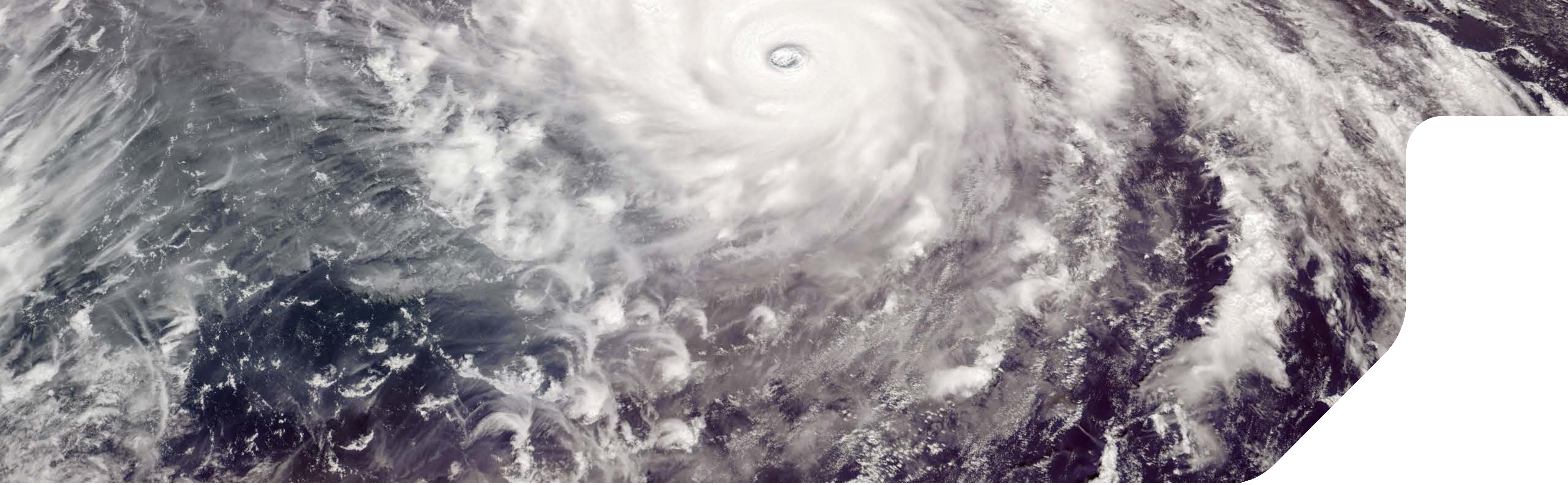


NORTH ATLANTIC COAST COMPREHENSIVE STUDY OVERVIEW - SESSION 2

UNDERSTANDING WHAT'S UNDER THE HOOD

Jamie Carter, NOAA

Dr. Tayebeh TajalliBakhsh, RPS

Kelsey Ruckert, RPS

Oct. 2020

rpsgroup.com

MAKING COMPLEX EASY

NOAA Office for Coastal Management

Federal lead for national coastal management efforts (CZMA)

Primary programs:

- Digital Coast
- National Coastal Zone Management Program
- National Estuarine Research Reserves
- Coral Reef Conservation Program

North Atlantic Coast Comprehensive Study

The U.S. Army Corps of Engineers produced North Atlantic Coast Comprehensive Study (NACCS) in 2015 to address coastal storm and flood risk in the North Atlantic region. The study was designed to:

- Help local communities better understand changing flood risks associated with climate change
- Provide tools to prepare for future flood risks that can be customized for any coastal watershed

The Northeast Regional Ocean Council (NROC) worked with RPS to extract key model data and statistics and develop tools and services to easily work with these data.

www.northeastoceancouncil.org/naccs

What to Expect

Session 1 - NACCS overview: Informing coastal decisions in the Northeast

- A high-level overview of the NACCS and how it can be applied to coastal management in the Northeast and Mid-Atlantic.

Session 2 - NACCS technical session: Understanding what's under the hood

- Building on *Session 1- NACCS overview* offered on Oct. 21st, this more in-depth session will explore the technical components of NACCS.
- When? Session 2 will be offered twice to provide flexibility in scheduling:
  - October 27, 2020, Tuesday | 10am - 11:30am Eastern Time
  - October 29, 2020, Thursday | 10am - 11:30am Eastern Time

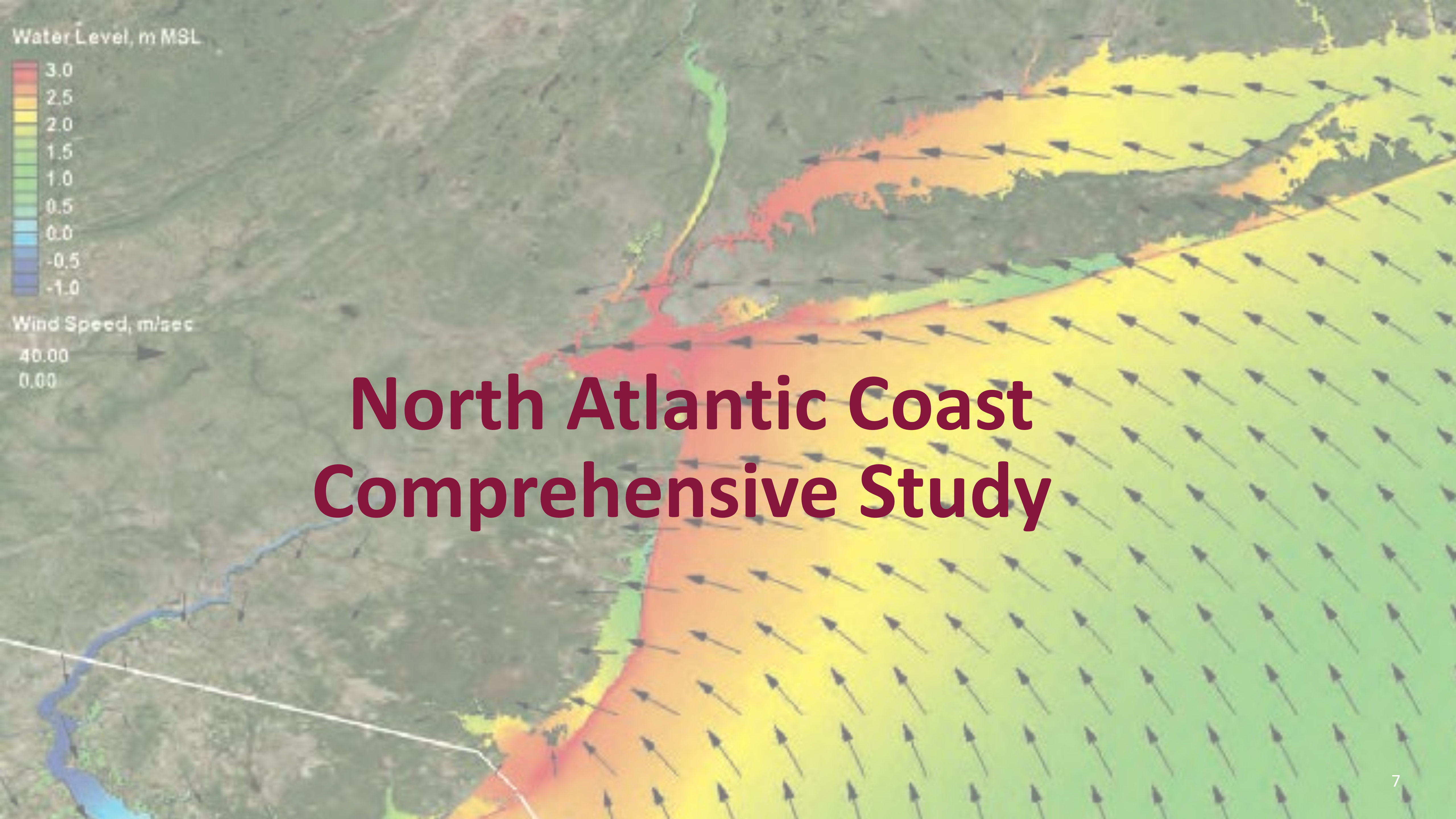
Outline

- Introduction
- NACCS modeling overview
  - Storm basics (Synthetic tropical , historical extratropical storm)
  - Modeling approach
  - Model output
- ArcGIS GeoDatabase overview
  - How to access the results from different servers
  - Mapping the results from the geodatabase
  - Case Study

Last Session

Discussed:

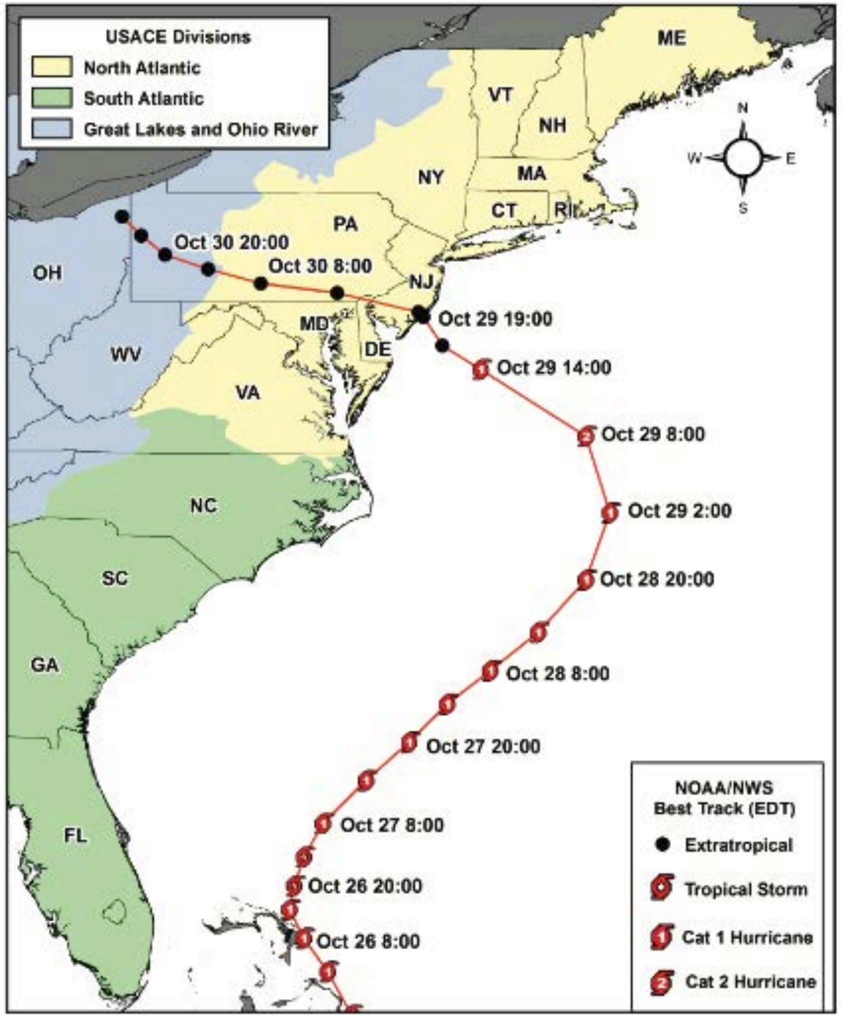
- NACCS and other coastal flooding products
  - So many maps …. most appropriately for education/awareness purposes
  - Should not be used as the sole source for specific risk management decisions.
- Use case(s) of NACCS
  - Nonlinear interaction of tide, sea level rise and storm surge
  - Limitation of bathtub approach



North Atlantic Coast Comprehensive Study

NACCS

- North Atlantic Coast Comprehensive Study (NACCS) , a two-year study by the USACE
- Included atmospheric, wave and storm surge modeling for the North Atlantic region, including coastal areas of all NROC member states.
    - To provide critical information for effective flood risk management project planning, design, and performance evaluation, providing the joint probability of coastal storm environmental forcing parameters.
    - To provide tools to better prepare for future flood risks.



Goals of NACCS

Provide a risk management framework; and
Support resilient coastal communities

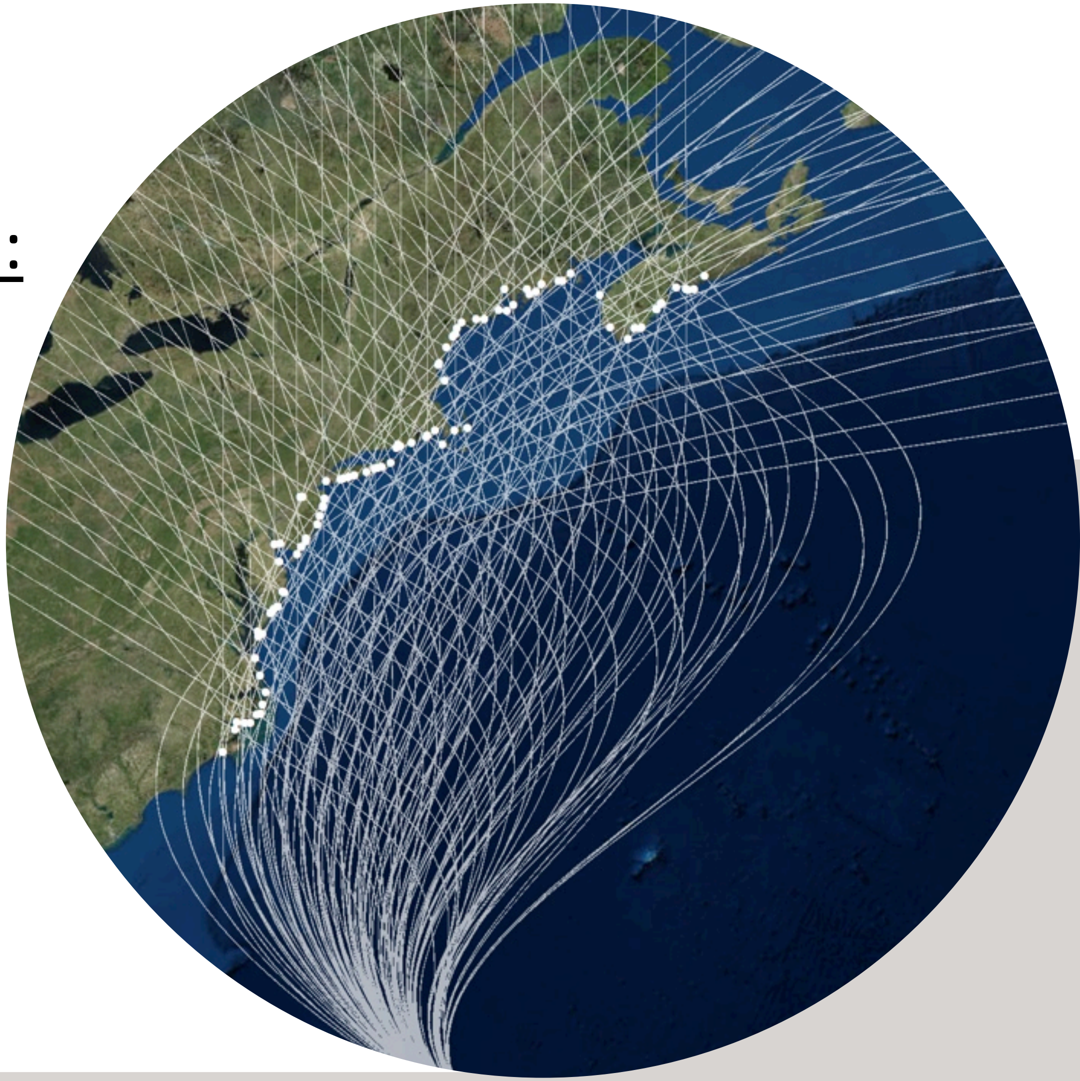
Concepts of resilience include:

- anticipate (prepare, avoid);
- resist (withstand);
- recover (bounce back); and
- adapt (evolve, transform).

Floods are the most common and costly hazard affecting communities and the hazard that is most predictable (FEMA 2013a).

NACCS Modeling Goals

- Wave and water level modeling study goals: simulating an efficient number of storms that covers the characteristics necessary to accurately describe the statistical nature of coastal storm response over the entire study region.
- This information is required for modern probabilistic project design and for risk assessment.



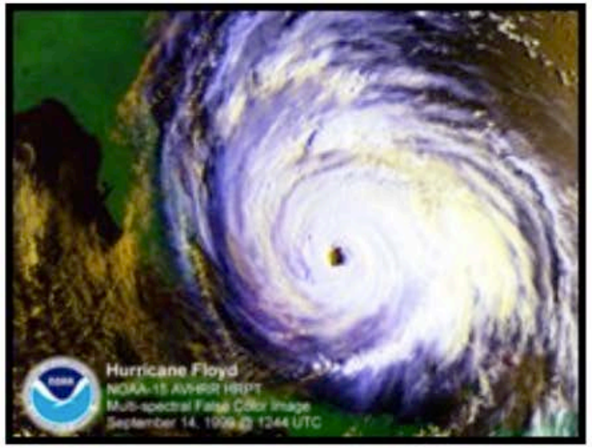
Storms in North Atlantic

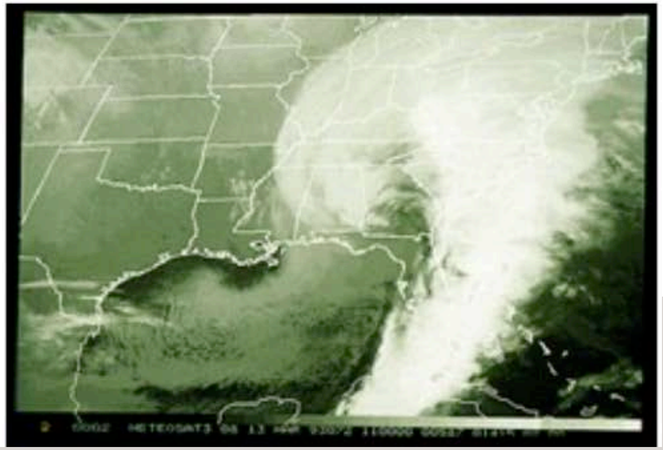
- Tropical Cyclone:

  A rotating, organized, warm-core system originating over tropical or subtropical waters and has a closed surface wind circulation about a well-defined center (e.g., tropical depression, tropical storm, hurricane).

