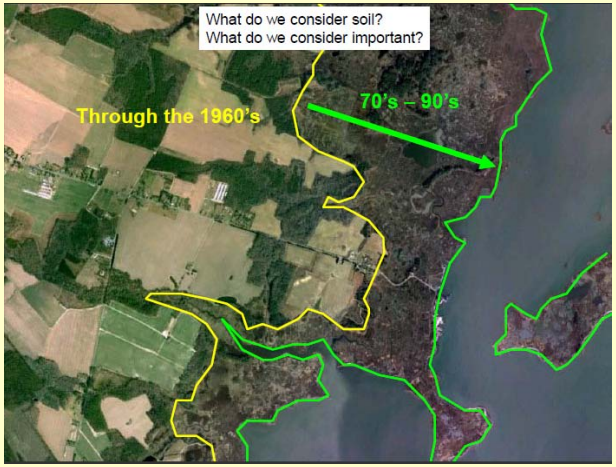
von Post 1862

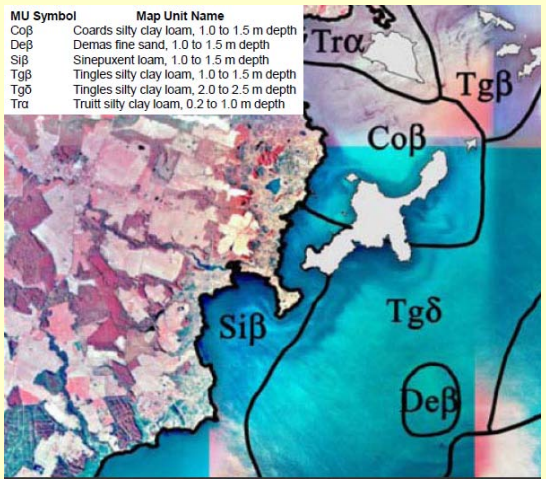
- 1st nomenclature for SAS
- Introduced terms “gyttja” and “dy” to describe limnic sediments.

Kubiena 1952

- Proposed a comprehensive soil classification system for Europe that included the neglected SAS.
- Included horizonation of SAS pedons.







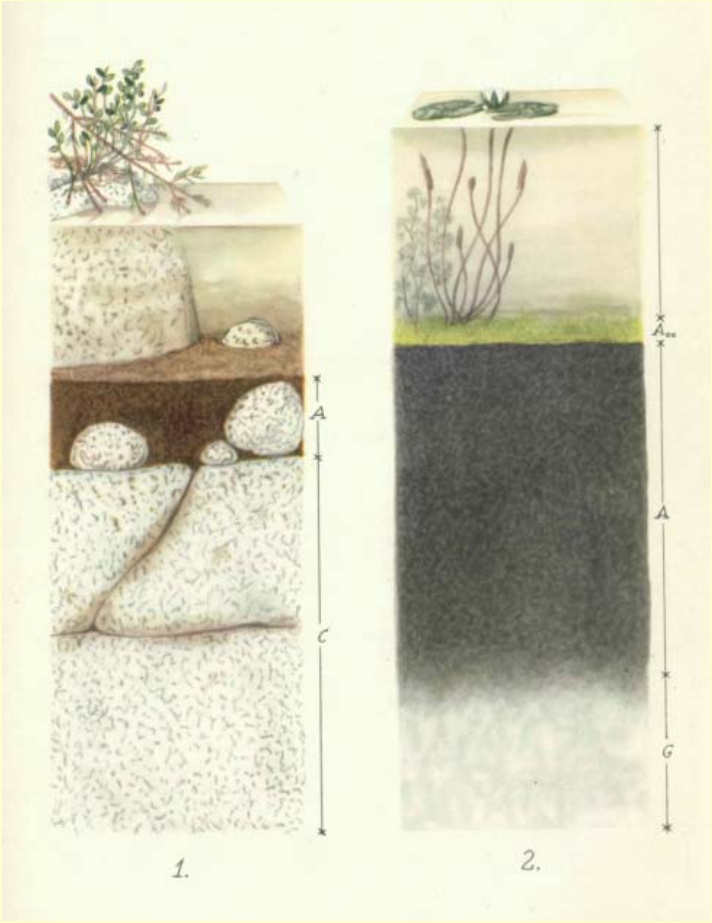
History (cont)

Muckenhausen 1965

- Proposed soil classification system for West Germany.
- “Subhydric” soils.

Pomamperuma 1972

- Used the term “soil” to describe uppermost layer of sediment in rivers, oceans, lakes – undergo pedogenic processes and have soil horizons.



Despite all this…

Soil Taxonomy (Soil Survey Staff) 1975 stated:

Soil, … is the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors. **Its upper limit is air or shallow water. At its margins it grades to deep water** or to barren areas of rock or ice.

For the most part Subaqueous materials were excluded from the definition of soil by;

- their permanent saturation beneath deep water
- need to support rooted vegetation

Most, but not all, were deterred…

Submerged Soils: A New Frontier in Soil Survey

G.P. Demas[1]

Through my assignments to four soil survey projects on the Atlantic Coastal Plain in Maryland and Delaware, I have become increasingly aware of situations where information about soils could go a long way towards providing the supporting data needed to make intelligent environmental management decisions. A major area of environmental concern, especially on the Delmarva Peninsula, is the deteriorating quality of both subsurface and surface water. Among the myriad of negative effects caused by poor water quality is the decrease in health and populations of aquatic organisms. Regulatory and voluntary programs are presently in place on the Delmarva Peninsula that address such items as nonpoint source pollution, on-site sewage disposal, sediment and erosion control, wetland protection and restoration, and the restoration and enhancement of aquatic plant and animal populations. Soil survey information is playing a key role in many of these programs through the gathering, interpretation, and dissemination of previously unavailable soil data directly related to environmental issues.

U.S. Subaqueous History

- Traditional soil survey conducted on land. Not a lot of work in Coastal Zone and tidal marshes until the 70's.
- In 1993 – "Submerged Soils: A New Frontier in Soil Survey" by George Demas published in Soil Survey Horizons.
- Most early work in Chesapeake Bay Region – Maryland/Delaware.
- George pioneered the concept of Subaqueous Soils differentiating them from sediment.
- 1999 Definition of soil includes shallow water..

George Demas 1958-1995

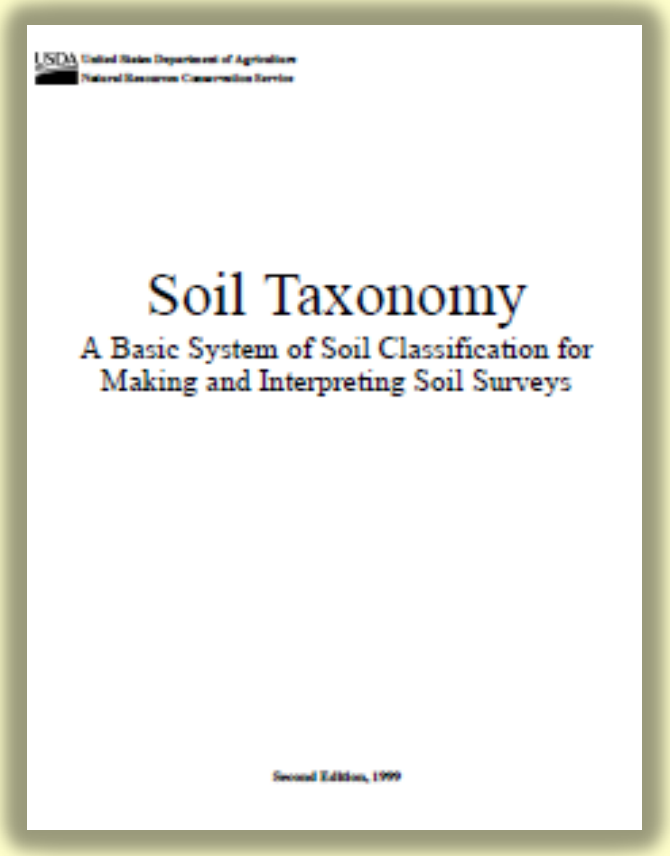
http://en.wikipedia.org/wiki/George_Demas

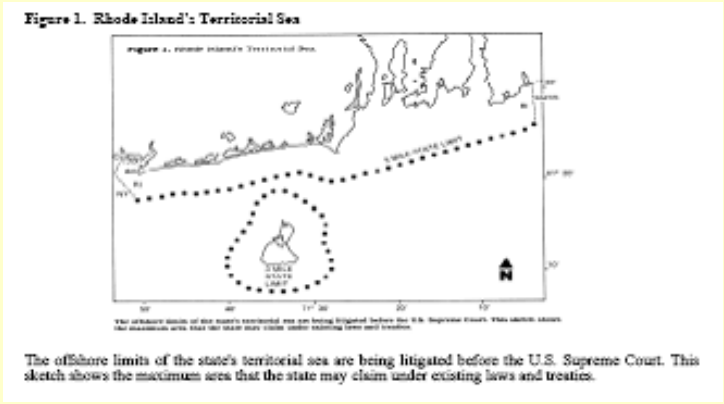
- NRCS Soil Survey Project Leader
- Pioneer of Subaqueous Soils
- USDA Secretary's honor for scientific research.
- SSSA Emil Truog award for outstanding contribution to soil science

Soil Definition Redefined!

- The upper limit of soil is the boundary between soil and air [or] **shallow water**…[not] too deep (typically more than 2.5 m*) for the growth of rooted plants.

* Arbitrary limit following Cowardin, RI limit is set at 5 m NAVD-88

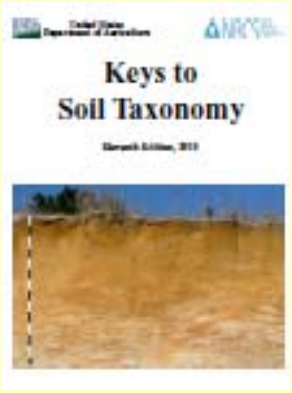




U.S. History

- 2001 – Bradley-Stolt thesis study in RI.
- 2003 – National Workshop on SAS – Delaware.
- 2004 – RI forms MapCoast, Dr. Mark Stolt sabbatical.
- 2005 Glossary of Landscape Terms, other areas begin mapping.
- 2006-2009 Proposal to amend Taxonomy & NASIS proposals, Interpretation studies.
- 2010 Eleventh Edition Soil Taxonomy released includes Wassents and Wassists.
- 2010 – 2nd National Workshop on SAS in Rhode Island.
- 2011 Ri completes 1st official Coastal Zone Soil Survey.

1st National Workshop on Subaqueous Soils, Delaware 2003



It's Official!