- Extratropical Cyclone:

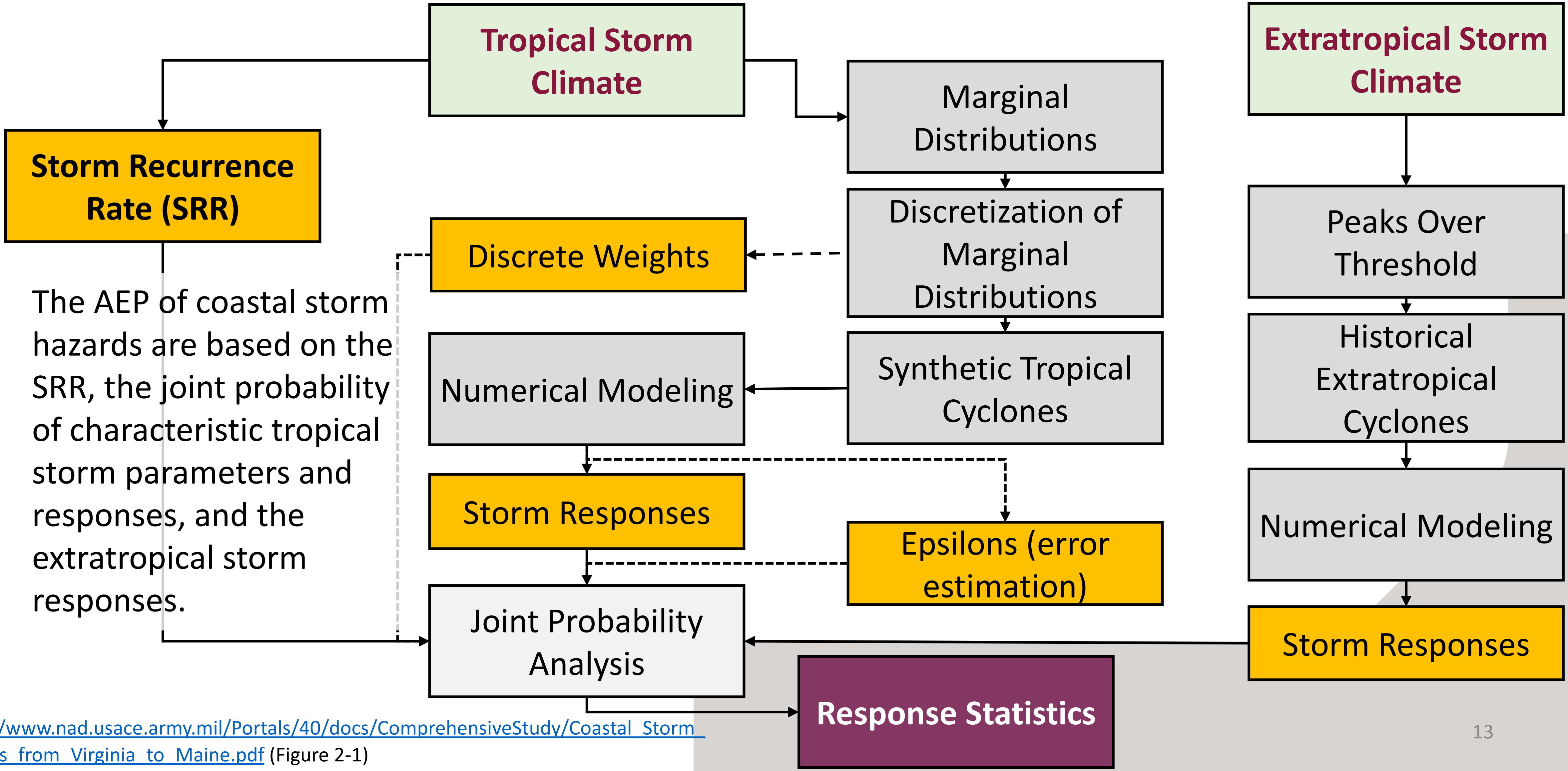
  A low-pressure system that primarily relies on baroclinic processes, getting its energy from the temperature contrast between warm and cold air masses in the atmosphere (e.g., Nor’easter).





METHODOLOGY

Joint Probability Analysis of coastal storm hazards

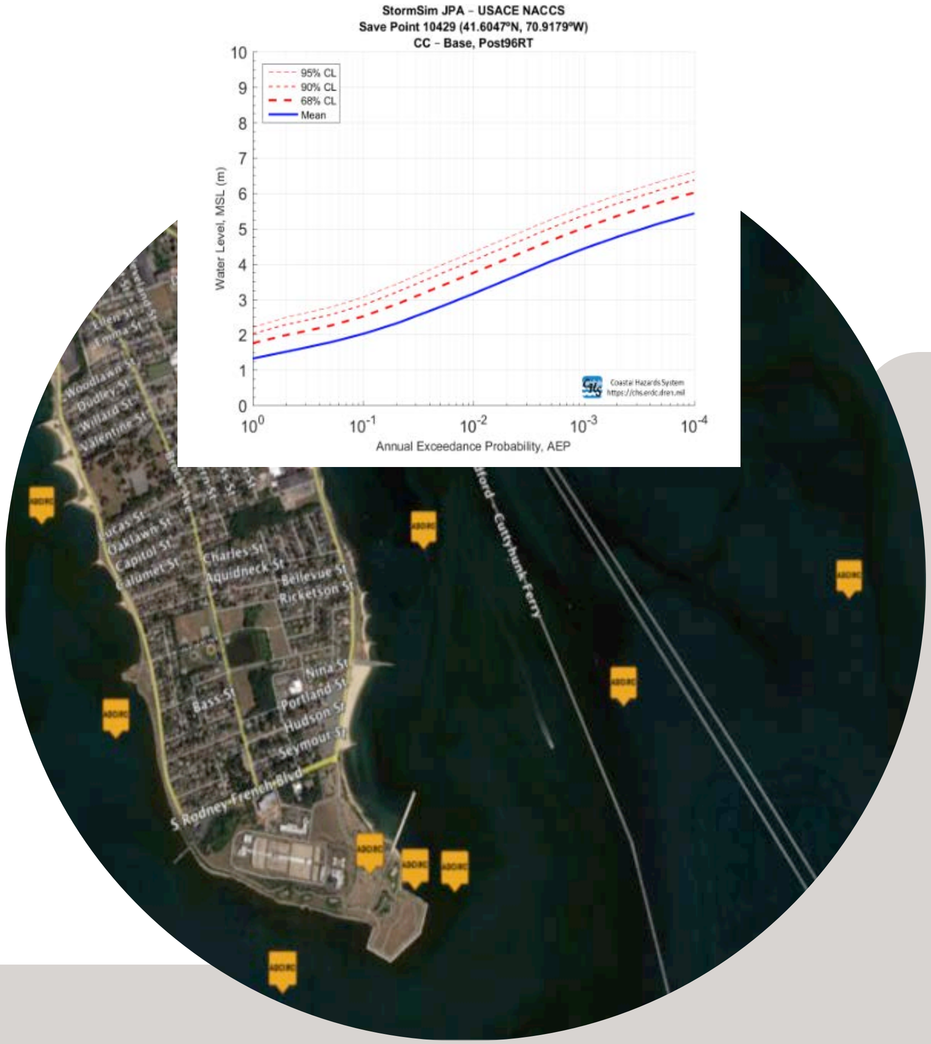


The AEP of coastal storm hazards are based on the SRR, the joint probability of characteristic tropical storm parameters and responses, and the extratropical storm responses.

https://www.nad.usace.army.mil/Portals/40/docs/ComprehensiveStudy/Coastal_Storm_Hazards_from_Virginia_to_Maine.pdf (Figure 2-1)

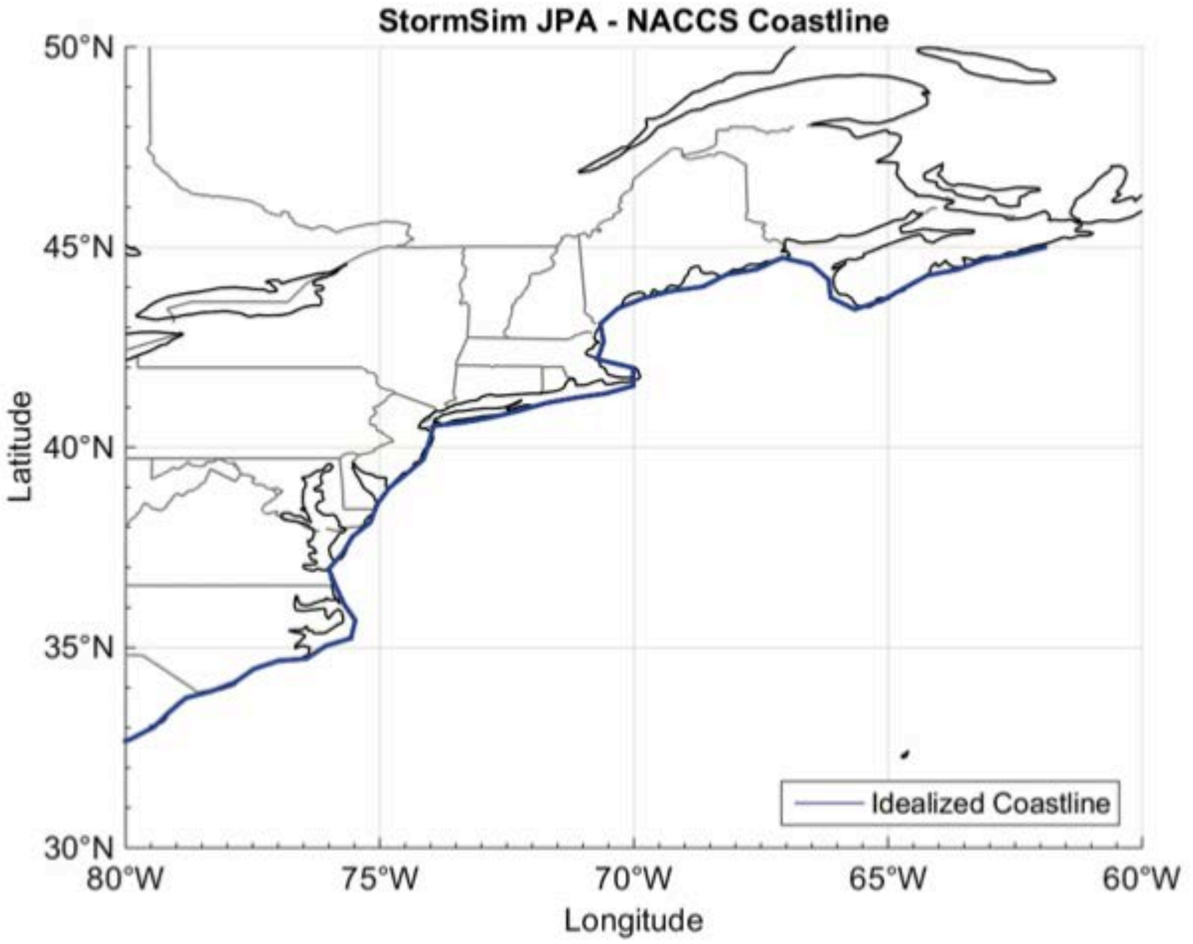
NACCS Statistical Methodology

- Required the development of:
  - A joint probability Method (JPM) model of TC forcing parameters in order to span the parameter and probability spaces.
  - Extreme value analysis (EVA) of historical extratropical cyclones (XC) responses.
  - For both XC and TC populations, extreme storms were efficiently sampled to accurately compute extreme statistical from high-fidelity modeling results.



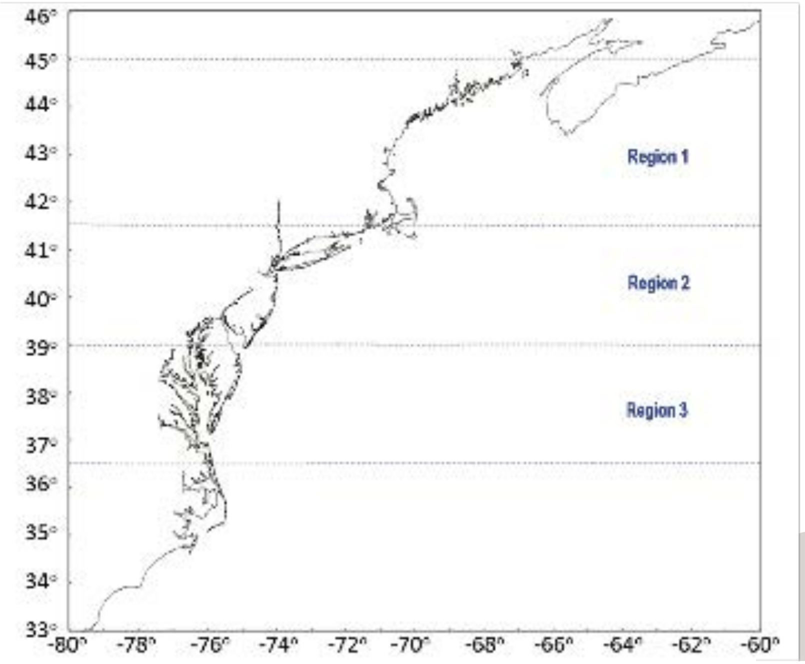
Tropical Cyclones

- The joint probability method with optimal sampling (JPM-OS) considers all possible combinations of TC meteorological parameters ;
- Synthetic TCs based on parameters for storms that impacted the region from Virginia to Maine:
  - track location (x_o),
  - heading direction (θ),
  - central pressure deficit (Δp),
  - radius of maximum winds (R_{max} or RMW), and
  - translational speed (V_f).
- Optimal sampling of the joint distributions of these parameters : 1,050 unique TCs.



Tropical Cyclones

- These storm parameters: inputs to wind model and pressure fields (planetary boundary layer (PBL))
- The JPM was critical to the storm selection process because storms are synthesized from the discrete joint probability distribution.
- The parameter ranges exceed the historical record but reasonably represent extreme potential storms.



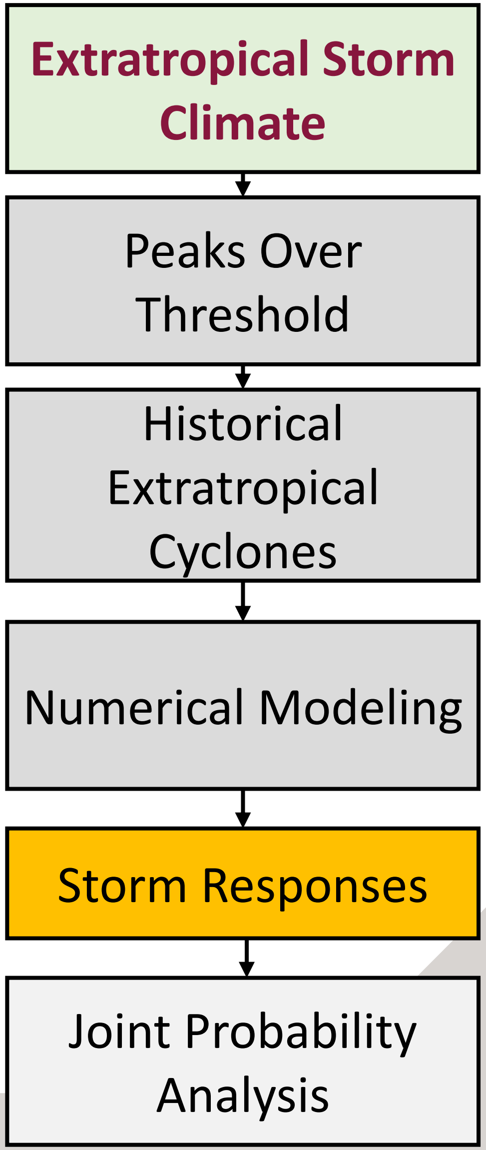
Tropical Cyclone Parameters	NACCS Subregion 3	NACCS Subregion 2	NACCS Subregion 1
θ	-60°, -40°, -20°, 0°, +20°, +40°	-60°, -40°, -20°, 0°, +20°, +40°	-60°, -40°, -20°, 0°, +20°, +40°
Δp	From 28 to 98 hPa at 5 hPa intervals	From 28 to 88 hPa at 5 hPa intervals	From 28 to 78 hPa at 5 hPa intervals
R_{max}	From 25 to 145 km, median of 54 km	From 25 to 158 km, median of 62 km	From 26 to 174 km, median of 74 km
V_f.	From 12 to 59 km/h, median of 27 km	From 14 to 88 km, median of 45 km	From 16 to 83 km, median of 49 km
Holland *B*	From 0.45 to 1.32	From 0.56 to 1.35	From 0.66 to 1.37

Extratropical Cyclones

- Using observation screening:

Storm surge and meteorological measurements (1938–2013) => 250 extratropical storms

- Using the peaks-over-threshold (POT) technique for largest water level values => reduced to an optimal amount of 100 historical XCs.

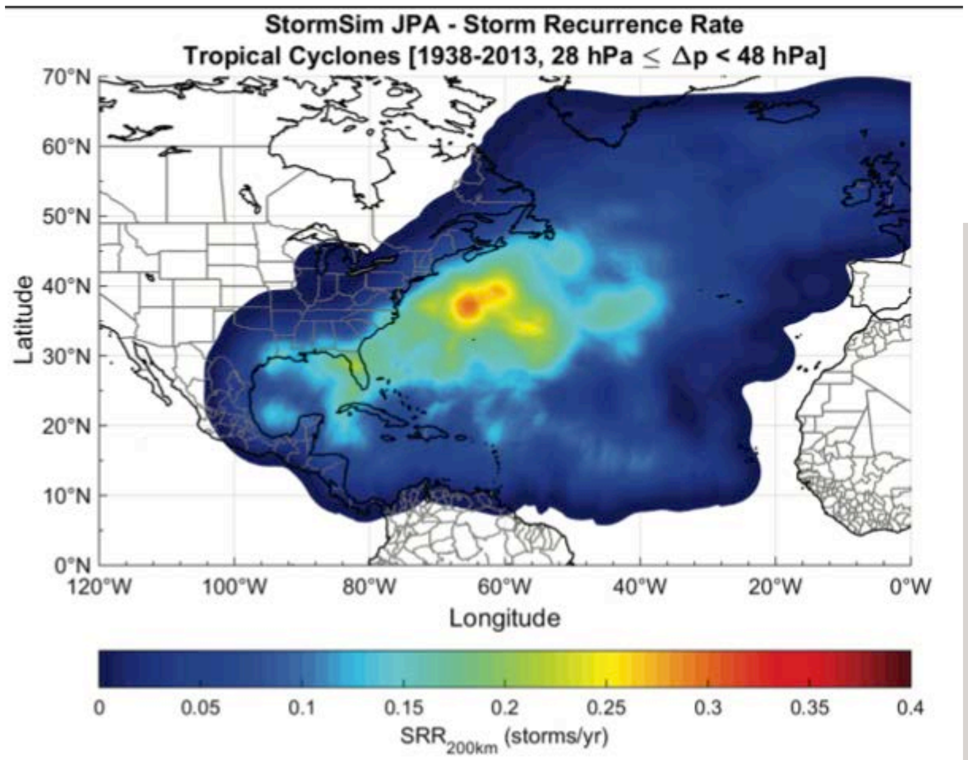


Spatially Varying Storm Recurrence Rate (SRR)

- To efficiently sample historical storms and to compute the spatial variation of storms, Gaussian kernel function (GKF) is used.