Subaqueous Soils 101

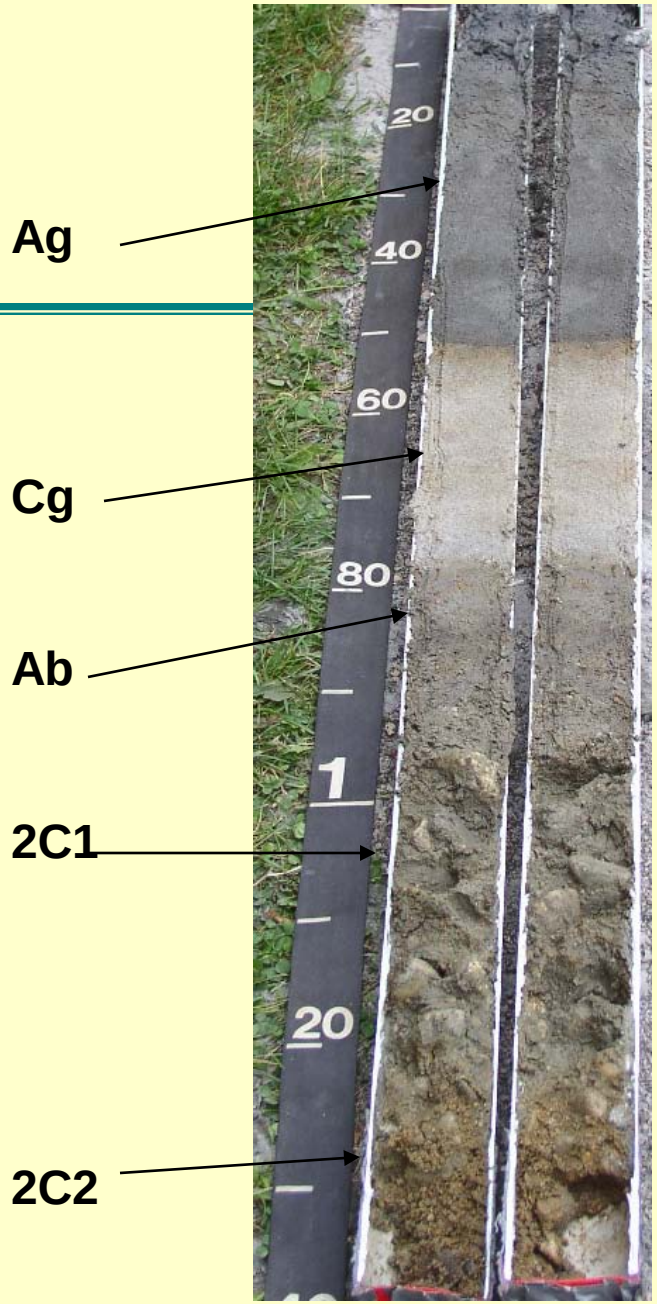
The debate: Is it soil or sediment?

Soil qualifying criteria:

1. Supplies nutrients to rooted plants.
2. Soil horizons formed by pedogenic processes.

Soil Formation: Soil Horizons

- Organic and mineral (A and C) horizons.
- Predominantly dealing with AC type soils (Entisols).
- Numerous buried A and O horizons.
- Some subaqueous and submerged soils have buried B horizons.



Subaqueous Soil Formation

Combination of Jenny's soil forming factors and Folger's sediment genesis factors:

Ss = f(C, R, O, B, F, P, T, W, CE)

Ss = subaqueous soil

C = Climate/temp.
O = Organisms
B = Bathymetry
F = Flow Regime
W = Water column attributes
T = Time
R = Relief/Landscape
P = Parent Materials
CE = Catastrophic events

Demas/Rabenhorst – Subaqueous Soil Forming Factors 2001

Pedogenic Processes: Additions/Losses/Transfers

Additions

- Additions of mineral sediments – alluvial deposits.
- Biological additions – shells, organisms.
- Anthropogenic additions – dredge material, mechanical disturbance.

Losses

- Erosion losses – wave and storm losses, tidal currents.
- Decomposition of organic matter.

Transfers

- Diffusion – hi to low concentrations.
- Bioturbation.

Bottom Line: Shallow Water Environments can best be studied as SOIL!

Soil Classification (1 slide only)

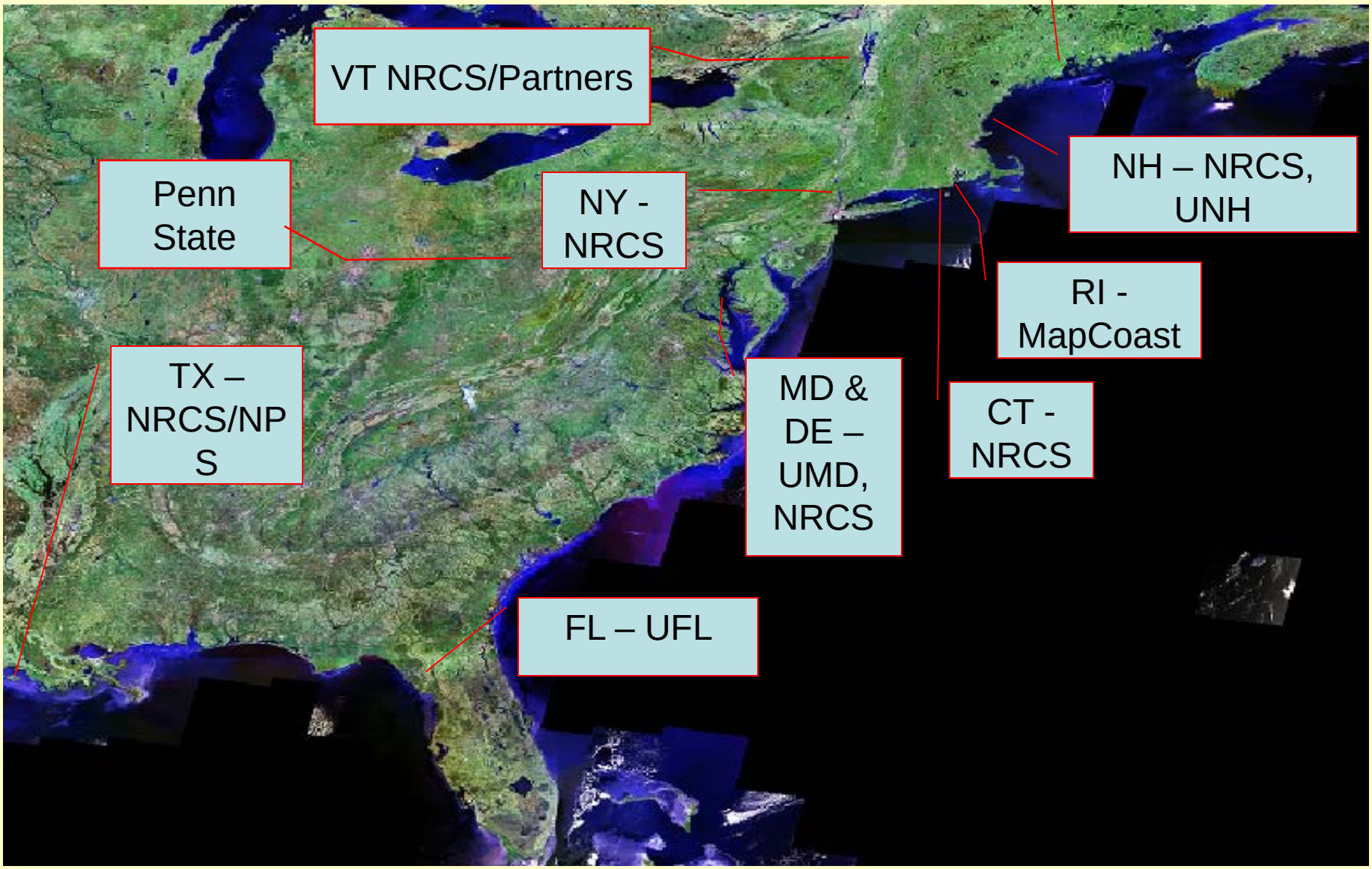
- Mainly developed 2005-2010 Stolt/Rabenhorst through the NCSS committees.
- Discussions on new orders….
- 11th Edition of Taxonomy added a new suborder to Entisols: Wassents (1st suborder) with 6 great groups and associated subgroups.
- Histosols added new suborder Wassists with 3 great groups.
- Broken out by having positive water potential > 21 hours/day in all years.
- Frasi GG have EC < 0.2 dS/m

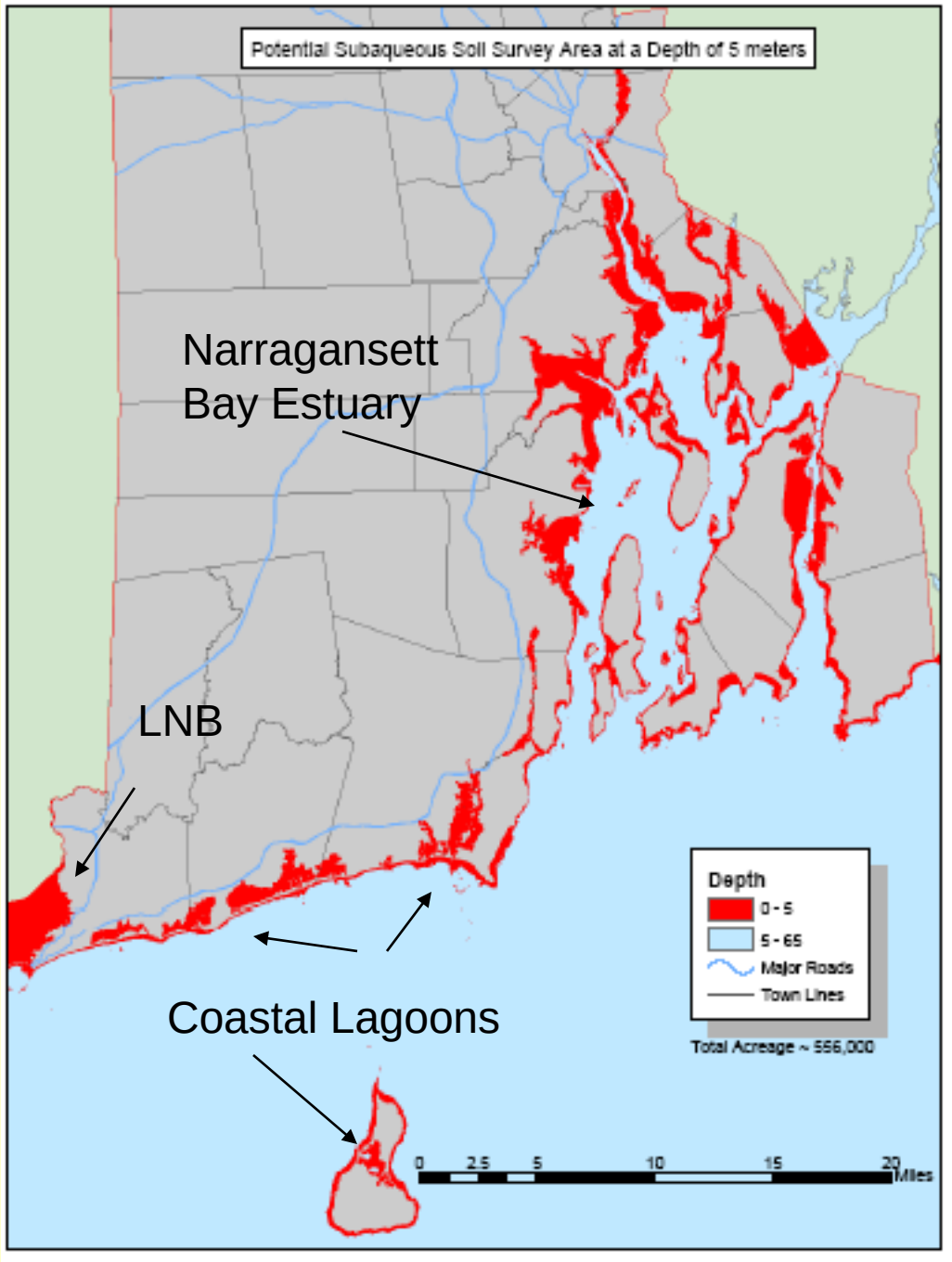
Nagunt - Mixed, mesic Sulfic Psammowassents Psammo -LFS or coarser, Sulfic – sulfidic materals 15 cm w/I 100 cm.

Billington -Thapto-histic Sulfiwassents Sulfi – Sulfidic w/I 50 cm, Thaptohistic – buried organic material w/I 100 cm.


Looks like a
Pishagqua Fluventic
Sulfiwassent Soil!

Who's doing What?





Rhode Island Stats:

Size = 1,214 sq. miles.
Shoreline = 347 miles.
Relief = 812 feet to sea level.
Population = 1 million (mostly along shoreline), 2nd most densely populated .
Geology/Soils: Bedrock is mainly Proterazoic to Paleozoic, late Wisconsinan glacial till/fluvial, soils are mostly Inceptisols, Entisols, and Histosols.
Subaqueous Soils: Approximately 300,000 acres (areas <5m and coastal soils). Additional ~50,000 freshwater ponds.

RI NRCS Subaqueous Timeline

- 1996 – Complete SSURGO soils available for terrestrial RI.
- 2000 – 2001 Bradley, Stolt subaqueous soil survey thesis Ninigret Pond, RI.
- 2002 – 2003 RI NRCS Adopts “Working Waters” Strategy – $1 million eelgrass funds, major emphasis in coastal issues.
- 2003 - Gap in RI soil data identified – no subaqueous soil data to incorporate into site selection models, etc.
- 2004 - Top Priority placed by the STC for the soil staff to develop an action plan: Establish a Center for Excellence in SAS.

2004 Develop strategy:

a. Internal = proposal for an MLRA project office for coastal and subaqueous soils for MO-12.

b. External = work with URI to organize an end-users conference to obtain input from our customers.

=

MapCoast is Born!

www.mapcoast.org

Common Ground

MapCoast understands the need to develop a **common hierarchal system** of coastal soil and sediment classification that encompasses **all disciplines** including biology, wetlands, geology and pedology.

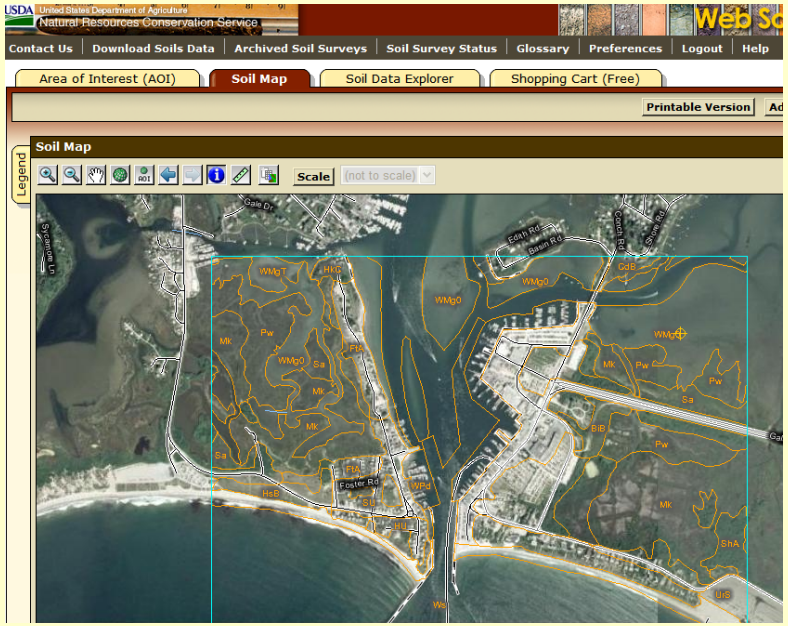
www.mapcoast.org

Common Objectives

- Develop mapping **standards** and **protocols** to produce accurate and useful maps.
- Build multiple **interpretations** of the data to service the coastal resource management community.
- Ensure that data collected will be made **available** to all users.
- Work will be conducted in a **cooperative** manner.
- Partners will **share** resources, technology, and knowledge.
- Provide **training** and **educate** users about the soils and sediment data and maps.

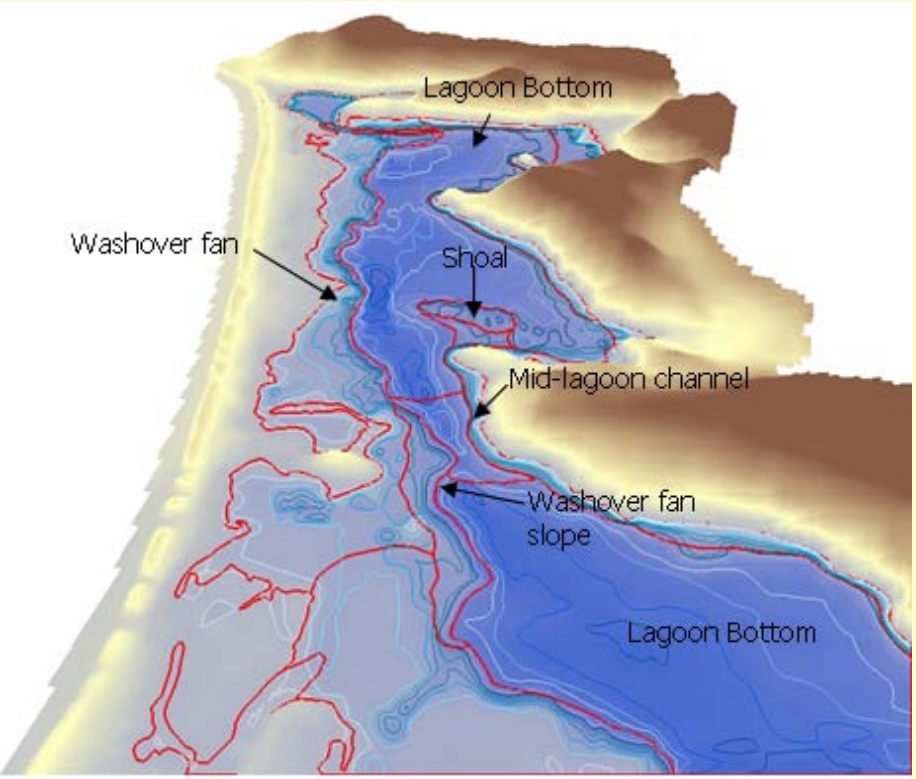
MapCoast - Timeline

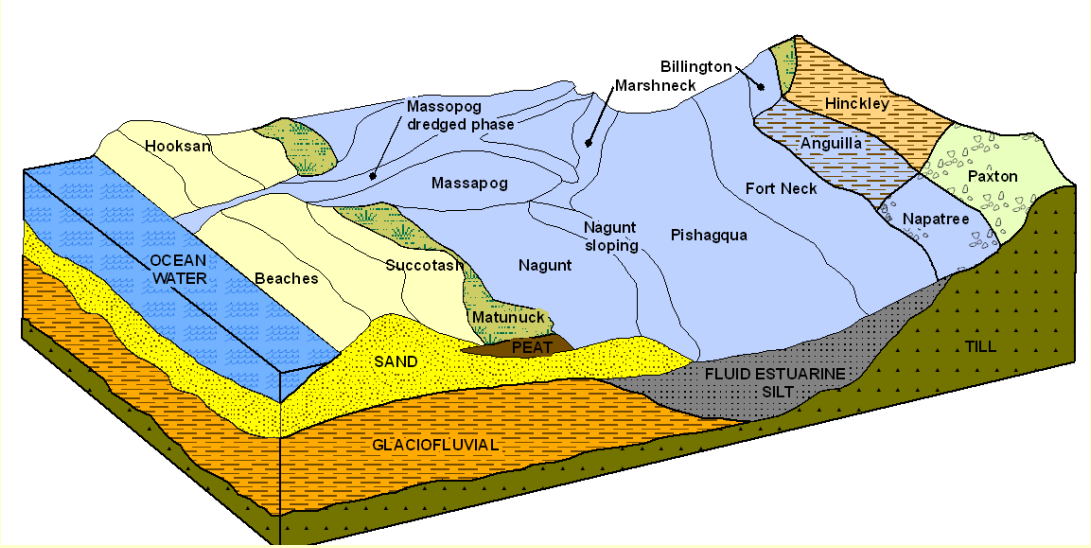
- 2004 – user conferences, develop mapping protocol, map Ninigret Pond.
- 2005 – 2rd user conference to provide Ninigret data. Feature on local news.
- 2006 – 3rd user conference (both U.S. Senators) release of the MapCoast IMS. Research, and more input from coastal community.
- 2007-2009 Coastal Zone Soil Survey in production, more outreach, technology, NOAA paper, CMECS, Soil Taxonomy.
- 2010 – 2nd National Workshop in RI. Freshwater study initiated, data reviewed for SSURGO.
- 2011 - RI completes 1st Coastal Zone Soil Survey, more research, Phase II begins.



Mapping Procedure

- Need to develop a bathymetric map which is used for subaqueous landform identification.
- Can use existing NOAA charts or create detailed bathymetry using fathometer and RTK GPS.
- Detailed bathymetry was the number 1 data need at our user conferences.
- Bathymetric data collection and interpolation method has been developed by MapCoast.
- Traditional imagery is also helpful.





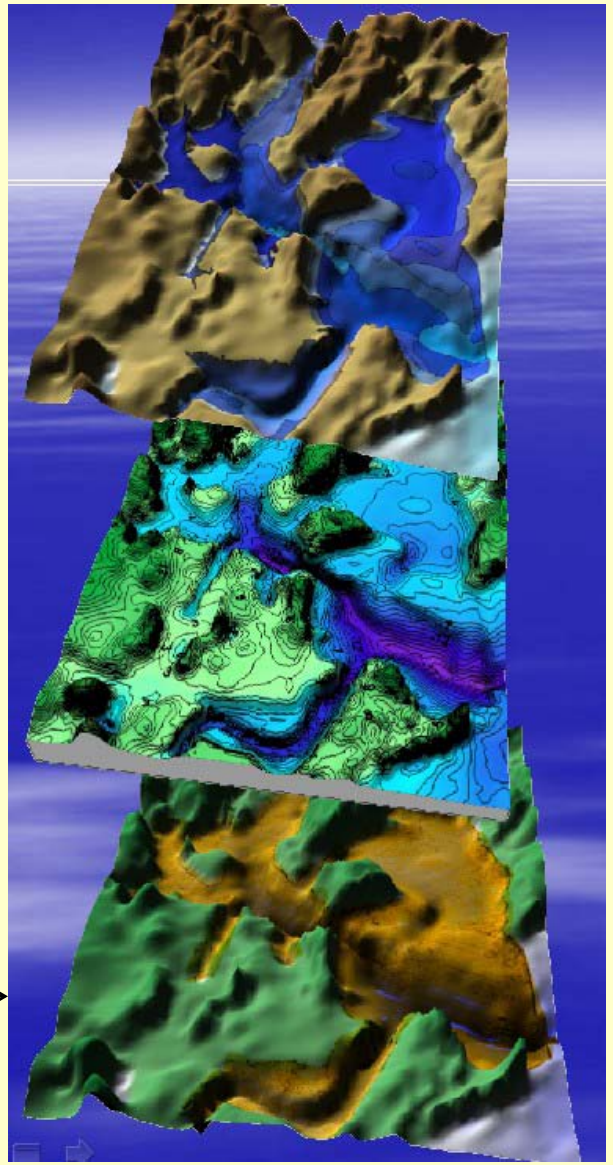
Mapping Procedure

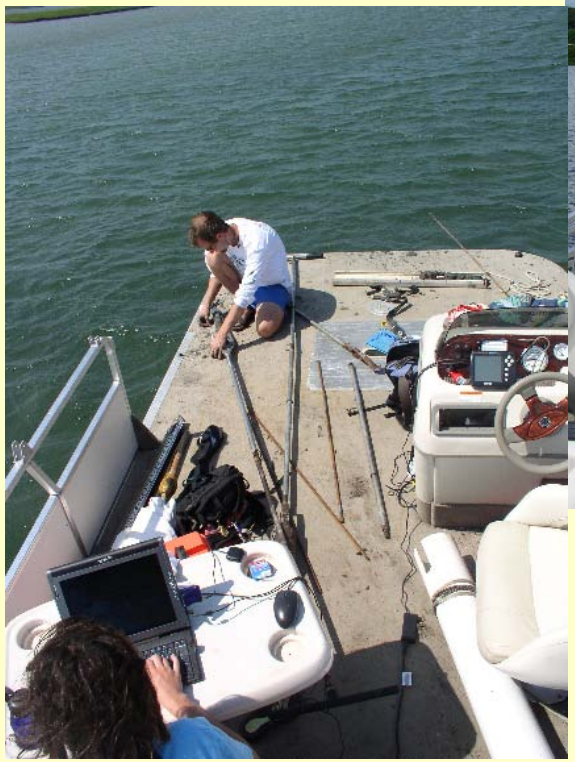
- Develop soil-landscape model using subaqueous soil formation factors.
- Identify and delineate landforms to determine soil map unit breaks.
- Map the area using standard NCSS procedure. Bucket augers and McCauley peat corers are used to investigate morphology.
- Vibracore techniques are used for deep and detailed observations.
- Describe, sample, classify pedons-series-map units – compile map.