Gaussian kernel function (GKF):

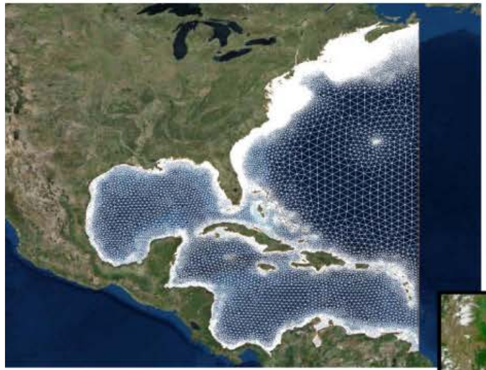
- establishing a grid of nodes where estimates of the SRR are sought.
- All storms within this gridded space can be counted at any given node, but the weight assigned to each storm decreases with increasing distance from storm to node (PDF)



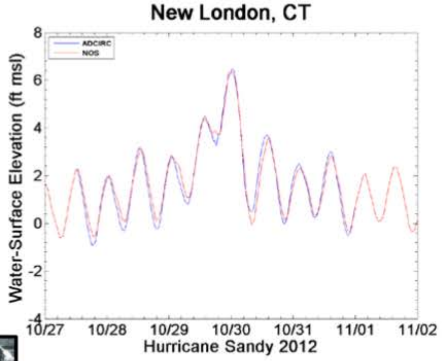
MODELING APPROACH

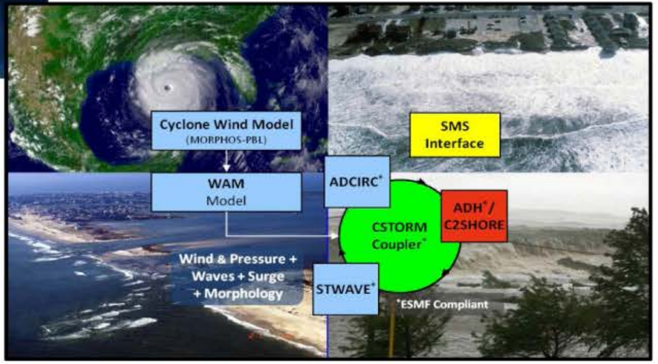
NACCS

ADCIRC

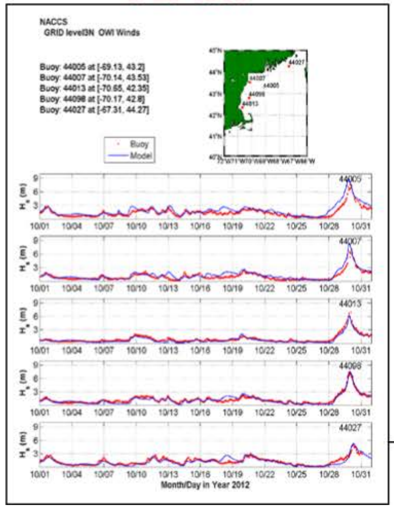


CSTORM-MS
High Fidelity Modeling





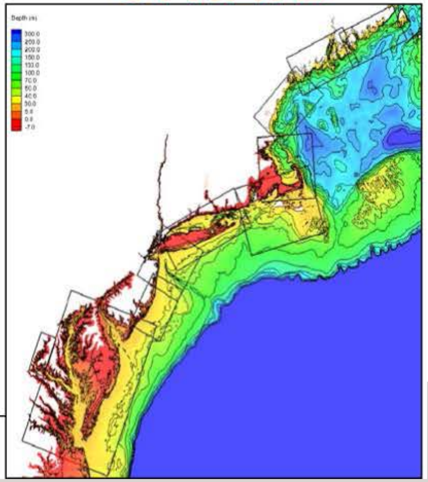
WAM

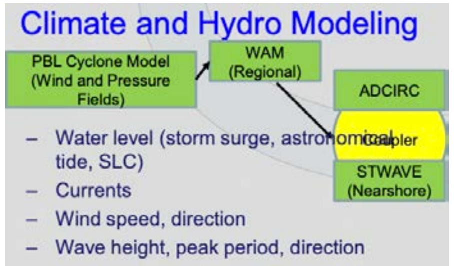


CSTORM-MS: **C**oastal **STORM** **M**odeling **S**ystem

WAM: **WA**ve Prediction **M**odel
STWAVE: **ST**eady-State Spectral **WAVE** model
ADCIRC: **AD**vance **CIRC**ulation Model

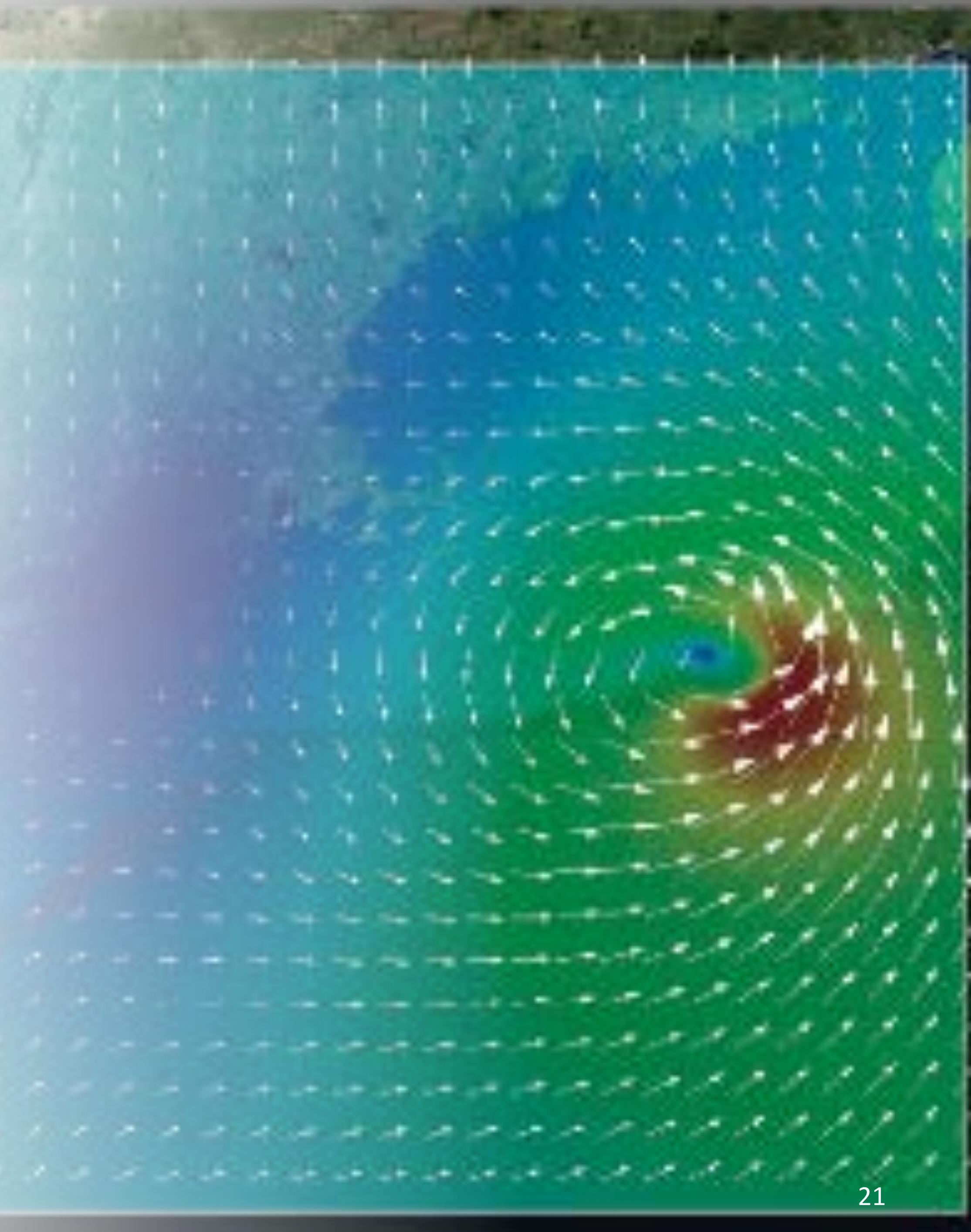
STWAVE





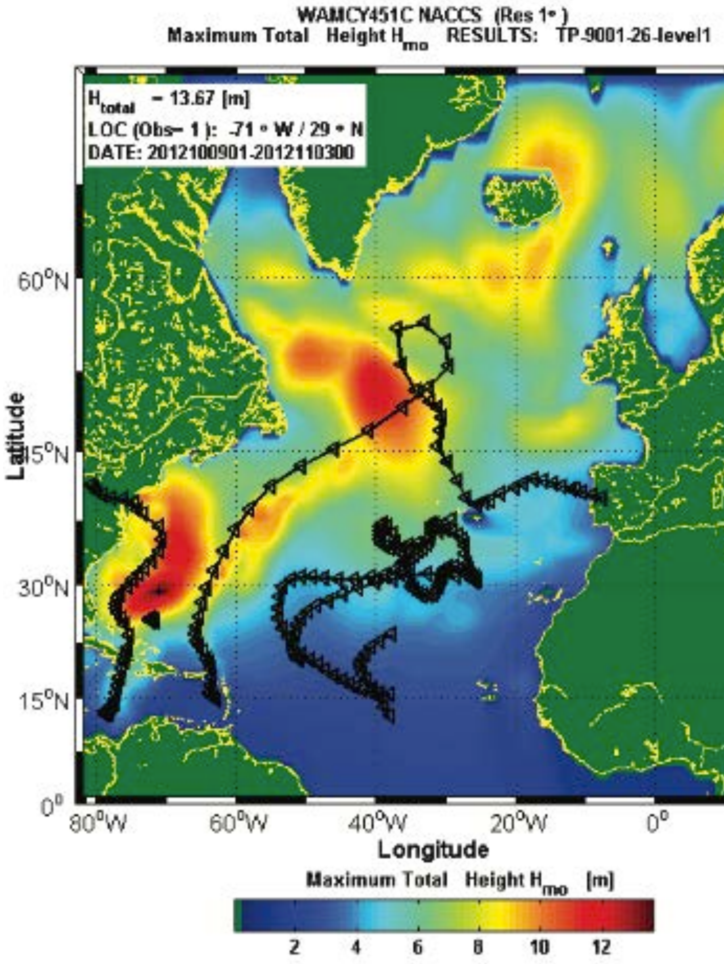
XC and TC wind and pressure fields

- Planetary Boundary Layer (PBL) model was used for generation of wind and pressure fields.
- Oceanweather Inc. (OWI):
  - generated extratropical wind and pressure fields for the 100 historical XC events
  - expanded the landfall parameters of the 1050 TC into a full track time history to drive the model



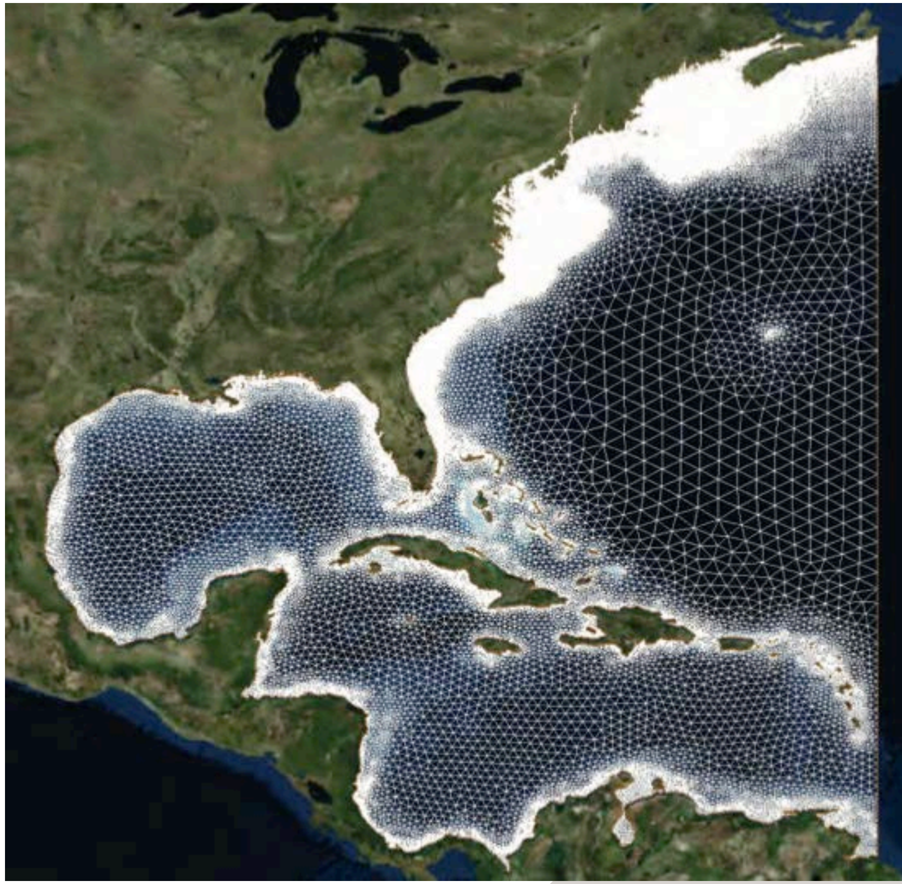
Offshore Wave Generation

- WAM: simulation of the 100 extratropical and 1050 synthetic tropical storm events
  - to provide offshore deep water wave boundary conditions for the nearshore steady-state wave model STWAVE.
  - Accounting for all wave energy, swell energy in the presence of a high-frequency wind-sea component will be unaffected in the decay stages of a primary storm as energy is transmitted to the coast.



Storm Surge Modeling

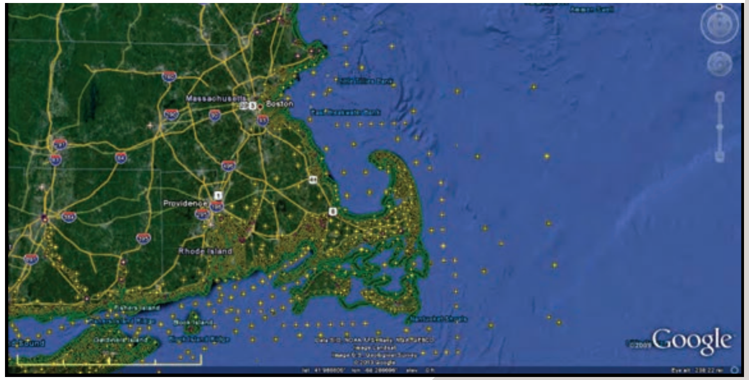
- ADvanced CIRCulation (ADCIRC) model to simulate the surge and circulation response to the storms:
- high resolution in areas of complex shoreline configuration and bathymetry.
- **3.1 million computational nodes**
- **6.2 million elements**
- The largest elements: in the Caribbean Sea, 40km nodal spacing
- The smallest elements nodal spacing: 10 m.
- Flooding and drying of these areas during storms, extracting the 20 m topographic contour



ADCIRC high-frequency Model Output

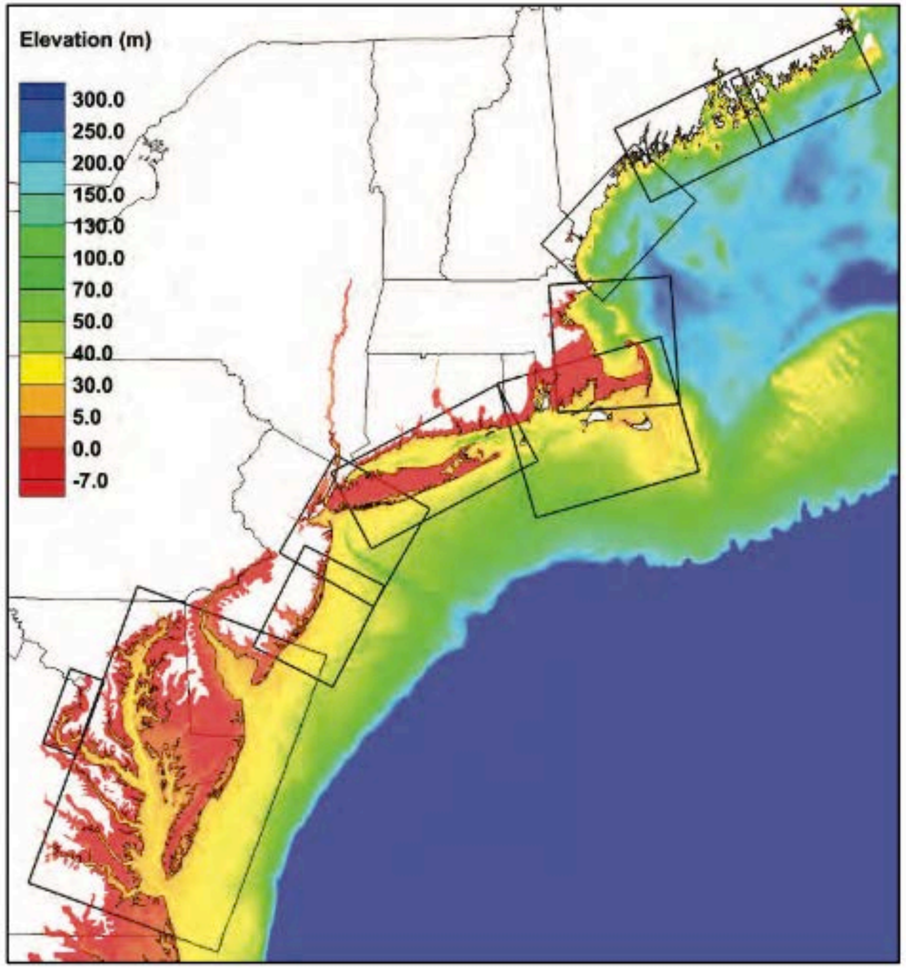
Save-point locations :

- provide useful information at District project sites
- can be applied as boundary forcing conditions for local refined numerical models
- are more easily accessible than the global solutions.
- provide frequent nearshore time-series information for a smaller subset of points
- the total number of save points: ~19k.



Nearshore Wave Modeling

- State spectral WAVE (STWAVE): simulates nearshore wave transformation, between the offshore and the shoreline (typically depths of less than 40 m)
- Ten STWAVE grids, *tightly* two-way coupled with ADCIRC , to represent the underlying physical processes of the storm events.
- ADCIRC passes water elevations and wind fields to multiple instances of STWAVE. Upon completion, STWAVE passes wave radiation stress gradients to ADCIRC to drive wave-induced water level changes (e.g., wave set- up and setdown).