Soil landscape map →

Bathymetry →

Acoustic map →





	A	B	C	D	E	F	G	H	I	J	K
1	Site Number:	PJ034		Mapping Unit:		Lbs		Description			
2	Date:	7/31/2007		Location Description:		Bluff Hill Cove				YSI Readings (type in values)	
3	Start Time:	10:38 AM		Water Depth (ft):		6.8	Temp(F)	77	Surface	sal 26.49; do 6.59; pH 7.83	
4	End Time:	11:00 AM		Bottom Type:		soft-bottom			Mid	sal 26.53; do 6.76; pH 7.81	
5	Surveyors:	JT, MB, MP, AS		SAV cover:		none			Bottom	sal 26.76; do 7.68; pH 7.88	
6	Waypoint:	4		Observation Method:		McCauly					
7	UTM Easting:	291387		Site Notes:							
8	UTM Northing:	4585108									
9				Vibracore spot; dive observation - no veg							

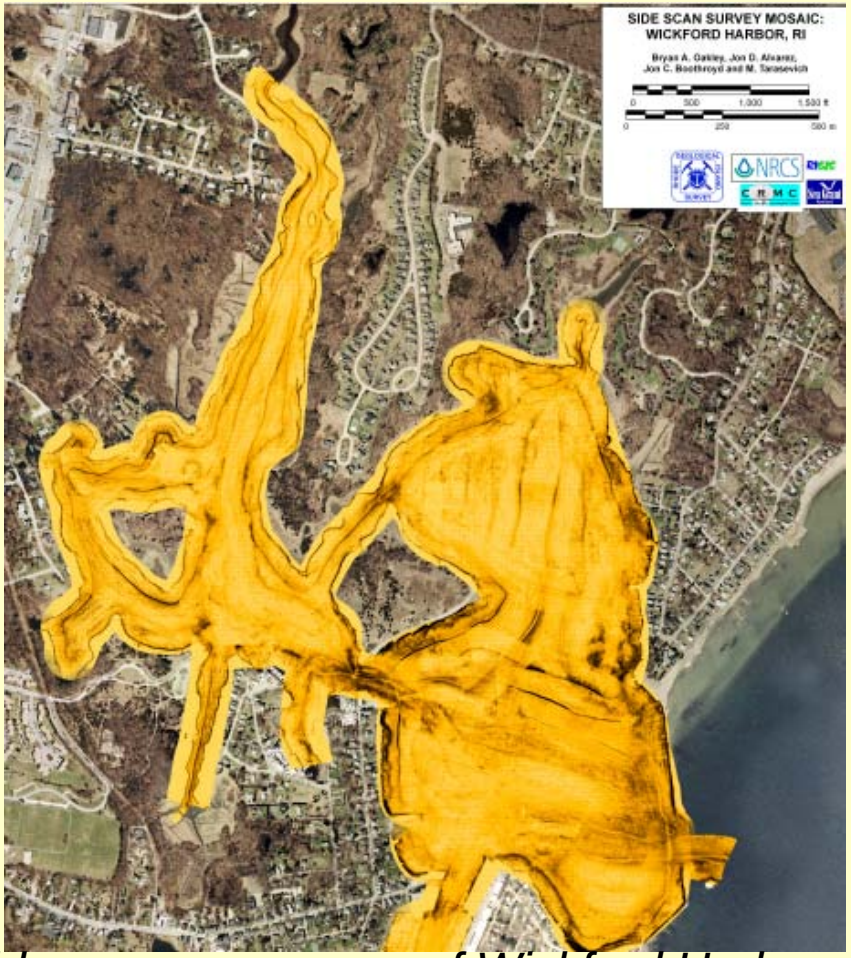
10	Horizon	Depth (cm)	Boundary Dist.	Field Texture Class	n-value	Munsell Color (Matrix)	Redox features color/conc	Field Coarse frags (%)	Shell frags (%)	H_2S odor	Notes
11	Ag	0-8		fsl	1	5Y 2.5/1			common tiny clam shells	slight	EC 15.7; pH 7.2; marine
12	Cg1	8-30		fsl	1	5Y 3/1				slight	marine
13	Cg2	30-50		fs	0.7	5Y 3/2				slight	70 cm EC 12.4; pH 7.1; few fine plant frags; marine
14	Cg3	50-70		fs	0	5Y 4/1				slight	common med plant frags; marine
										Not Taken	

PJ033 | PJ034 | PJ035 | PJ036 | PJ037 | PJ038 | PJ039 | PJ040 | PJ041 | Chocelet

Remote Sensing

The MapCoast field crew also employs the following technology to map underwater features:

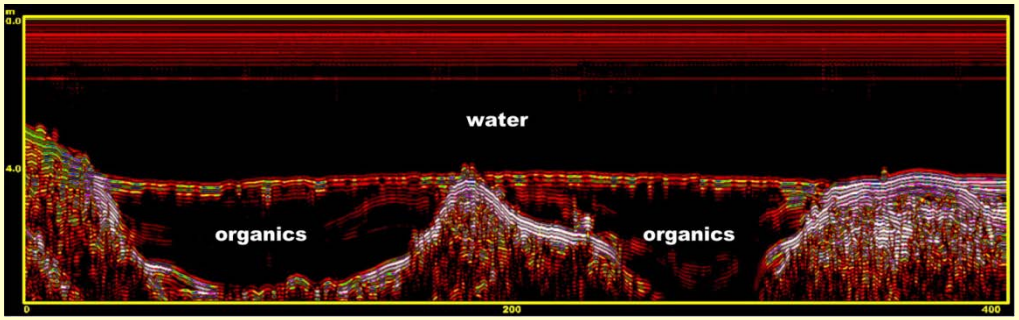
- Side-scan sonar (acoustic map).
- Subbottom – structures down to 70 feet.
- High Resolution Imagery (4”) & Pictometry.
- SPI Imagery.
- Still and video images of the bottom.
- GPR and EMI for Coastal Soils.



Side-scan sonar map of Wickford Harbor

Ground Penetrating Radar

- Premier geophysical tool for fresh water SAS (not saline).
- Provides high resolution bathymetry and subsurface information (peat, till, stratified).
- Works in areas of thick SAV.
- Numerous GPR units available in Northeast.
- Surveys being done currently in VT (Missisquoi Bay) and RI to map ponds.
- Interpreted data is used to create contour maps of interfaces and bathy.



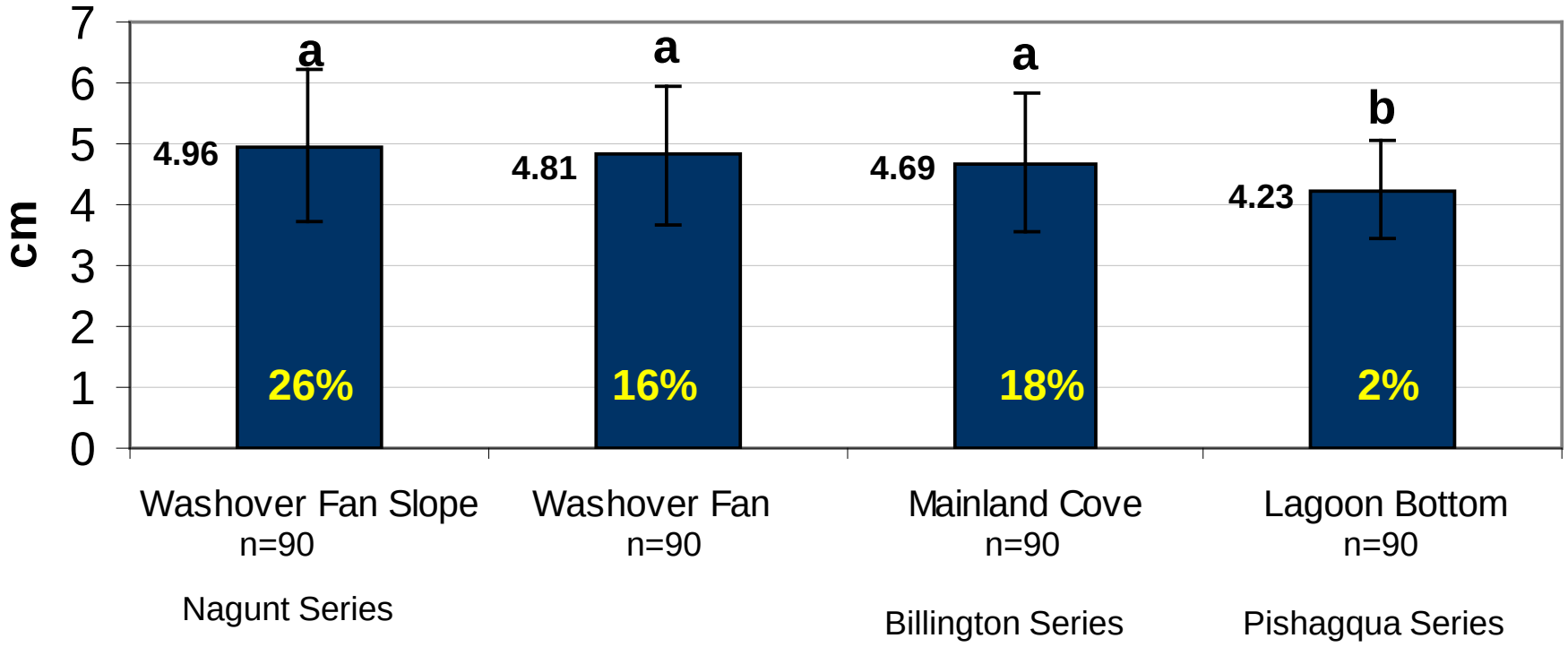
Research and Interpretations

- MapCoast currently has 7 thesis/doctorate studies on shallow water mapping. Other ongoing research also.
- Long list of interpretations needed (user conference).
- Baseline data is needed for chem/physical properties and classification of soils.
- Applications to Technical Soil Services.

- **SAV Restoration**
- **Crab Habitat**
- **Clam Stocking**
- **Management for Sustainable Production - Shellfish**
- **Nutrient Reduction**
- **Benthic Preservation Site Identification**
- **Wildlife Management**
- **Critical Habitats for Wading Shore Birds**
- **Nurseries and Spawning areas**
- **Habitat Protection for Horseshoe Crabs**
- **Dredging Island Creation**
- **Tidal Marsh Protection and Creation**
- **Bathymetric Map**
- **Navigational Channel Creation/ Maintenance**
- **Effects of Dredging on Benthic Ecology**
- **Off Site Disposal of Dredge Spoil**
- **Acid-Sulfate Weathering Hazards**
- **Dune Maintenance/Replenishment**

http://nesoil.com/sas/interpretations.pdf

Ninigret Pond Mean Oyster Length (cm)
October 2008



After one growing season more than 25% of the Washover Fan Slope oysters were within 15 mm of legal size or were legal sized.

Only 2% of the lagoon bottom oysters were within 15 mm of legal size.

Dredge Deposits Mesocosm Study

Major dredging planned for Harbor of Refuge

Sand would replenish nearby East Matunuck State Beach

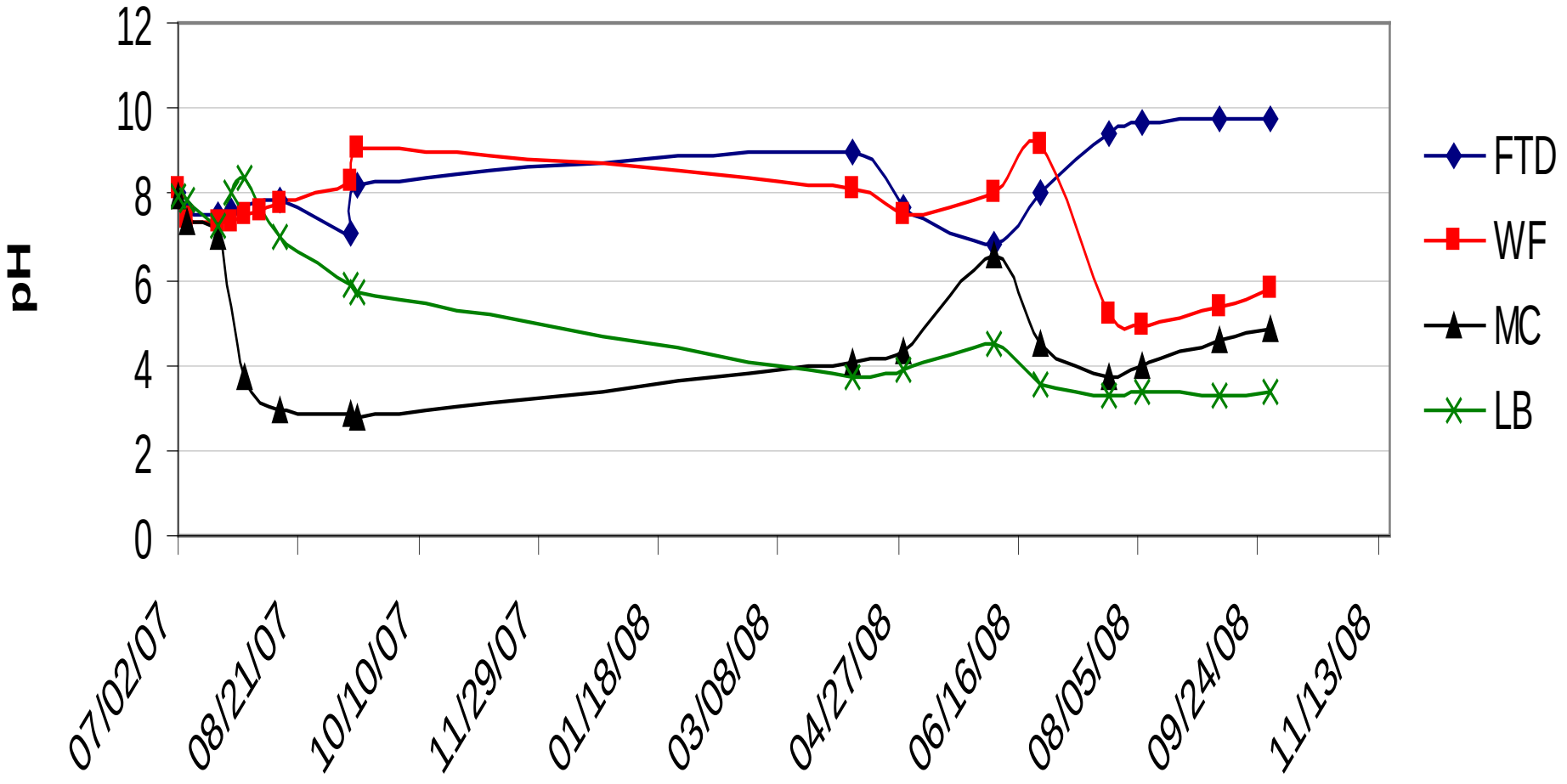
By GALEN McGOVERN

SOUTH COUNTY – A proposal by the U.S. Army Corps of Engineers to dredge the Harbor of Refuge and east and west channels into Point

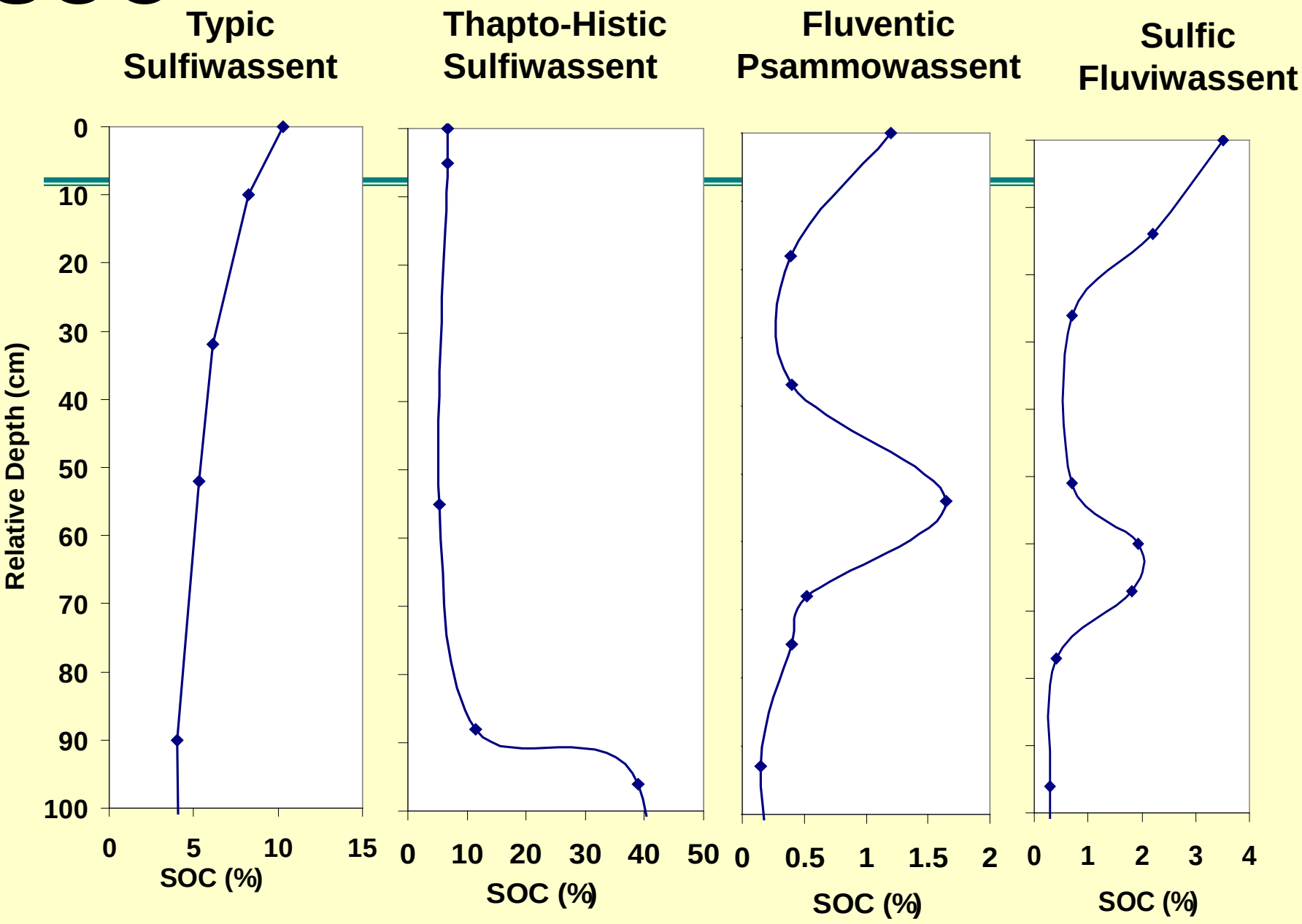
be picked up by a local sponsor," according to Walsh.

Bruce Kaiser, director of Administrative Services for South Kingstown, hopes if the current is right that the South Kingstown Town Beach

Ninigret Leachate pH

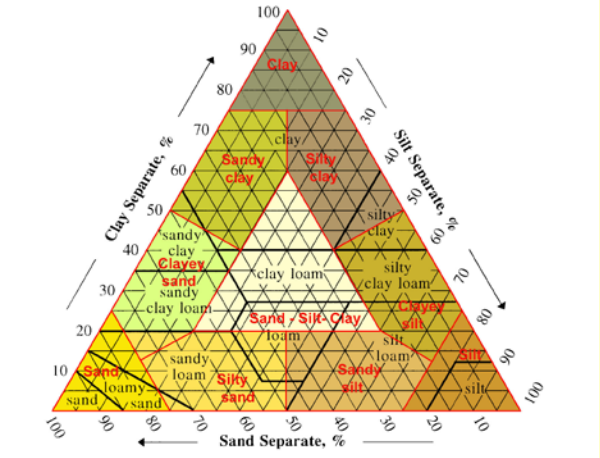


SOC


Typic Sulfiwassent
Thapto-Histic Sulfiwassent
Fluventic Psammowassent
Sulfic Fluviwassent
Relative Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
SOC (%)
0
10
20
30
40
50
SOC (%)
0
0.5
1
1.5
2
SOC (%)
0
1
2
3
4
SOC (%)