NACCS Scenarios

The combination of parameter variations resulted in a total of 1050 tropical storms, and 100 extratropical storms.

1) base condition, was modeled on mean sea level with wave effects but without astronomical tides or long-term sea level change.

2) the same base condition as described in the first set but with each storm modeled on a unique randomly selected tide phase.

3) the same as the second set except that it was modeled with a static water level adjustment of 1.0 m to simulate a potential future global sea level rise (GSLR) scenario.

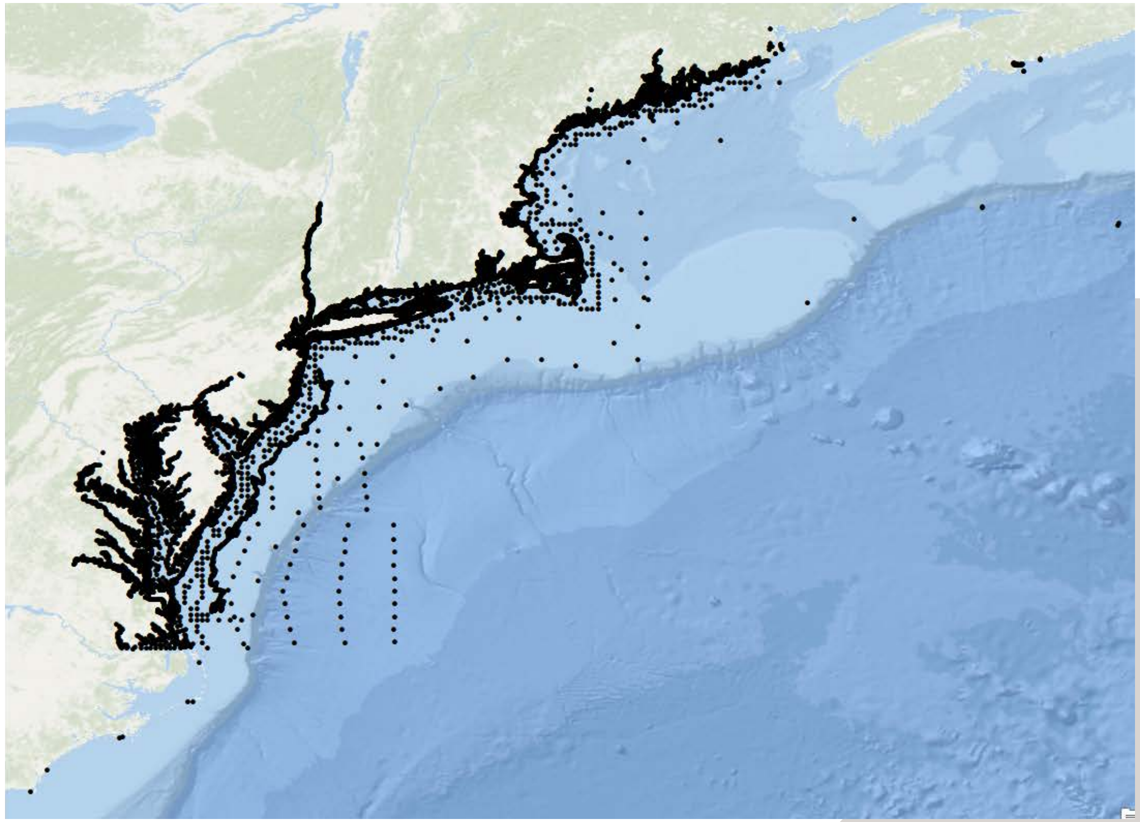
4) linear superposition of 96 randomly selected tide phases to the base condition set.

OUTPUTS

Output of SavePoints

Storm surge, wave heights, and extremal statistics estimated in from the Joint Probability Analysis:

- Mean water level and significant wave height at 1-yr through 10,000-yr return periods
- 95th percentile confidence level water level and significant wave height at 1-yr through 10,000-yr return periods
- 98th percentile confidence level water level and significant wave height at 1-yr through 10,000-yr return periods
- Peak (or maximum) water level and wave height from all storm events



Storm Response Statistical Analysis

- The NACCS JPA model was built based on the historical storm climatology of both TCs and XCs.
- These model save point locations were chosen to ensure optimal coverage of the study region. The joint probabilities of these responses were computed for separate and combined TC and XC statistical families.
- The statistical analysis of the response of the 1150 simulated storms was conducted at nearly 19,000 save point locations to produce response statistics including annual exceedance probability (AEP) and average recurrence interval (ARI).
- In addition, epistemic uncertainty was quantified and represented as confidence levels (CLs).

Annual Recurrence Interval

- **Recurrence interval** (also called return period or reliability level) is on average how often a given event is expected to occur over a given duration.
- **Annual exceedance probability** (**AEP**) is the probability that a given event will be equaled or exceeded in any given year.

Decision makers *often* value events with a low probability of occurrence (high reliabilities) for flood protection.

Region/Country	Return period (year)	Reliability level	AEP (%)
The Netherlands	250 – 10,000	1 in 250 – 1 in 10,000	0.4 – 0.01
USA	100 & 500	1 in 100 & 1 in 500	1 & 0.2
Japan	100 – 200	1 in 100 – 1 in 200	1 – 0.5
The United Kingdom	30 – 200	1 in 30 – 1 in 200	3.3 – 0.5
Vietnam	50	1 in 50	2

Jonkman (2013)
IWR (2011) Flood Risk Management Approaches: As Being Practiced in Japan, Netherlands, United Kingdom, and United States, United States Army Corps of Engineers Institute for Water Resources (IWR) IWR-2011-R-08.

Confidence Levels

Confidence levels (CL) provide information regarding the reliability or certainty/uncertainty of an unknown value.

A 95th percentile confidence level has a 95% probability that the calculated confidence level value encompasses the true value.

Example:

95% CL 100-yr water level = 3.14 m

95% certain that the true 100-yr water level does not exceed 3.14 m

$$\mathrm{CL} = \bar{x} + z\frac{\sigma}{\sqrt{n}}$$

$\bar{x}$ = sample mean

σ = standard deviation of the sample

n = sample size

z = Z value

Confidence Level (%)	Z-Score
95	1.645
98	2.0

NACCS_SavePoint_9137.txt - Notepad

File Edit Format View Help

```
NACCS Save Point ID:                9137
Latitude:                           41.293900
Longitude:                          -71.556900
Depth (NAVD88):                     41.0007 meters
Conversion factor (NAVD88 to MSL): -0.1040
```

ARI* (yrs)	Water Level (m) Mean	Water Level (m) Upper 95% CI	Wave Height (m) Mean	Wave Height (m) Upper 95% CI
1	1.08	1.79	4.19	5.41
2	1.25	1.99	5.18	6.40
5	1.49	2.20	6.30	7.46
10	1.66	2.38	7.05	8.19
20	1.82	2.59	7.71	8.84
50	2.05	2.88	8.58	9.70
100	2.25	3.14	9.14	10.26
200	2.49	3.43	9.65	10.78
500	2.86	3.79	10.22	11.35
1,000	3.12	4.05	10.57	11.70
2,000	3.36	4.30	10.89	12.04
5,000	3.64	4.58	11.36	12.56
10,000	3.84	4.77	11.88	13.13

*ARI = Annual Recurrence Interval

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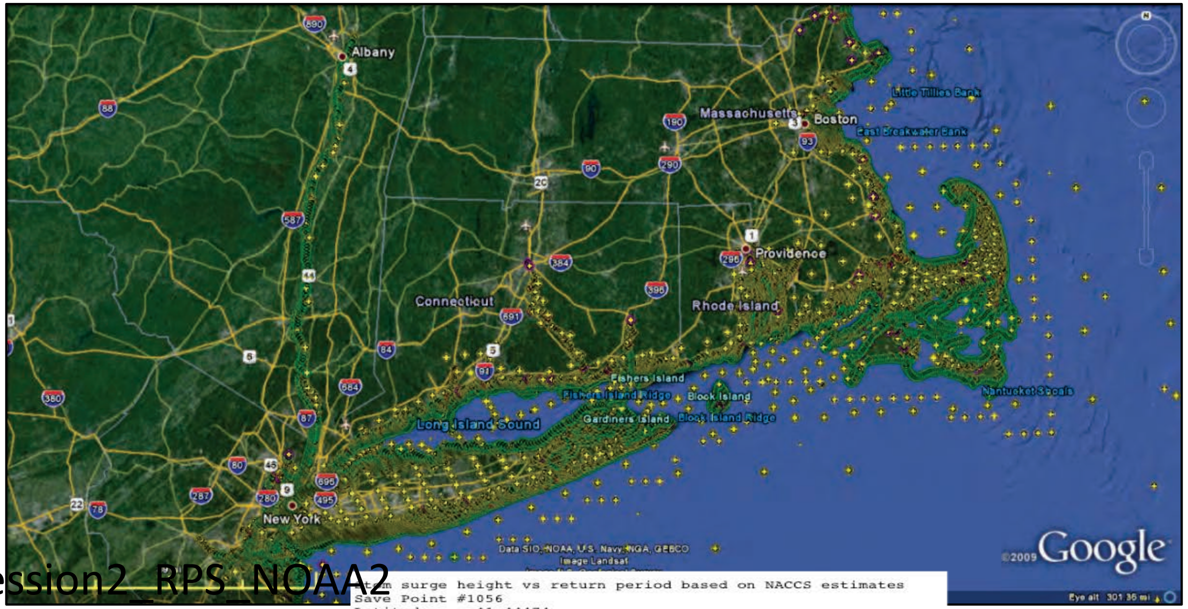
NACCS Outputs



- Compute probabilities of coastal storm parameters

<u>Output</u>

- Data at Save Points (not full grid)
- 1-10,000 year return periods:

<u>ADCIRC model save points</u>

- Storm recurrence rates
- Peak water levels from
  - 1050 Tropical Cyclone simulations (synthetic)
  - 100 Extra Tropical simulations (historical)
- Water level return periods with associated confidence intervals

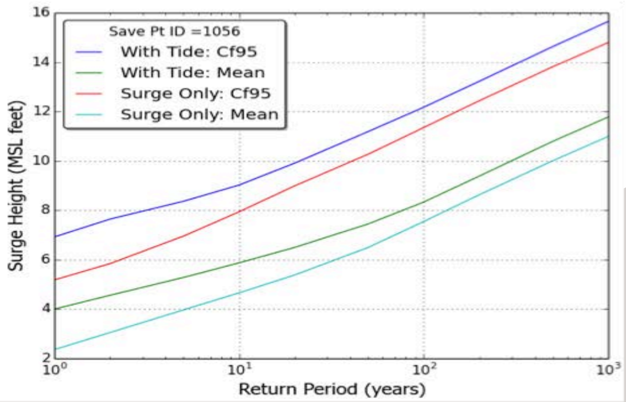
<u>STWAVE model save points</u>

- Peak wave heights from STWAVE

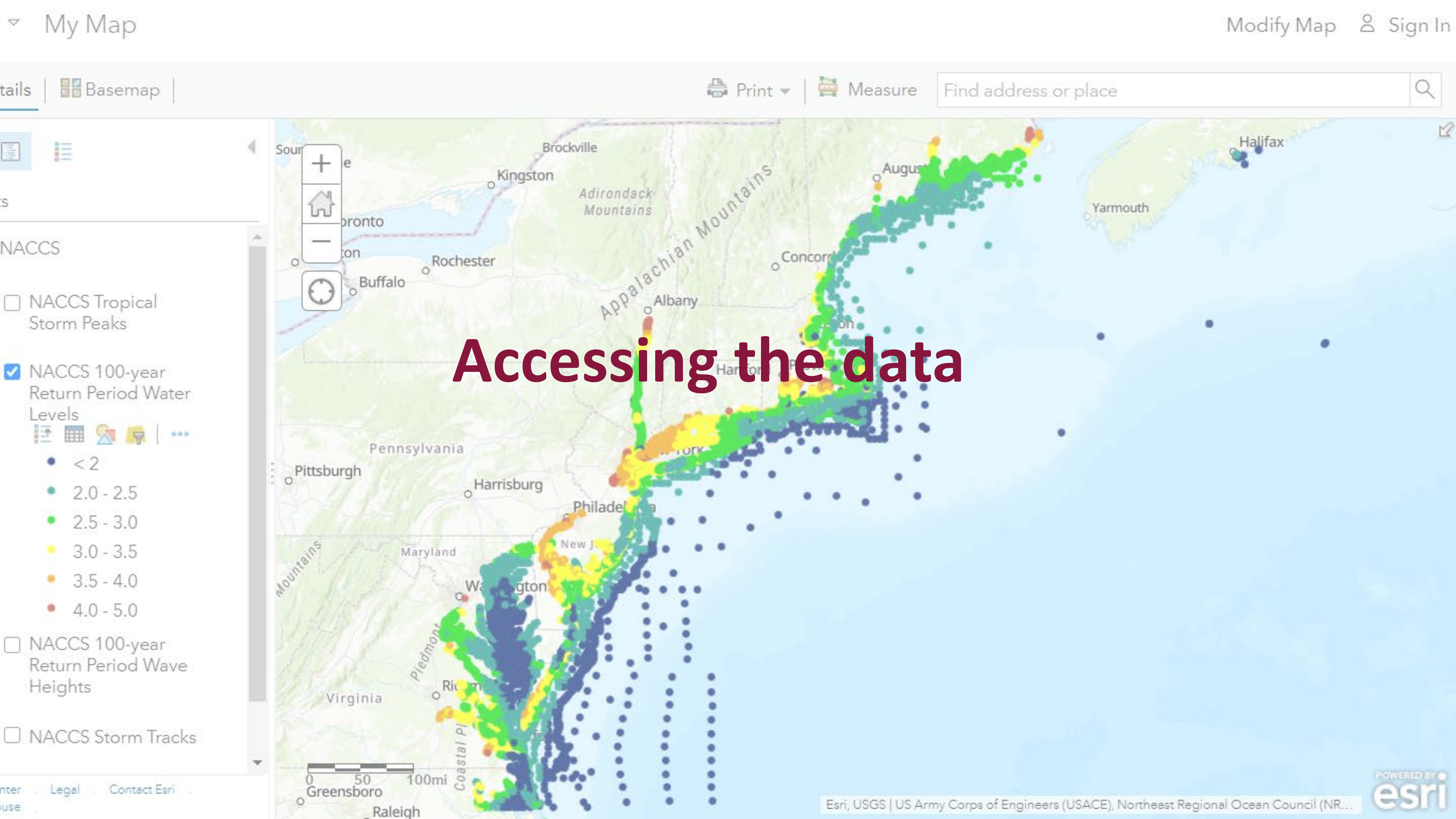
NACCS_session2_RPS_NOAA2

[illegible] surge height vs return period based on NACCS estimates
Save Point #1056
Latitude 41.44474
Longitude -71.34537

Return Period (yrs)	Surge Only: Mean (m)	Surge Only: Mean (ft)	Surge Only: Upper 95% Confidence (m)	Surge Only: Upper 95% Confidence (ft)	With Tide: Mean (m)	With Tide: Mean (ft)	With Tide: Upper 95% Confidence (m)	With Tide: Upper 95% Confidence (ft)
1	0.72	2.4	1.58	5.2	1.22	4.0	2.11	6.9
2	0.93	3.1	1.78	5.8	1.39	4.6	2.33	7.6
5	1.21	4.0	2.12	7.0	1.61	5.3	2.55	8.4
10	1.42	4.7	2.42	7.9	1.79	5.9	2.75	9.0
20	1.64	5.4	2.74	9.0	1.98	6.5	3.02	9.9
50	1.98	6.5	3.13	10.3	2.27	7.4	3.41	11.2
100	2.30	7.5	3.46	11.4	2.54	8.3	3.71	12.2
200	2.63	8.6	3.79	12.4	2.86	9.4	4.03	13.2
500	3.05	10.0	4.21	13.8	3.29	10.8	4.46	14.6
1000	3.35	11.0	4.51	14.8	3.59	11.8	4.77	15.6
2000	3.63	11.9	4.79	15.7	3.89	12.8	5.06	16.6
5000	3.96	13.0	5.12	16.8	4.24	13.9	5.42	17.8
10000	4.19	13.7	5.35	17.6	4.49	14.7	5.66	18.6