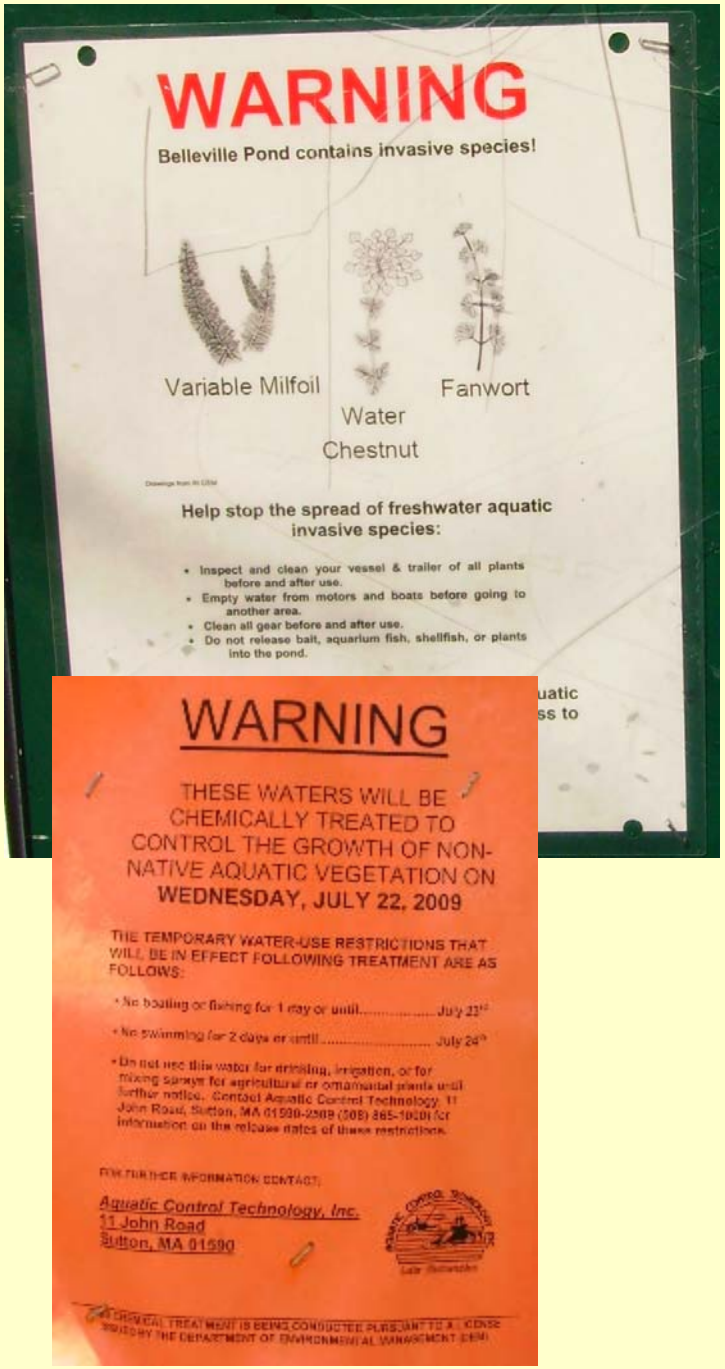
NASIS/Pedon PC Proposals

- Oxidized pH.
- Color change with addition on peroxide.
- Multiple primes.
- Water depth.
- Manner of failure.
- Si subordinate distinction.
- Official Soil Series additions/deletions.
- Sheppard's Classification.
- Subaquic drainage class.
- Moist incubation 8-16 weeks.
- Frasi modifications.



Fresh-Water SAS

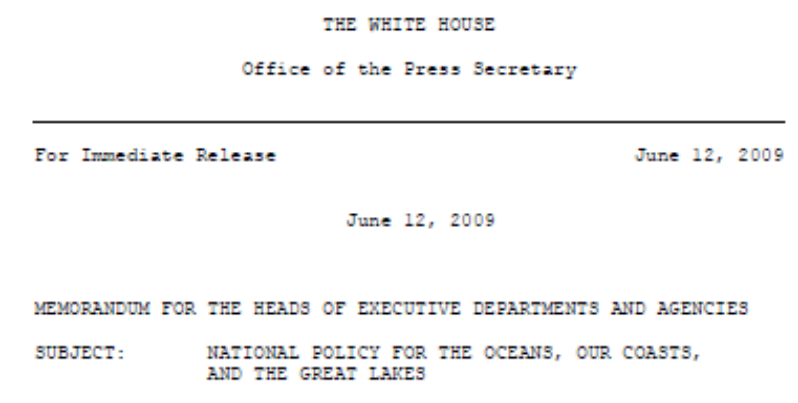
- Frasiwassents and Wassists
- Numerous requests for fresh-water data/map.
- Limited studies to date – RI, MA, VT and PA.
- RI work ongoing, needs include dam removal, peat thickness/volume (restoration), invasive species, habitat.



Why Map SAS– “So What”

“Talking Points”

- The 2004 U.S. Commission on Ocean Policy identified the need for “accurate and seamless living and nonliving marine resource data with bathymetry, and other natural features across the shoreline, coastal zone, near shore areas, and open ocean waters” (Recommendation 25-7)
- By 2010 75% of Population is expected to live w/in 50 miles of the coast.
- None to little mapping currently available for shallow water landscapes.
- **Coastal Soil and Sediment Mapping Helps us Better Manage, Protect, and Restore our States Underwater Marine Landscapes**



THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release June 12, 2009

June 12, 2009

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

SUBJECT: NATIONAL POLICY FOR THE OCEANS, OUR COASTS, AND THE GREAT LAKES

The Task Force's recommendations and frameworks should be cost effective and improve coordination across Federal agencies.

This memorandum covers matters involving the oceans, the Great Lakes, the coasts of the United States, and related seabed, **subsoil**, and living and non-living resources.

Marine Spatial Planning!

REED SECURED FEDERAL FUNDING FOR RHODE ISLAND FOR FISCAL YEAR 2006

Natural Resources Conservation Service (NRCS) Soil Survey Management Office: $100,000

The Natural Resources Conservation Service (NRCS) will receive $100,000 to develop coastal and underwater soil mapping techniques, classification, and soil analysis, as well as provide ongoing training.[Click to go back to the top of the page.]

Pawtuxet Cove Federal Navigation Project Maintenance Dredging: $1,440,000
Cranston/Warwick

The Army Corps of Engineers will receive $1,440,000 to remove 90,000 cubic yards of material to restore the 6-foot entrance channel, turning basin and anchorage area in Pawtuxet Cove. The Pawtuxet Cove Federal Navigation Project is an important ay for vessel traffic serving both the cities of Cranston and Warwick. [Cl o go b e top of the page.]

Narrow River Aquatic Ecosystem Restorat ect: $150,000
Narragansett/South Kingstown

The Army Corps s w ceive ,000 in feder nd nt a feasibility study v to rest tuari itats along th rr r in Narragansett ar t Kingstown ps of Enginee pr a Preliminary Res to red tion between ow and Rhode Island Sound. [C o the t th .]

Roger Williams University er r Ag tu velopment (CAD): $1,000,000
Bristol

Roger Williams (RWU) in Bristol will receive $1,000,000 to support the establishment of a C r Aquaculture Development (CAD). The CAD will be established within the University's s cessful Center for Economic and Environmental Development which has an active aquaculture research program and operates the only shellfish hatchery in Rhode Island. [Click to go back to the top of the page.]

East Providence Waterfront Storm Water Management Analysis: $250,000

The City of East Providence will receive $250,000 to analyze and develop an innovative storm water management plan for its newly revitalized waterfront. [Click to go back to the top of the page.]

Bullocks Point Cove Federal Navigation Project Maintenance Dredging: $630,000
East Providence/Barrington

The Army Corps of Engineers will receive $630,000 to remove 50,000 cubic yards of dredged material to restore the project's 8-foot entrance channel, the 6-foot inner channel, and the 6-foot mooring and turning basins. [Click to go back to the top of the page.]

Charlestown Breachway navigation study: $90,000
Charlestown

The Army Corps of Engineers will receive $90,000 to complete a navigation study and initiate and complete the project design for the Charlestown Breachway and Inlet. There is growing concern for navigation safety through the breachway, which connects Ninigret Pond to Rhode Island Sound. The Army Corps of Engineers is considering a project to remove large boulders on the ocean side of the breachway as well as some dredging of the natural channel farther inland. The Corps will already be dredging in Ninigret Po habitat purposes under the South Coast Habitat Restoration Project, minimizi f the project.[Click to go b e top of the page.]

Boyd's Town alt Marsh Re ,000
Portsm

The R land Reso anag Cou rece ,000 to ontin ructi Boyd (Town esto roject. oject will estor 3 acr mar wildlife ry a ond b ing redge ial as wit al navi roje k to g the top of the pa

Brush ve ha orati
Warwi

The A rps o eers and the Rhode Island Coastal Resources Management Coun eceive $150,000 to continue to develop a feasibility study for Brush Neck Cove i Greenwich Bay.[Click to go back to the top of the page.]

Allins Cove Environmental Restoration: $300,000
Barrington

The Rhode Island Coastal Resources Management Council will receive $300,000 to continue the restoration of degraded coastal wetlands at Allins Cove in Barrington. This project will restore coastal habitat and salt marsh by improving tidal flushing through removal of dredged material associated with a Federal navigation project [Click to go back to

Ten Mile River Fisheries Restoration: $250,000

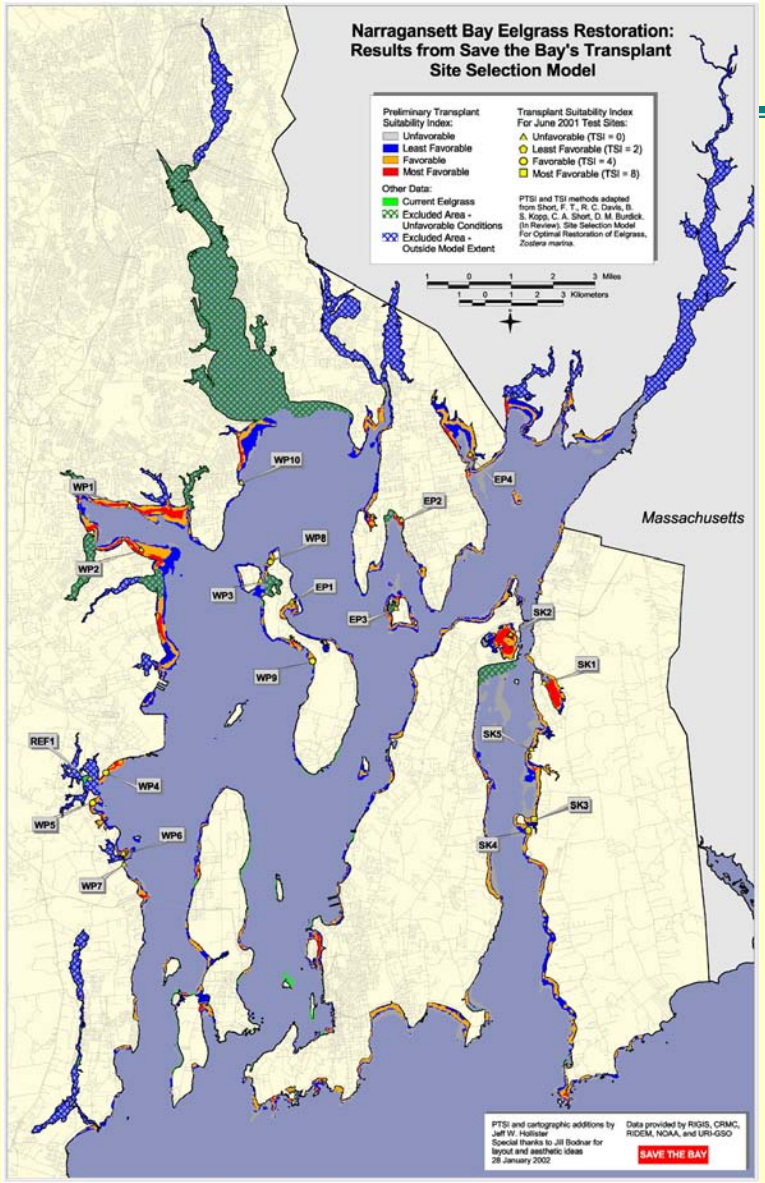
The Rhode Island Coastal Resources Management Council will receive $250,000 to support the restoration of fish runs in the Ten Mile River, which runs in eastern Rhode Island and southeastern Massachusetts. The construction of dams over the last 200 years has prevented fish passage to upstream spawning habitat. Restoring the fish run to the lower Ten Mile River would provide a wide range of benefits to the freshwater and marine fishery and to the surrounding communities. The bill also includes $14,000 for Inspection of Completed Works by the Army Corps of Engineers, $360,000 for Project Condition Surveys, and $525,000 for the Fox Point Hurricane Barrier to upgrade its 40-year old electrical system. [Click to go back to the top of the page.]

New England Lobster Disease Research: $3 million
University Of Rhode Island

The National Sea Grant College Program will receive $3 million to establish a cooperative research program to study the causes of lobster disease and the decline in the lobster fishery in New England waters. [Click to go back to the top of the page.]