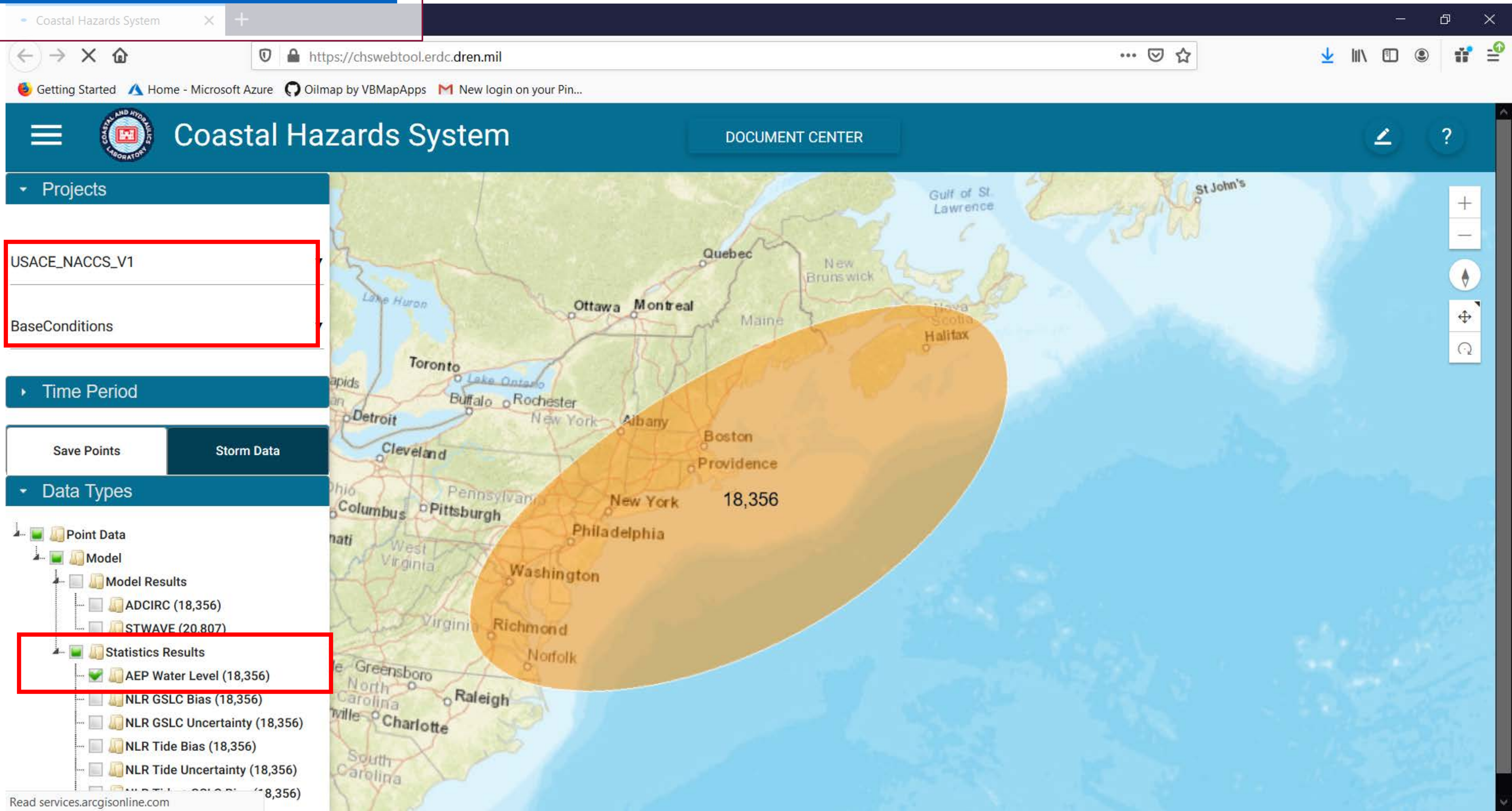
Accessing the data



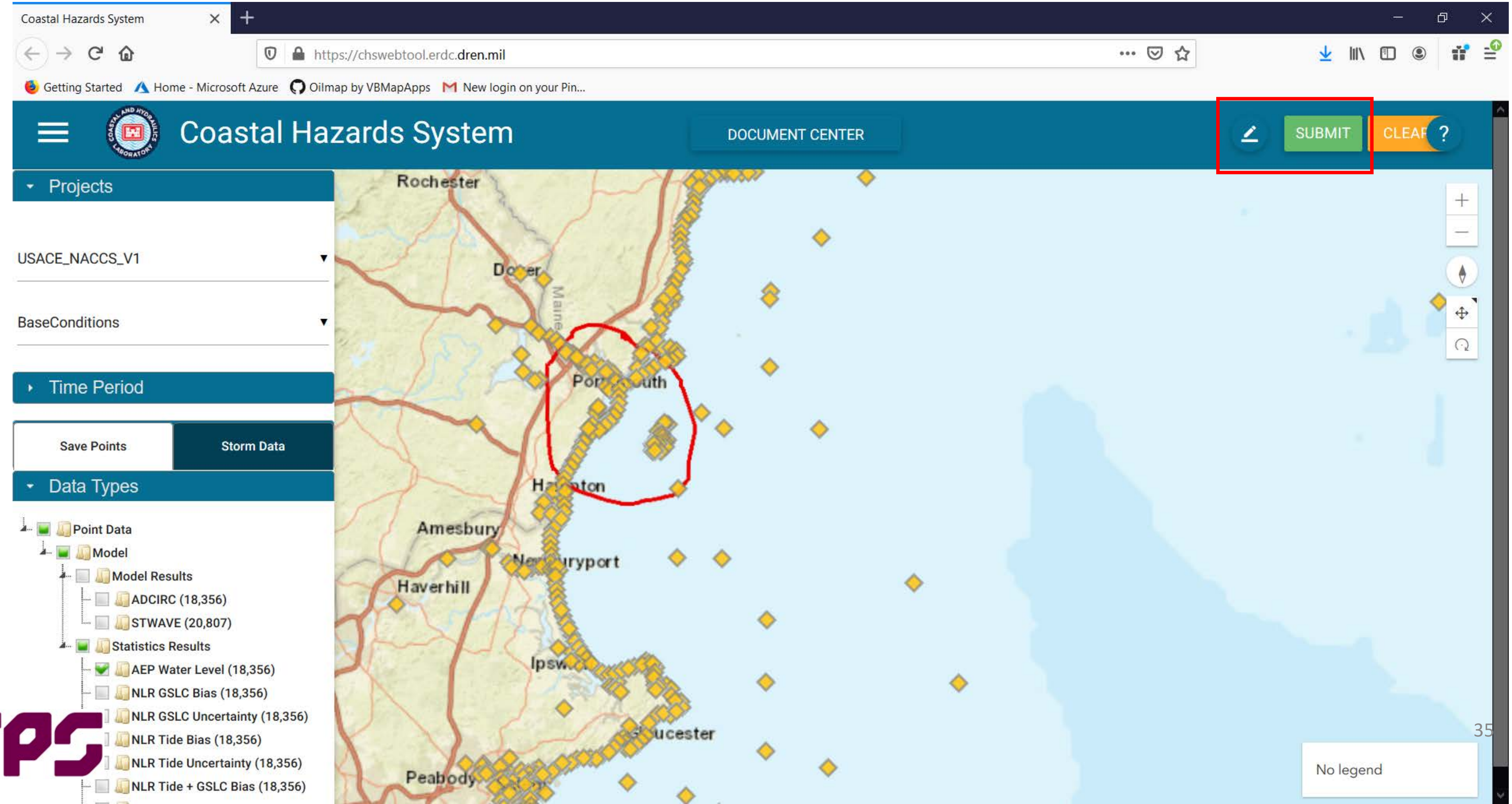
USACE COASTAL HAZARDS SYSTEM PORTAL

Full dataset:

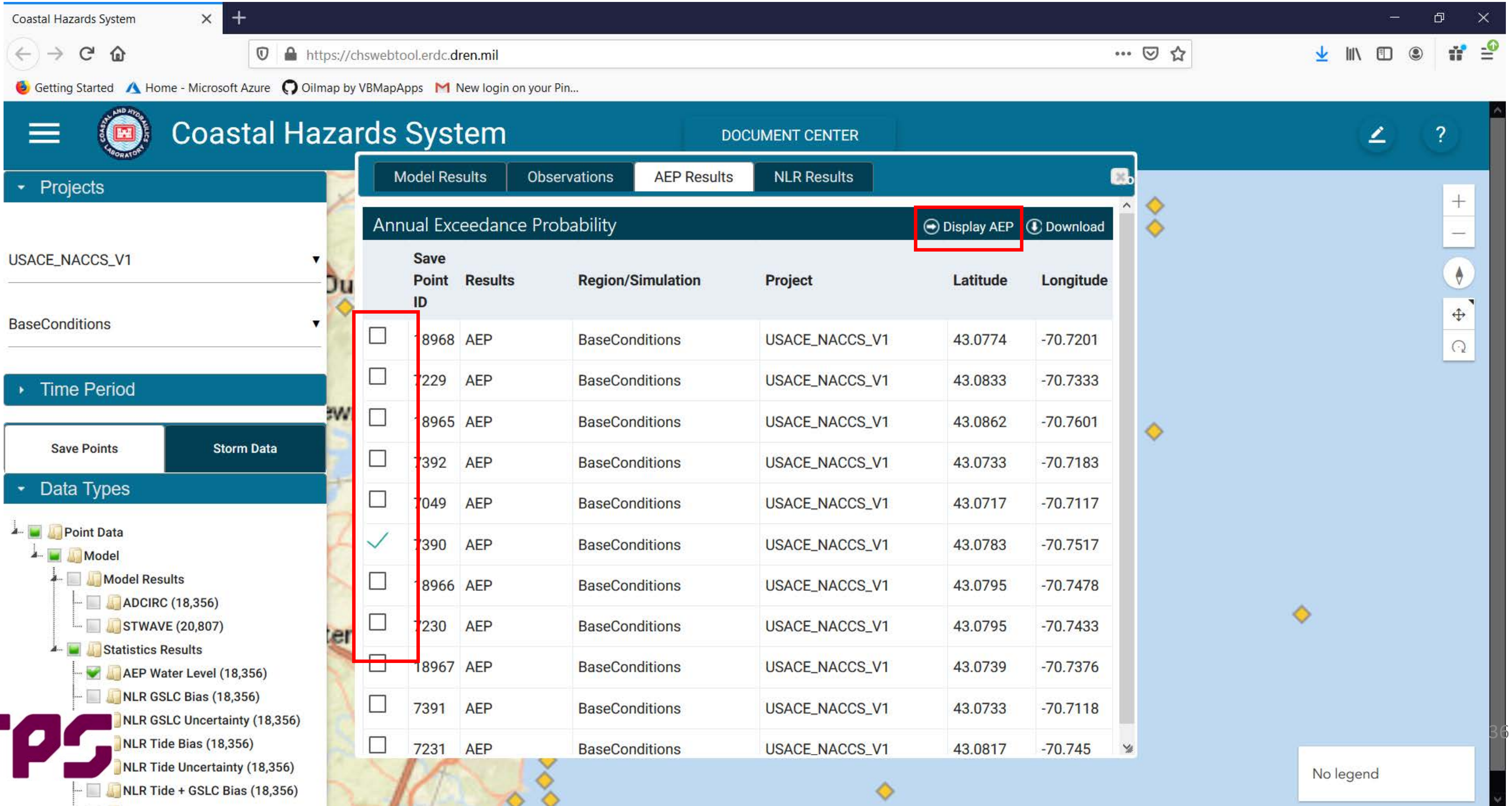
https://chswebtool.erdc.dren.mil/



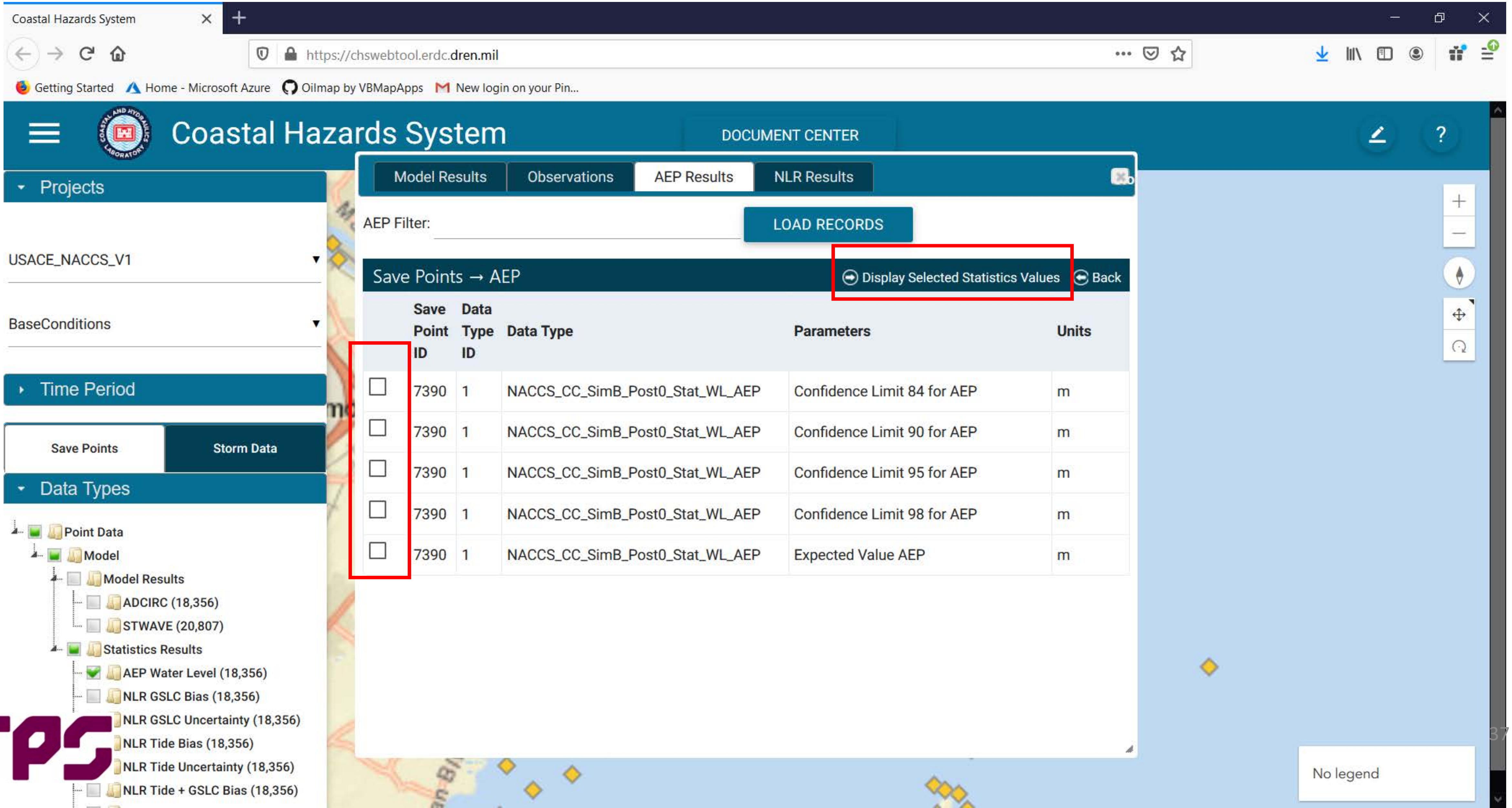
USACE COASTAL HAZARDS SYSTEM PORTAL



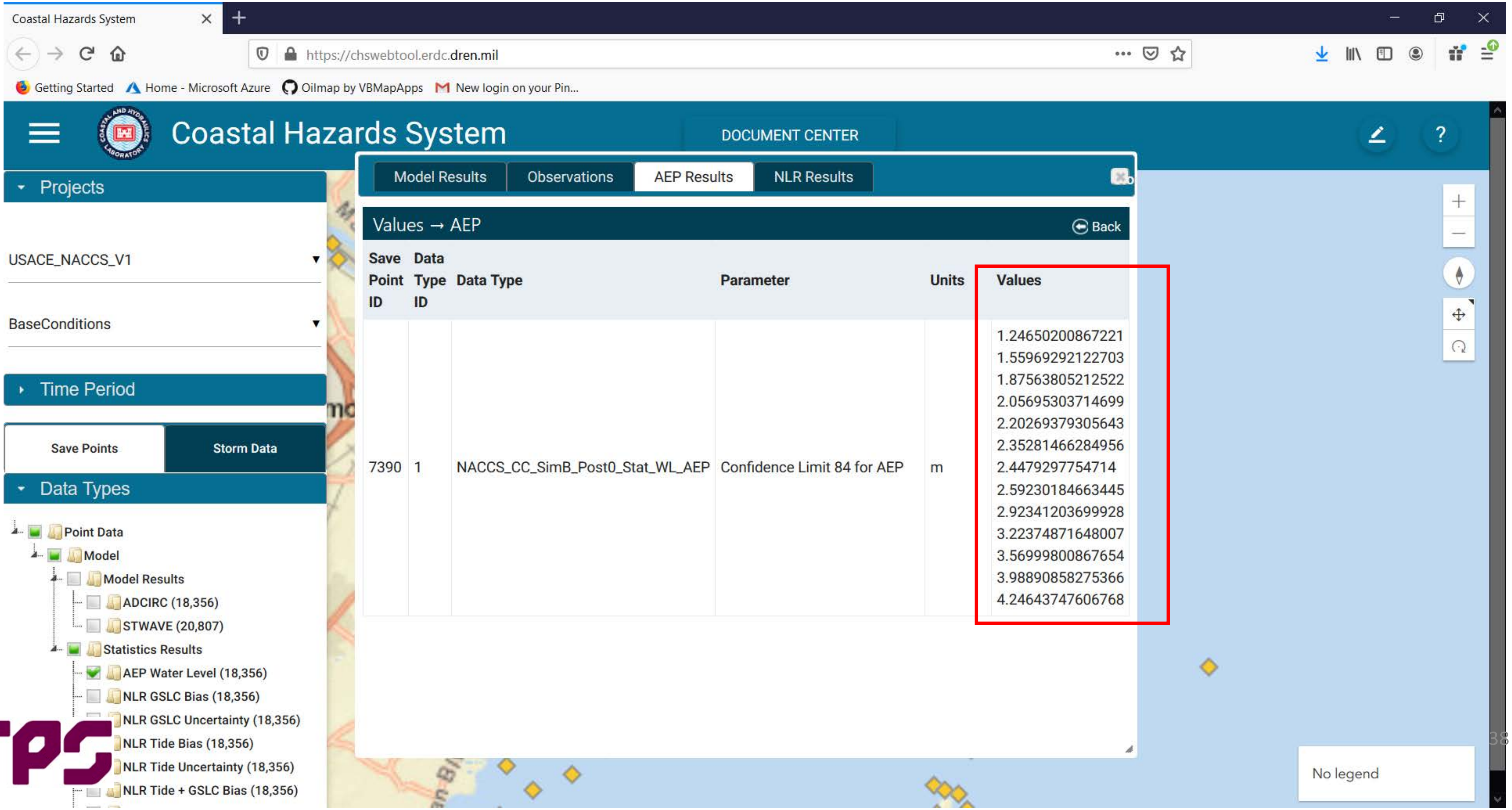
USACE COASTAL HAZARDS SYSTEM PORTAL



USACE COASTAL HAZARDS SYSTEM PORTAL



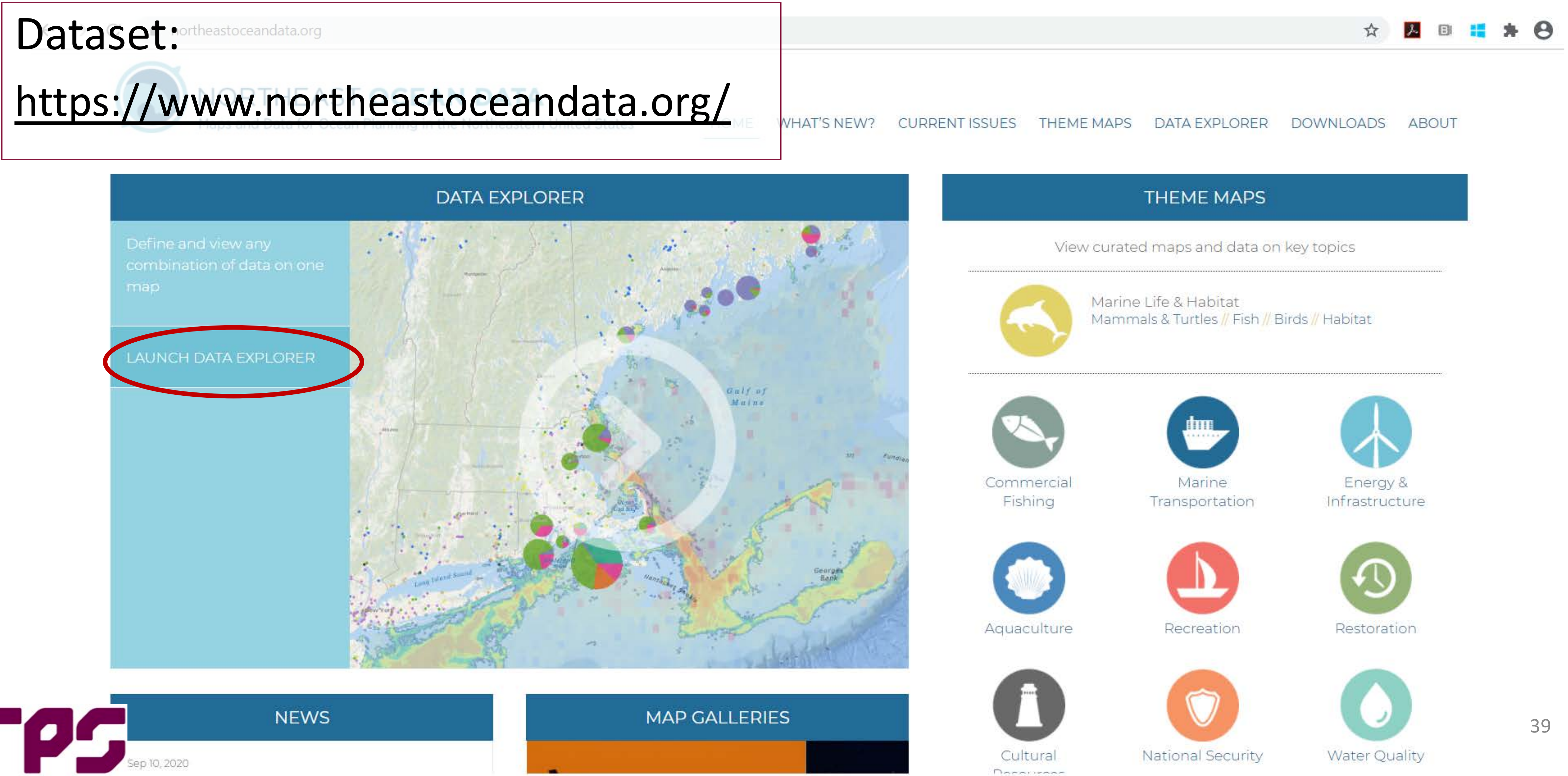
USACE COASTAL HAZARDS SYSTEM PORTAL



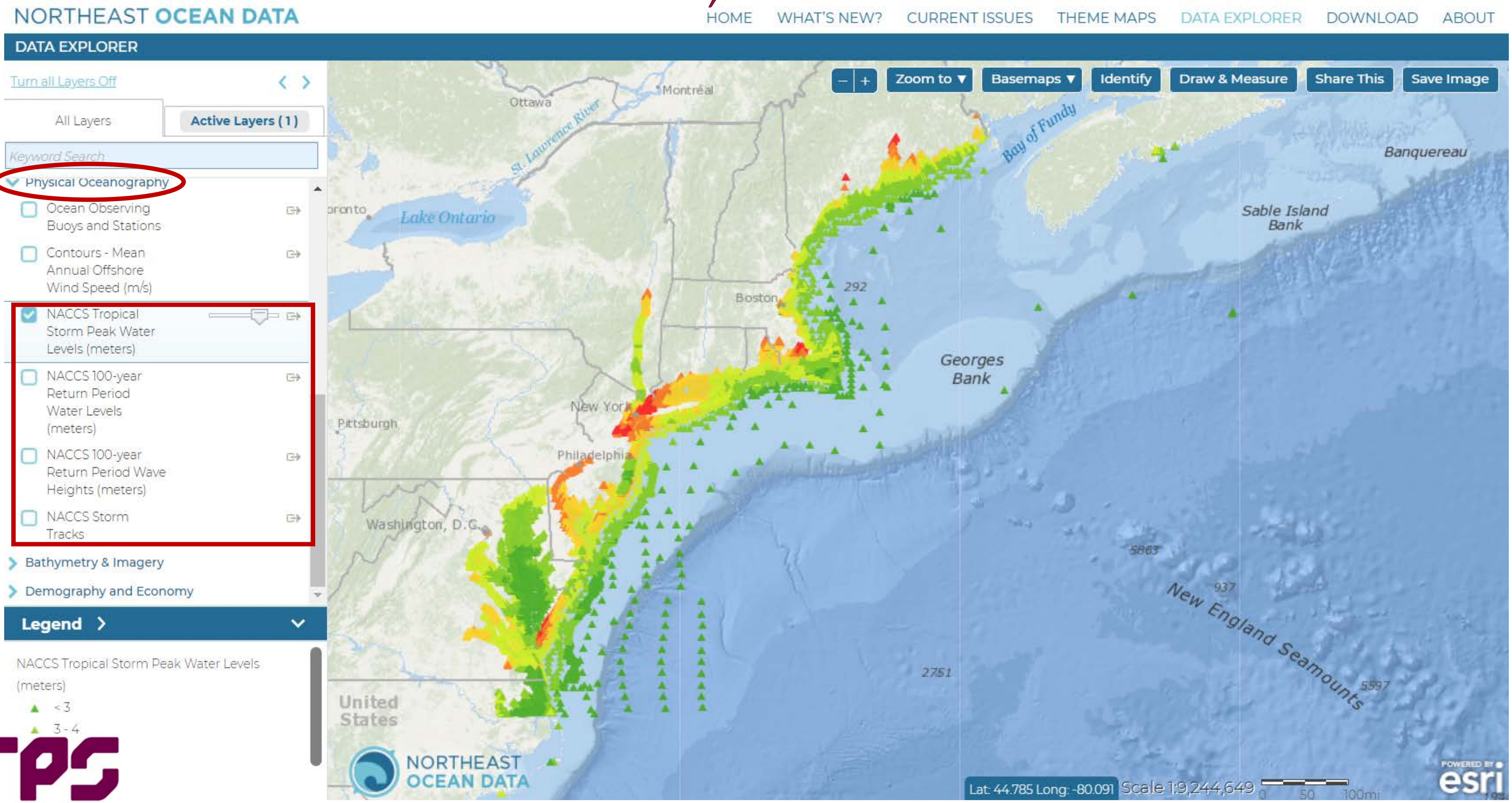
NORTHEAST OCEAN DATA, DATA EXPLORER

Dataset:

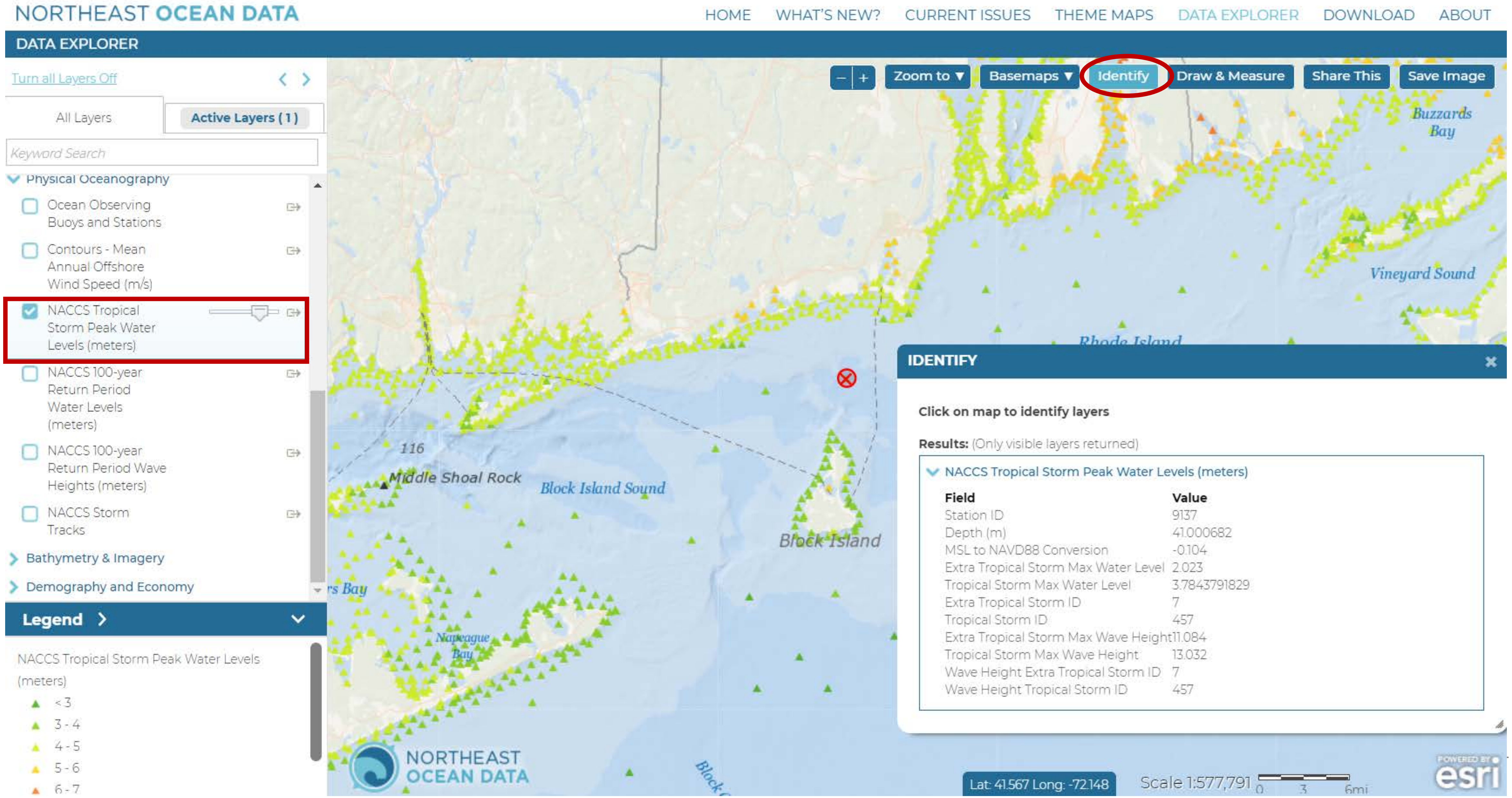
https://www.northeastoceandata.org/



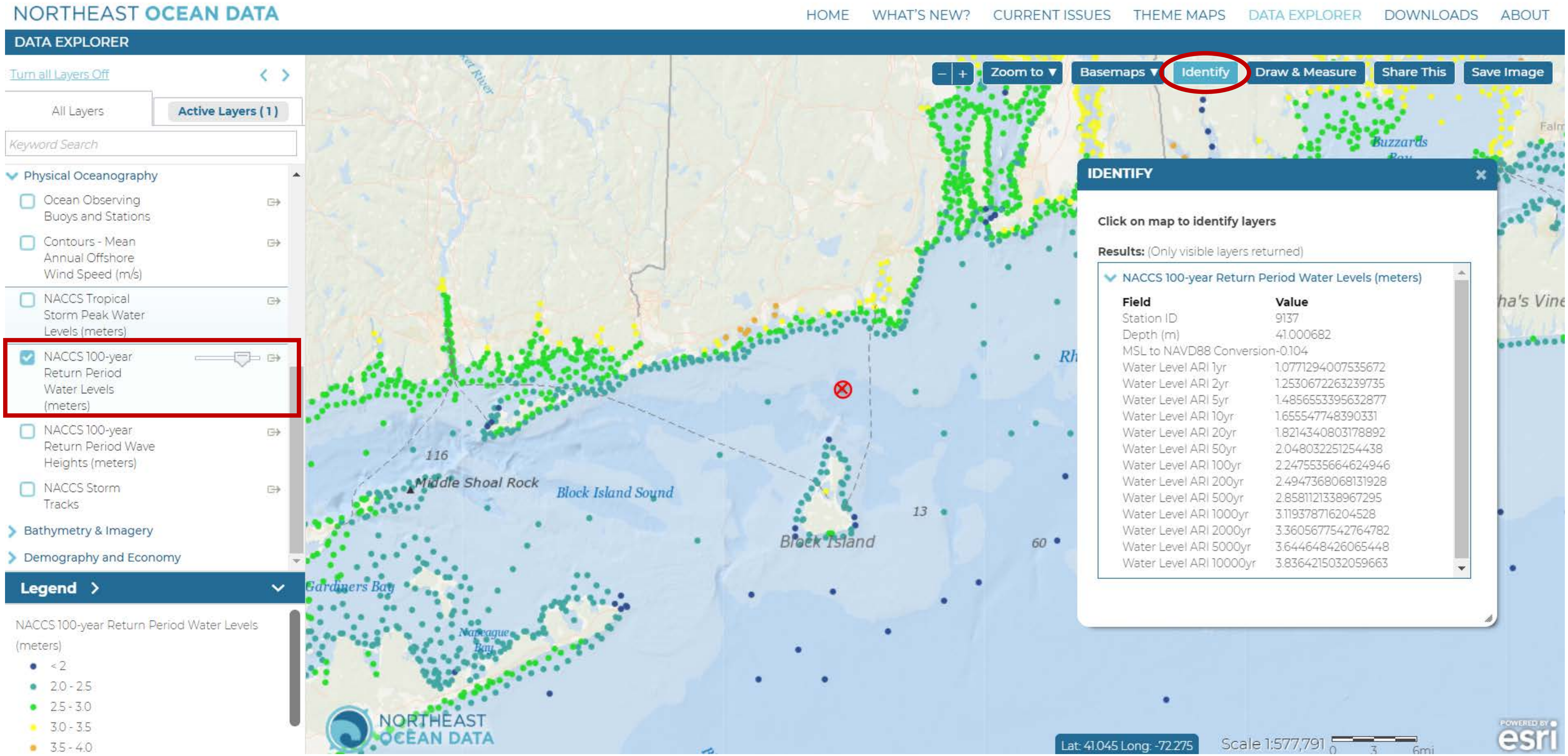
NORTHEAST OCEAN DATA, DATA EXPLORER



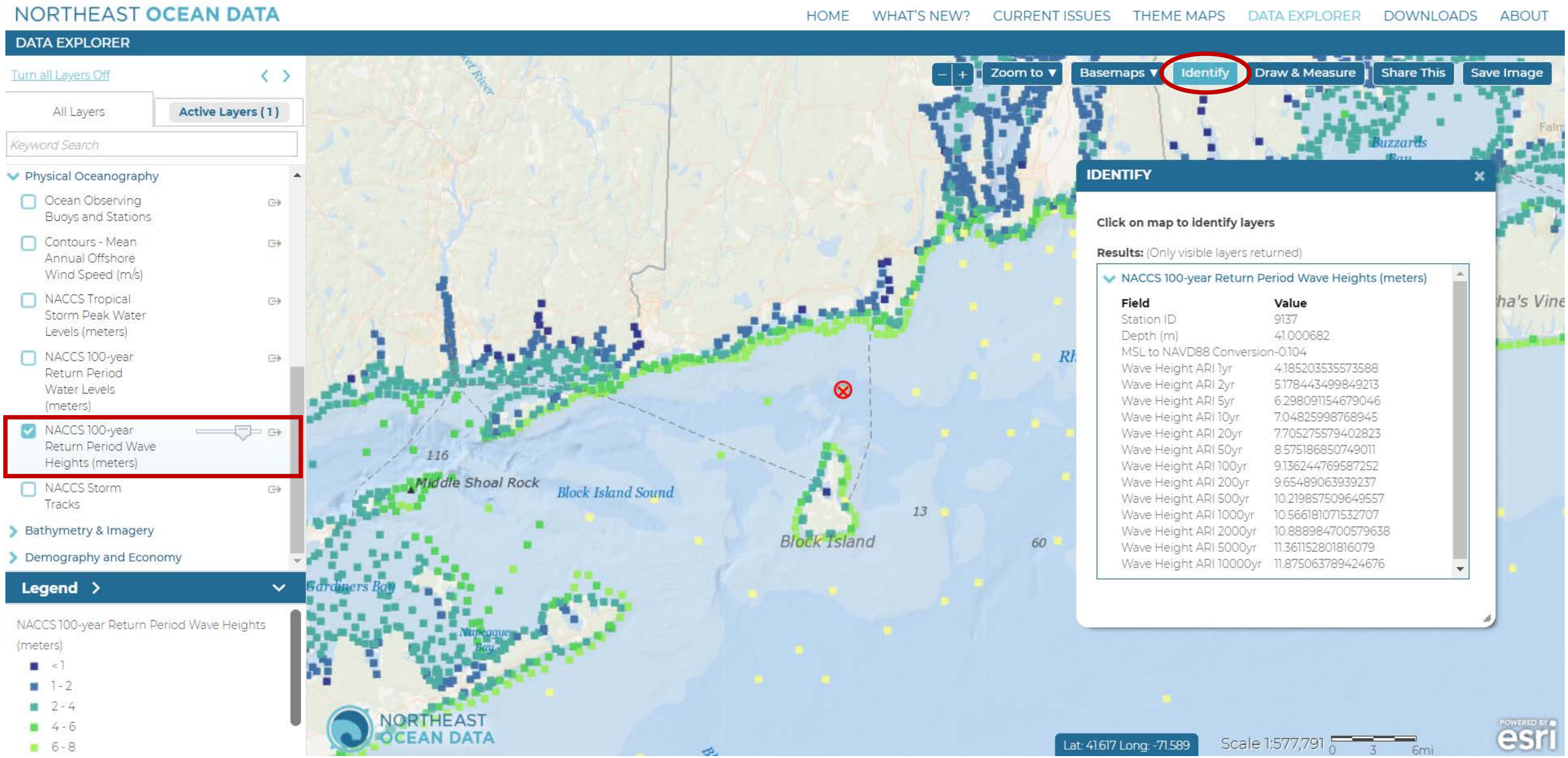
NORTHEAST OCEAN DATA, DATA EXPLORER



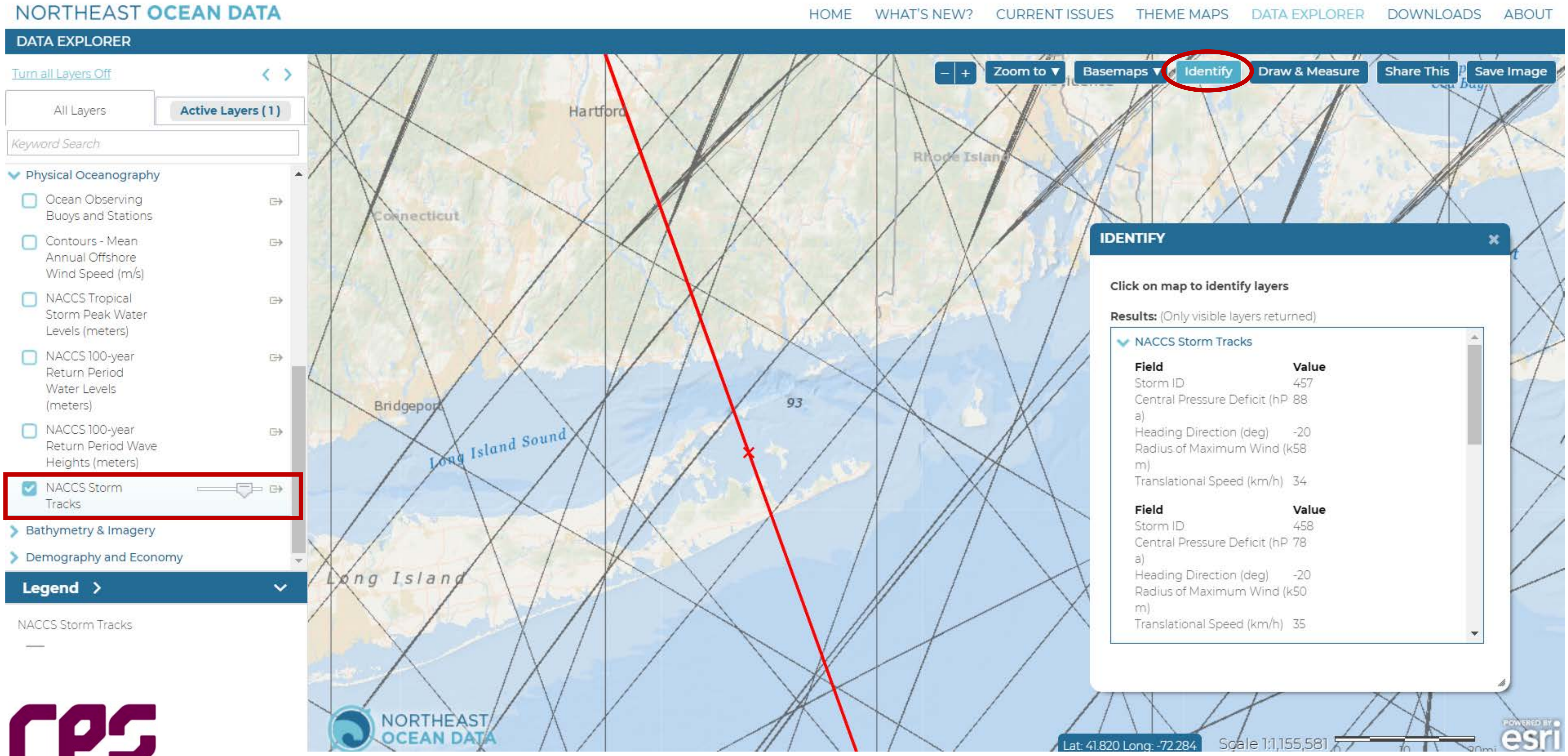
NORTHEAST OCEAN DATA, DATA EXPLORER



NORTHEAST OCEAN DATA, DATA EXPLORER



NORTHEAST OCEAN DATA, DATA EXPLORER



NACCSapi

Dataset:

http://52.73.191.103:3000/

Output format: JSON/GEOJSON

Supply a bounding box of lat., lon. (xmin,ymin,xmax,ymax):