$9 Milion

Restoration



Eelgrass Suitability Mapping: Critical Variables

Site Selection Model

Wave Exposure (exposure & current speed)

Soil Characteristics (texture, sulfide, organic matter)

Bioturbator Abundance

Temperature

Bathymetry (Critical Depth)

Missing!

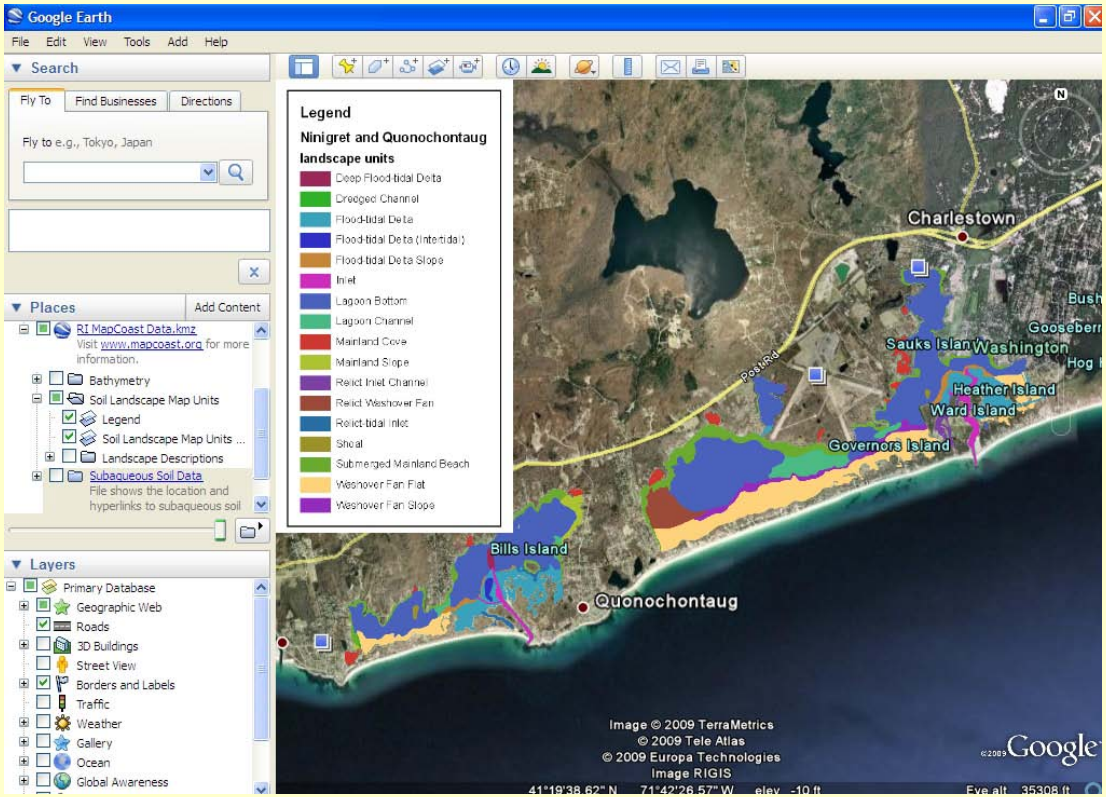
RI Oyster Restoration ~2 million

Examples of our Data

http://maps.edc.uri.edu/arcgis/services

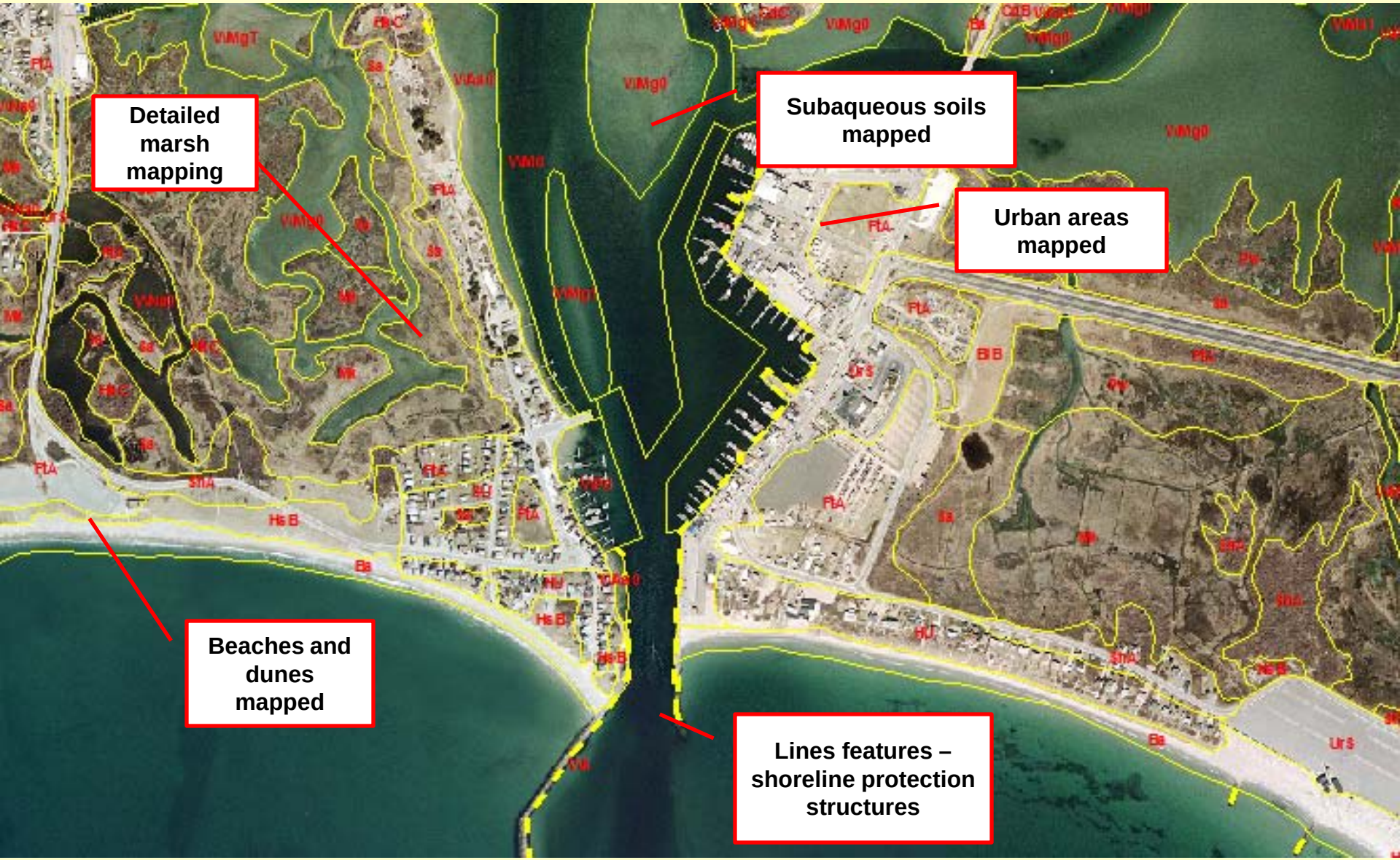
Google Ocean

AnalysisPC

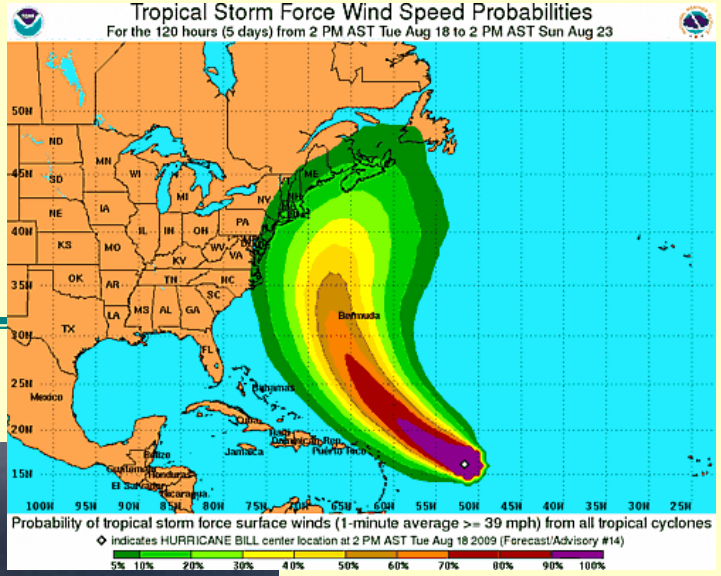


1996 RI SSURGO Map

2011 RI SSURGO

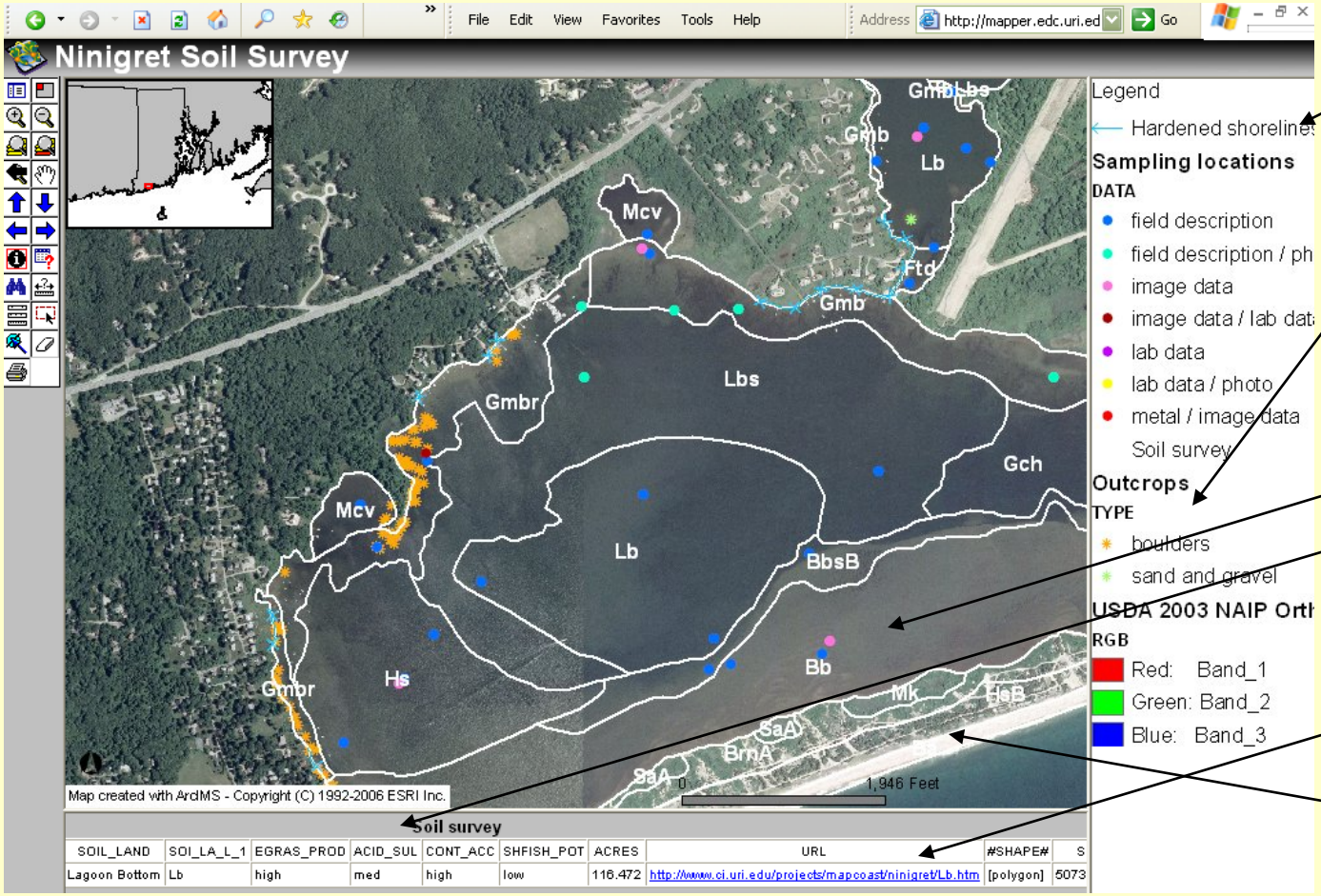


Questions


Tropical Storm Force Wind Speed Probabilities
For the 120 hours (5 days) from 2 PM AST Tue Aug 18 to 2 PM AST Sun Aug 23
Bermuda
Mexico
Jamaica
Probability of tropical storm force surface winds (1-minute average >= 39 mph) from all tropical cyclones
indicates HURRICANE BILL center location at 2 PM AST Tue Aug 18 2009 (Forecast/Advisory #14)

Questions?