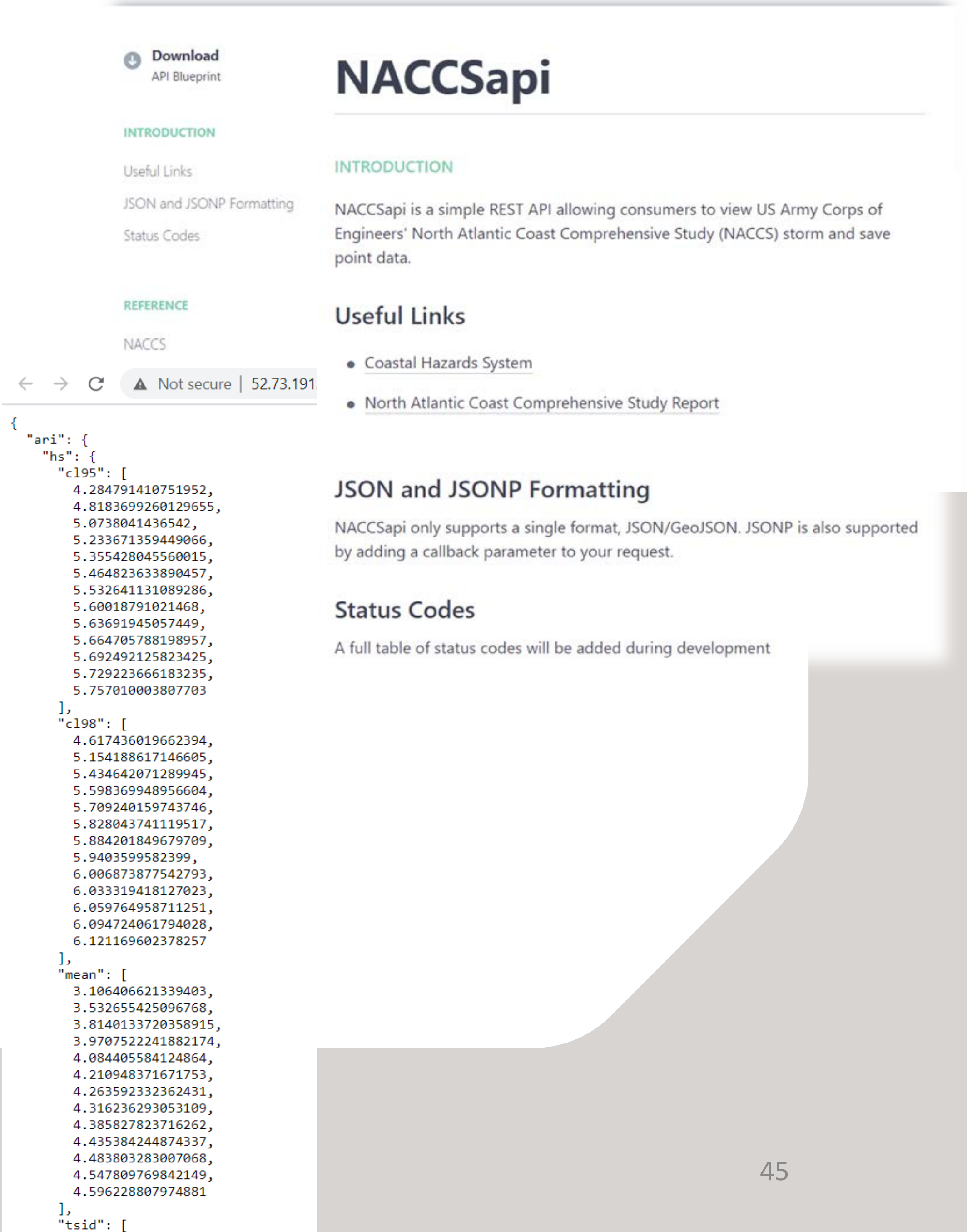
- EX: http://52.73.191.103:3000/points?bbox=-67%2C44%2C-66%2C45

Supply a savepoint ID to find:

- EX: http://52.73.191.103:3000/points/160

Supply a storm ID to find lat., Lon. of storm track:

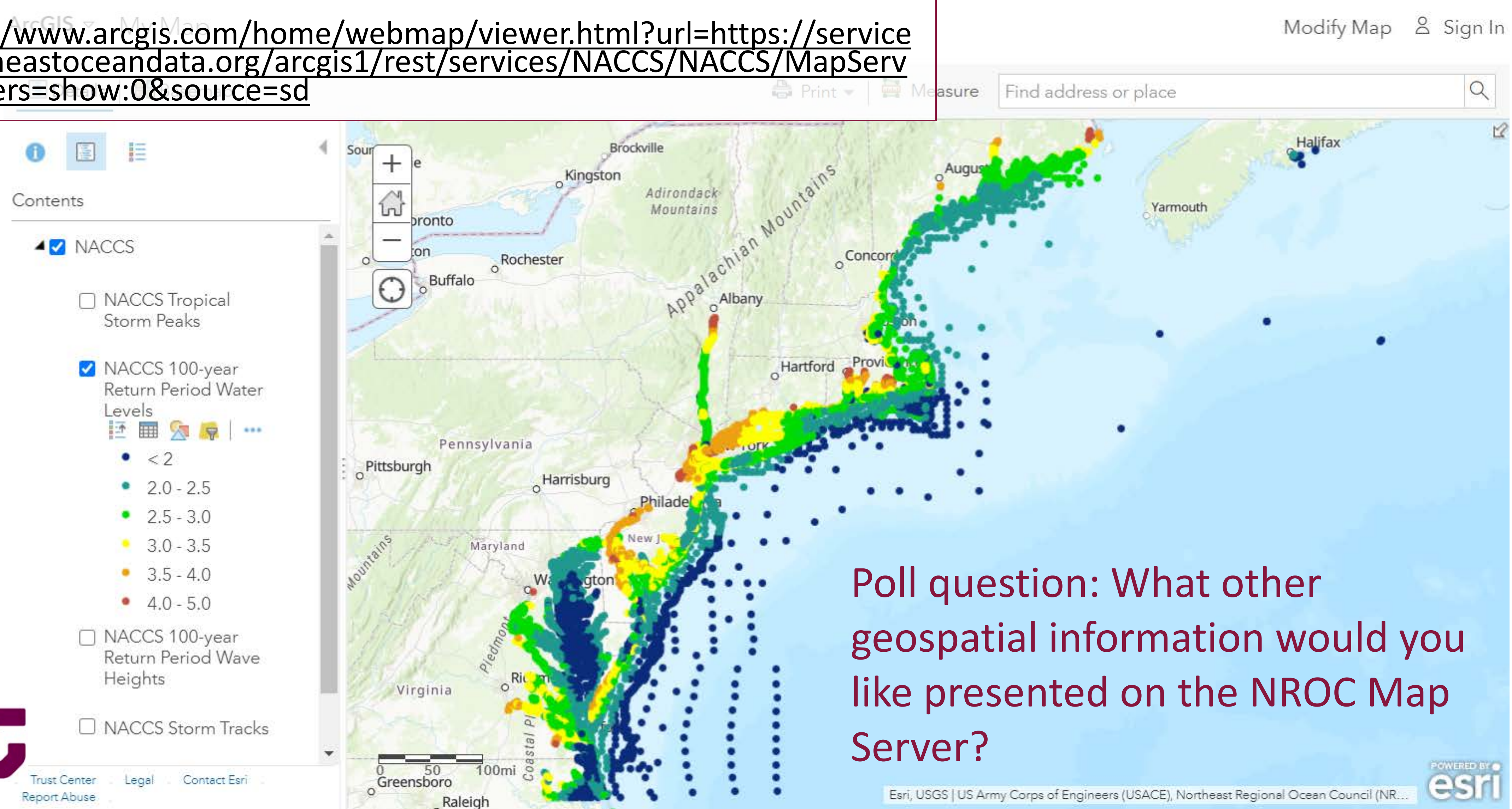
- EX: http://52.73.191.103:3000/storms/800



NROC ARCGIS MAP SERVER

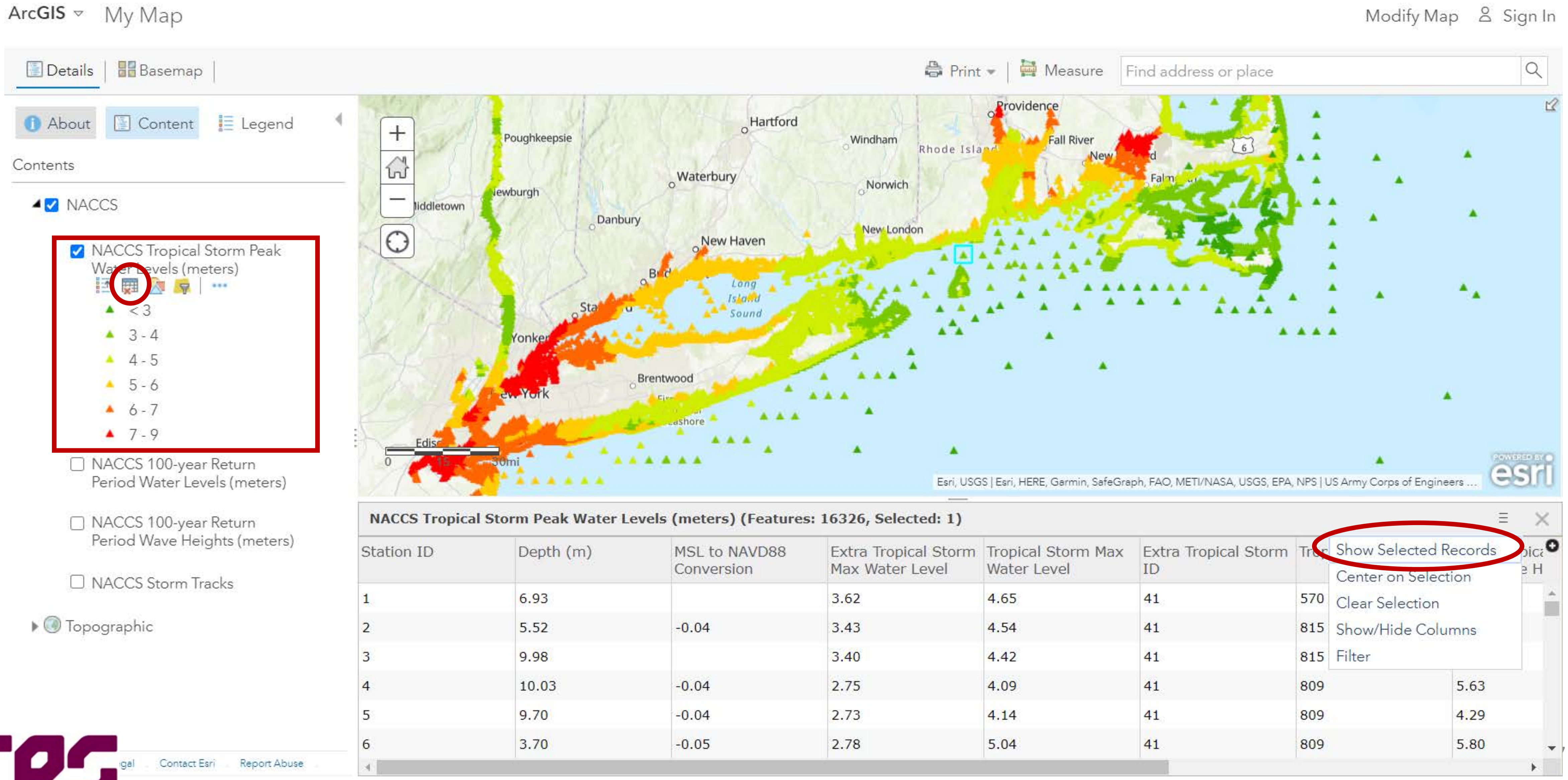
Dataset:

https://www.arcgis.com/home/webmap/viewer.html?url=https://services.northeastoceandata.org/arcgis1/rest/services/NACCS/NACCS/MapServer?layers=show:0&source=sd

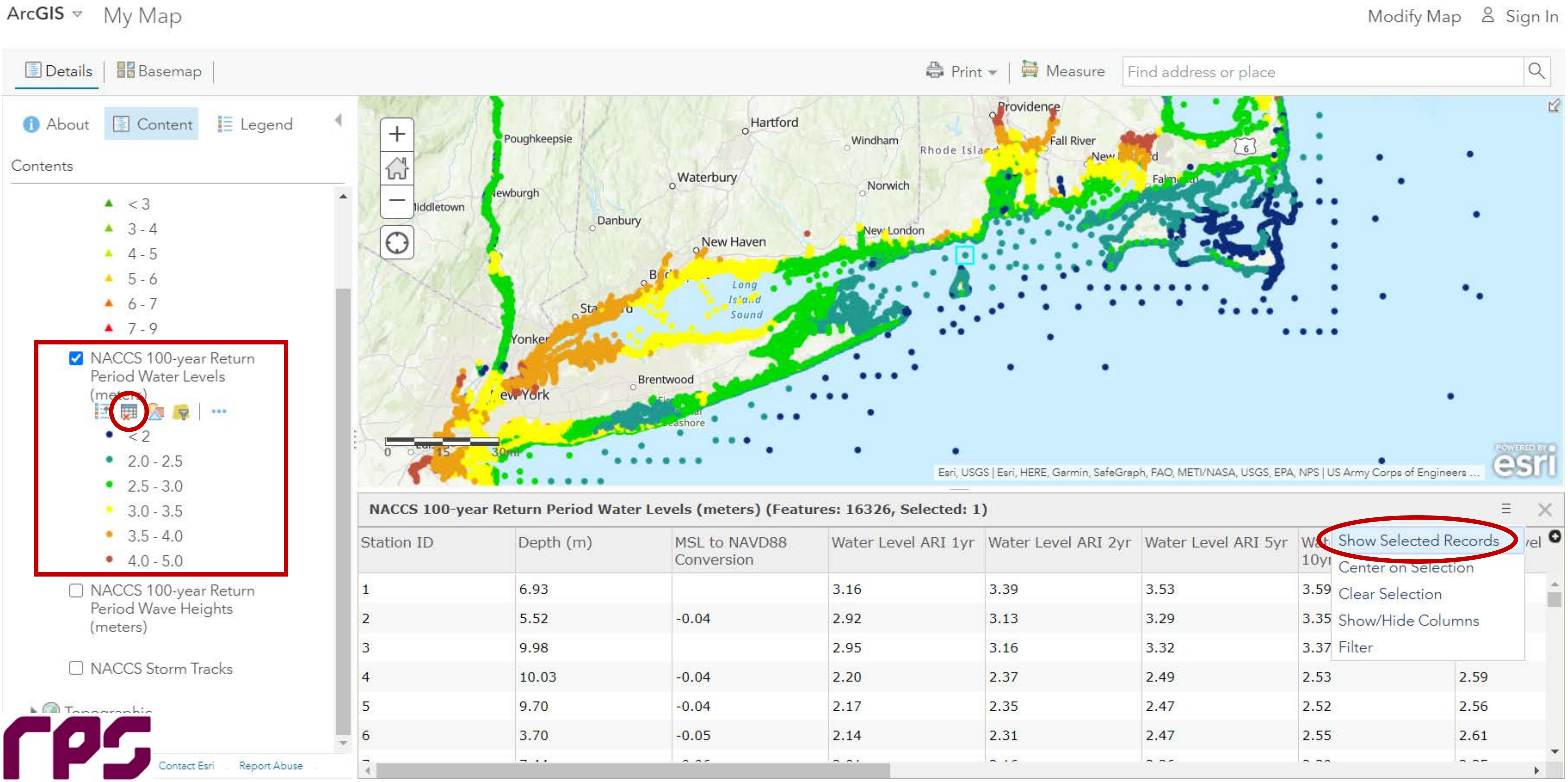


Poll question: What other geospatial information would you like presented on the NROC Map Server?