IMS Example



Lines – shoreline protection, etc.

Points – AdHoc spot symbols.

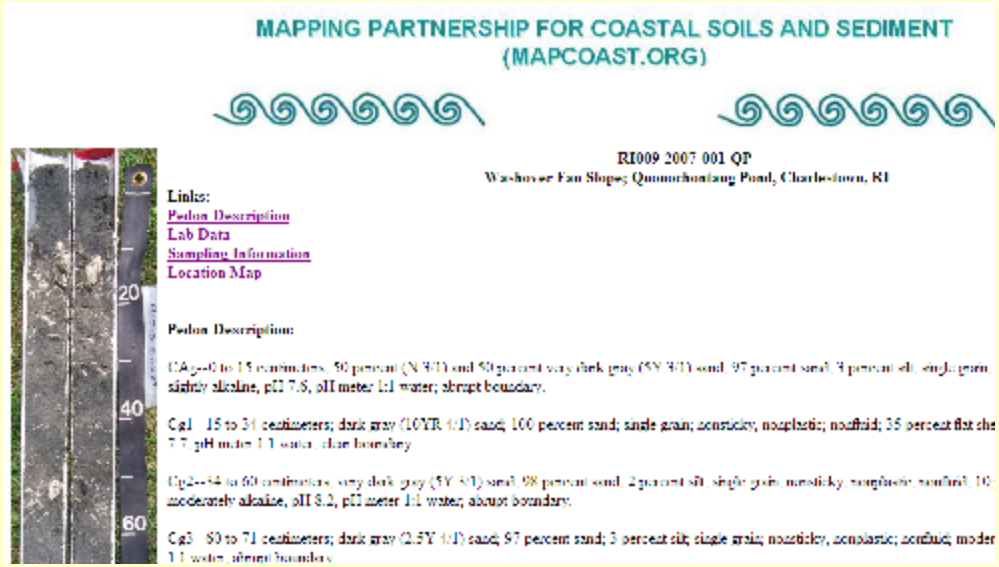
Polygons – spatial info with attribute data

Links

Coastal soils

Point/Pedon Data

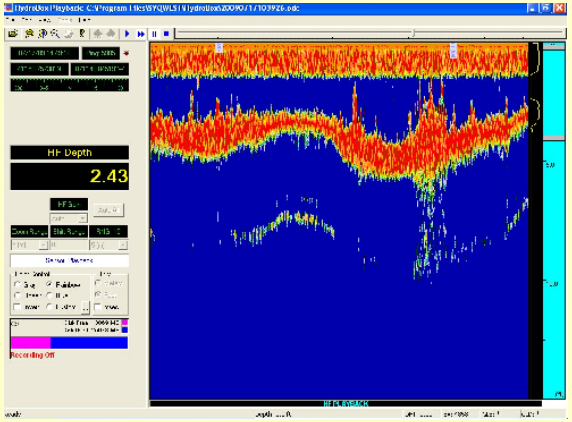
- 405 Pedons, 62 with lab data.
- Lab analysis includes PSA, OC, AVS/CRS, Incubation pH, metals, etc.
- 12 Series, 20 Map Units
- PedonPC & AnalysisPC used.
- Several Special Features (point/lines).
- All data linked and available (one cick), archive core stored at 4C.

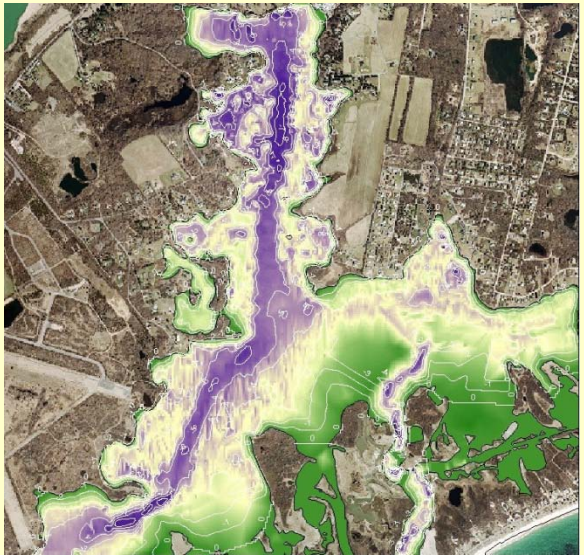


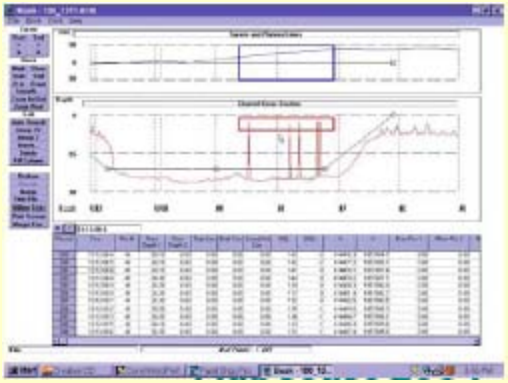
www.mapcoast.org or nesoil.com/sas

Bathy Methods -

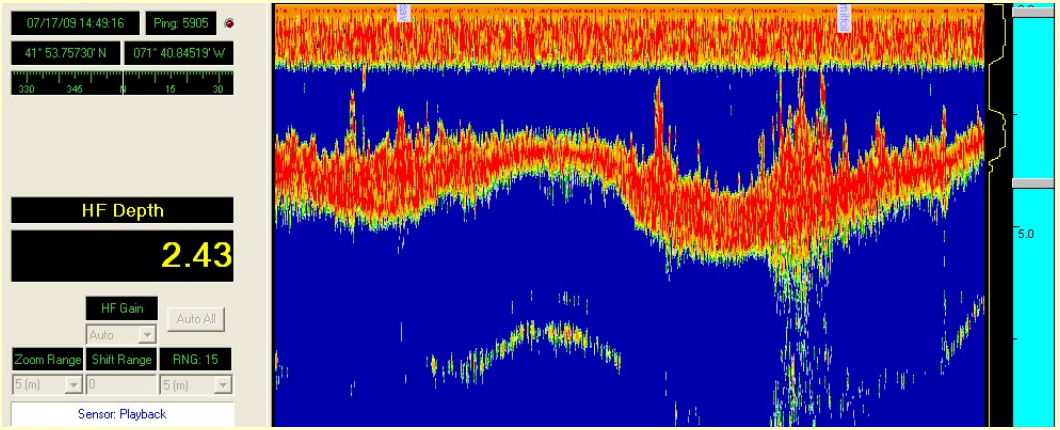
Detailed steps can be found on MapCoast Website.

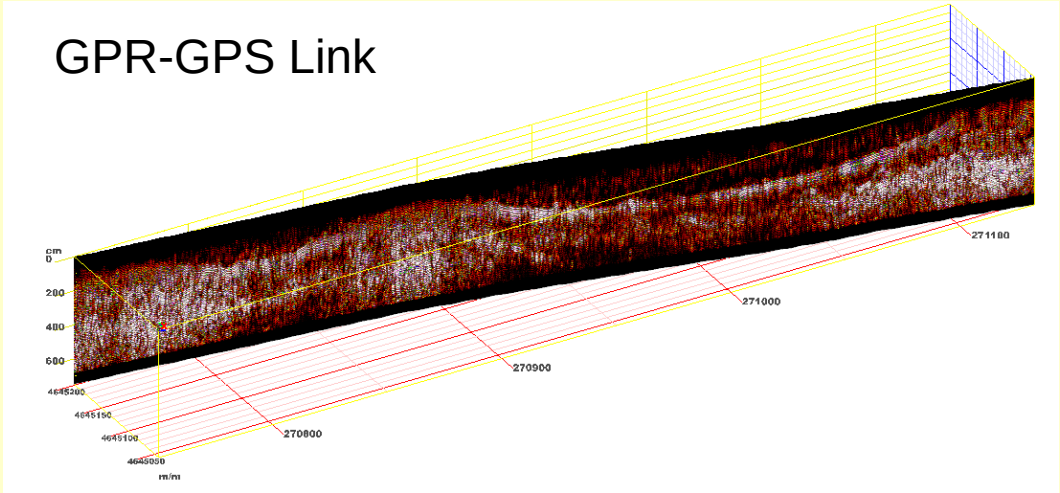






Freshwater Tools



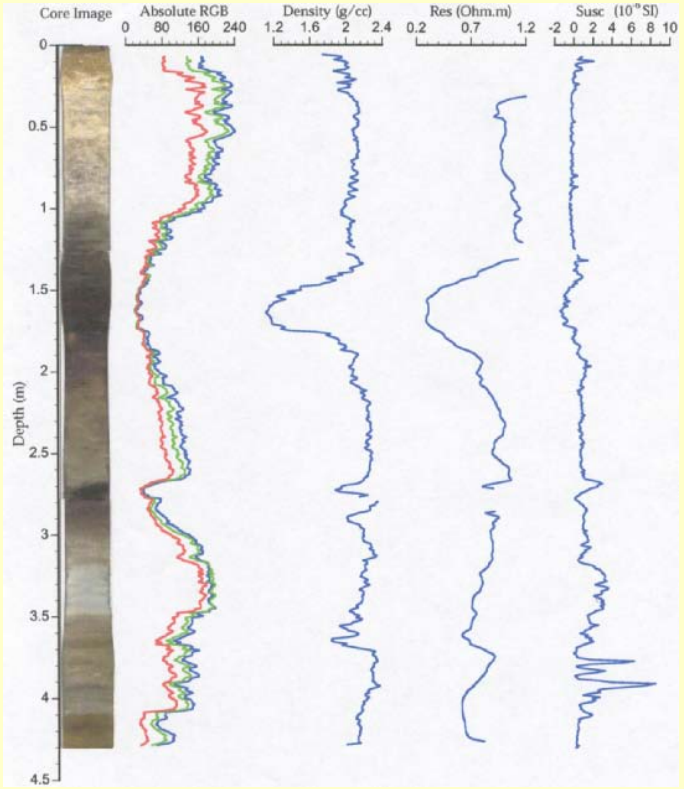


Core Cutting and Describing

cores are stored at 4C.

Cores are cut and a full description is taken. One section is sampled and imaged, the other is stored as an archive sample forever.

Core Imaging – *Geotek Core Analyzer and Niton XRF*



-High resolution image, RGB color, Density, Magnetic data, resistivity.

X-Ray Flourcence

-Heavy metal data 15 elements.

Rapid data collection.

Map Examples