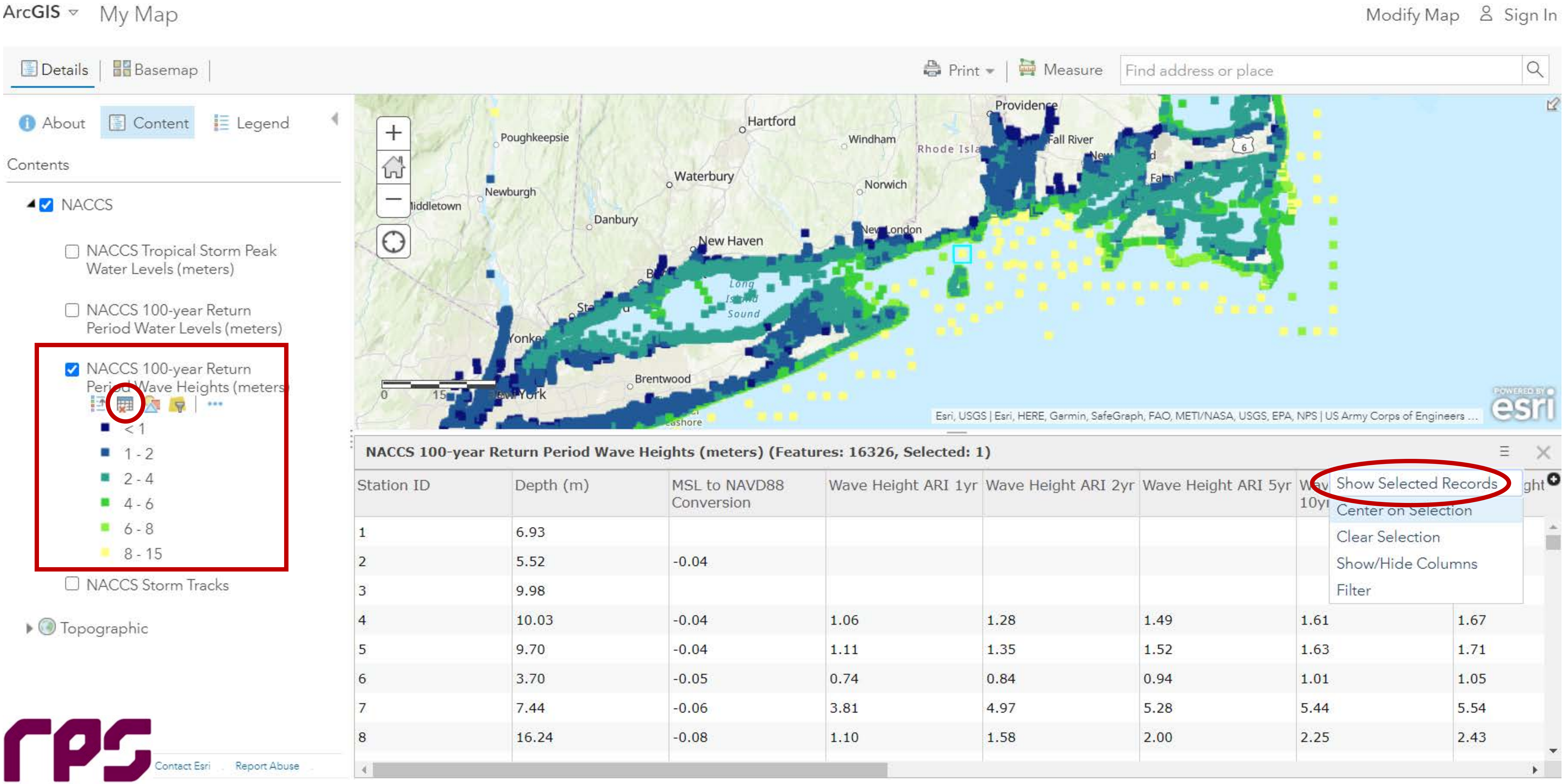
NROC ARCGIS MAP SERVER



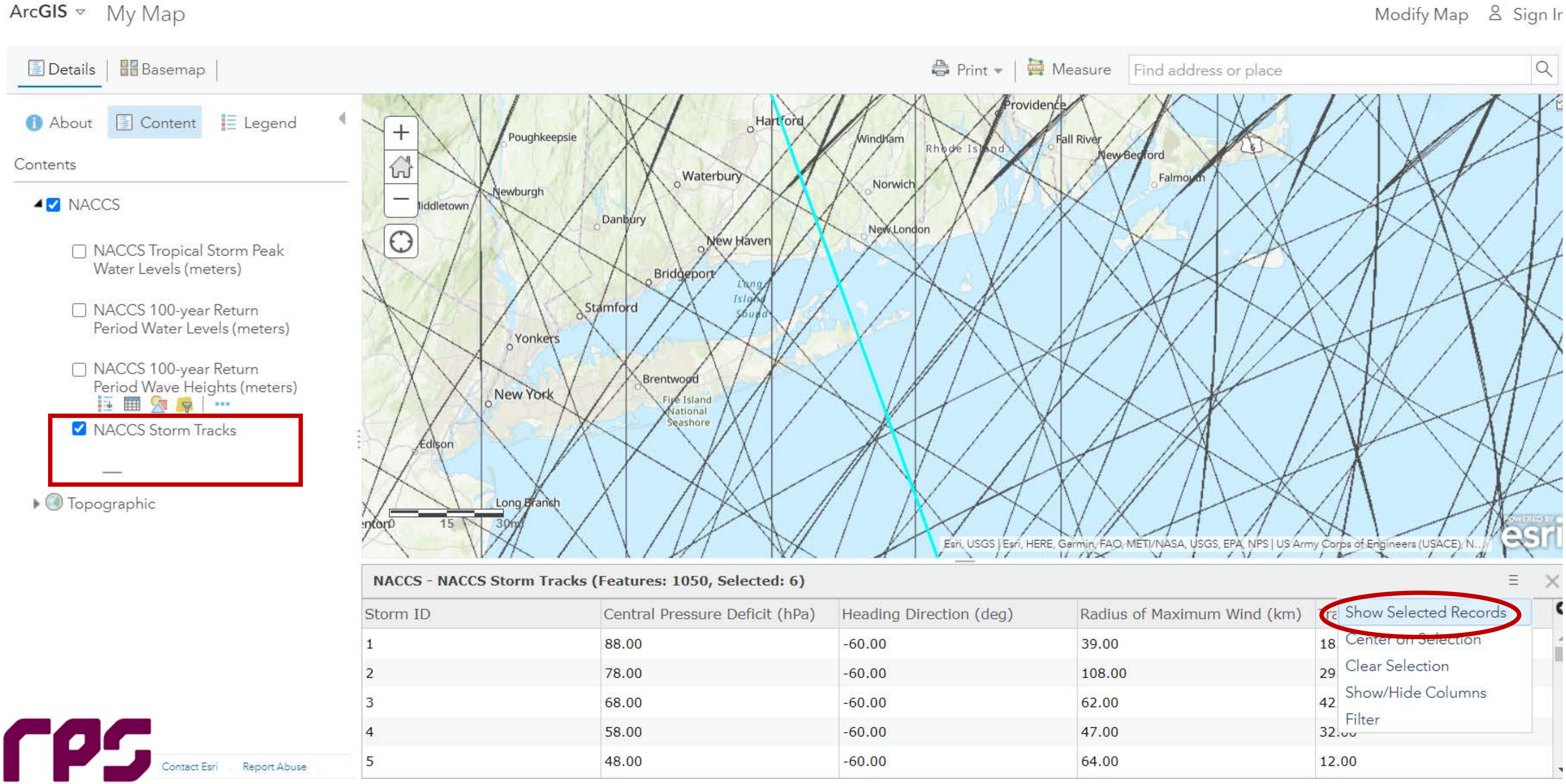
NROC ARCGIS MAP SERVER



NROC ARCGIS MAP SERVER



NROC ARCGIS MAP SERVER



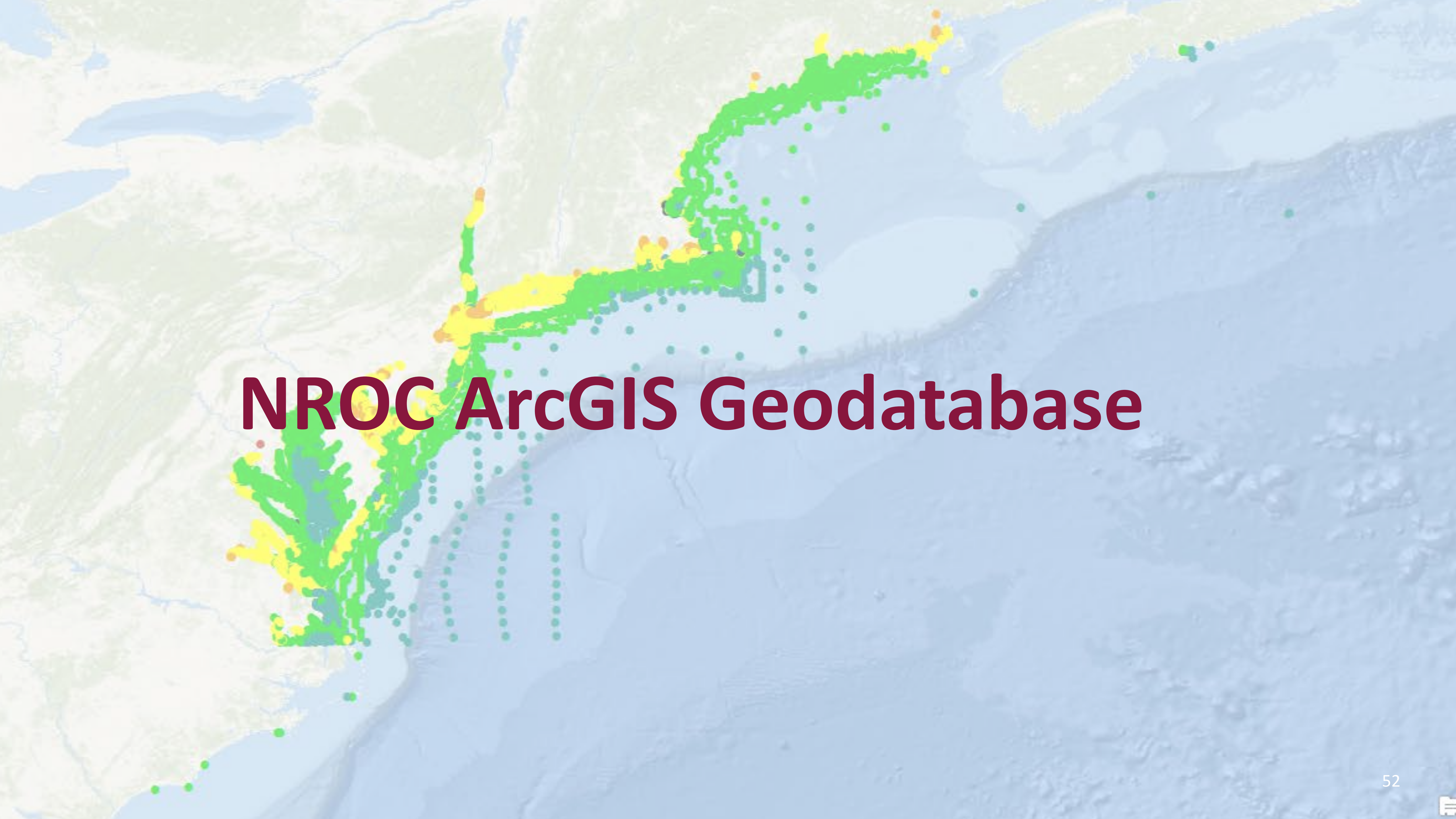
Additional ways to access the GIS data

1. Download the geodatabase and open in ArcGIS Desktop or ArcGIS Pro
2. Access the 4 map services (just a subset of the data – not the full geodatabase):
   a) Connecting to the Northeast Ocean Data Portal GIS Server:
      - Connect through ArcGIS Desktop or Pro as a "user" (no credentials are required), need the URL (https://services.northeastoceandata.org/arcgis1)

   b) Using ArcGIS Online can add map services to an ArcGIS Online Map

Poll question: Which software do you use to present coastal flooding geospatial datasets?

NROC ArcGIS Geodatabase



Downloading the Geodatabase

Website:

https://www.northeastoceancouncil.org/naccs/

Dataset:

http://www.northeastoceandata.org/files/metadata/NACCS/NACCS.zip

- Annual recurrence interval statistics for storm surge and wave height

The database system is designed to connect easily to a range of web portals and online viewers hosted by NROC states:

- The final database and API (http://docs.naccs.apiary.io/#) are hosted by the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS).
- Web services hosted by Northeast Ocean Data allow ArcGIS users to access the NACCS data.

For More Information:

- USACE North Atlantic Coast Comprehensive Study Website
- USACE NACCS Main Report
- USACE Report – NACCS Coastal Storm Model Simulations: Waves and Water Levels
- Presentation by RPS ASA at NROC Meeting (February 2017)
- Geodatabase object relationship diagram

Download:

- Metadata
- ArcGIS file geodatabase

ArcGIS Services:

http://50.19.218.171/arcgis1/rest/services/NACCS/NACCS/MapServer

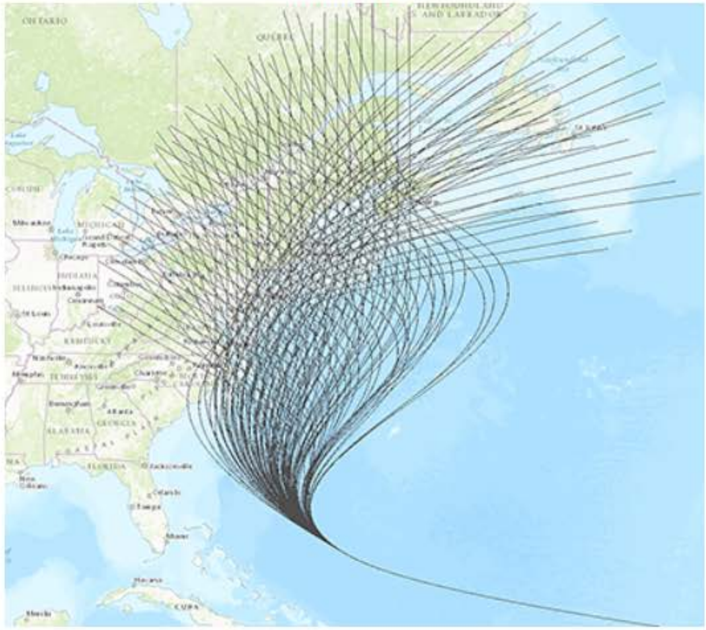
NACCS API:

http://docs.naccs.apiary.io/#

Links to the NACCS Maps:

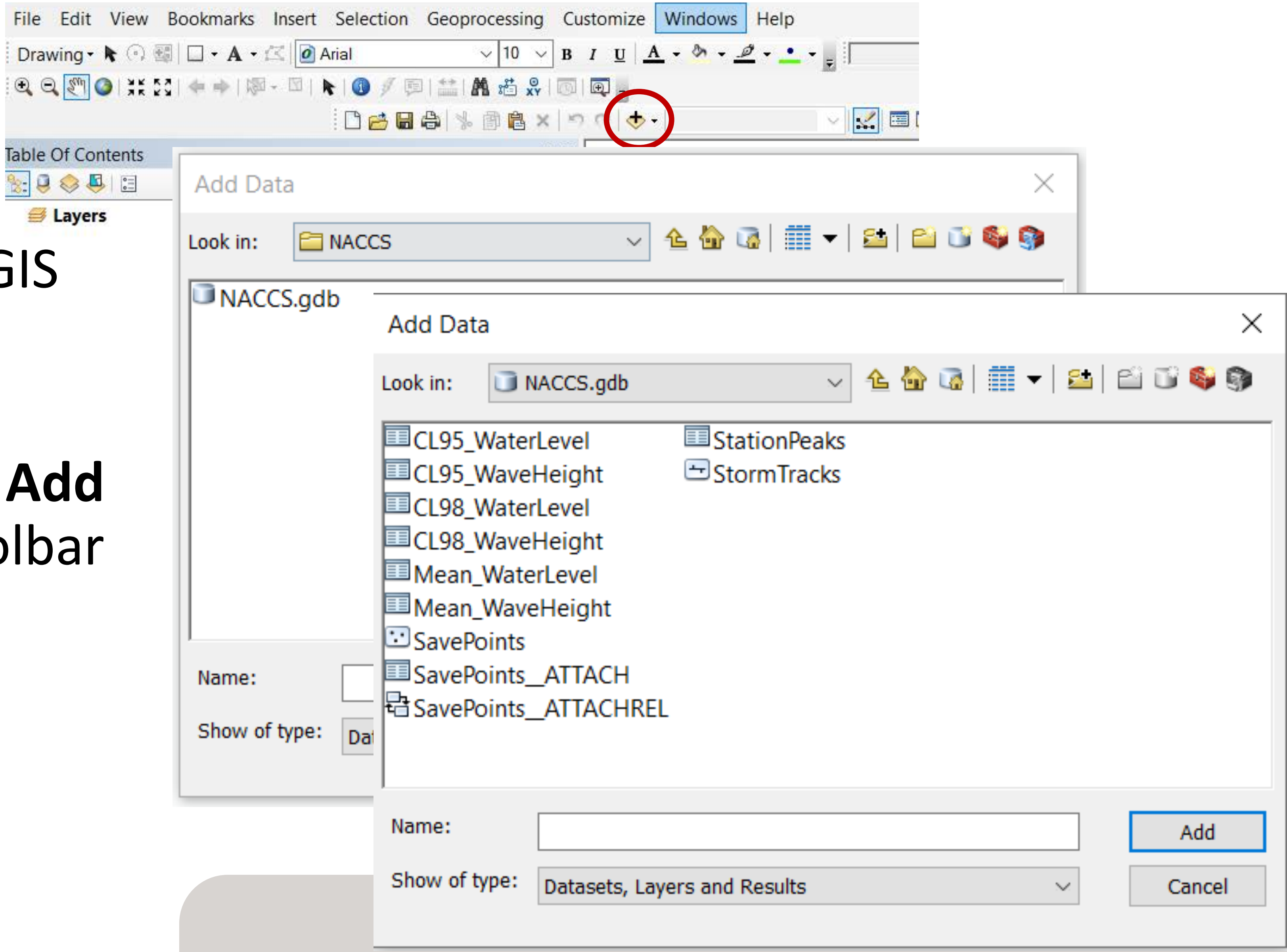
Maximum Predicted Water Levels

Storm Tracks

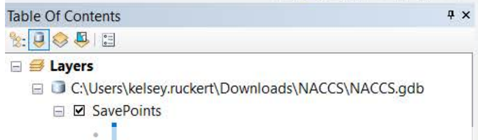


Opening the data in ArcMAP

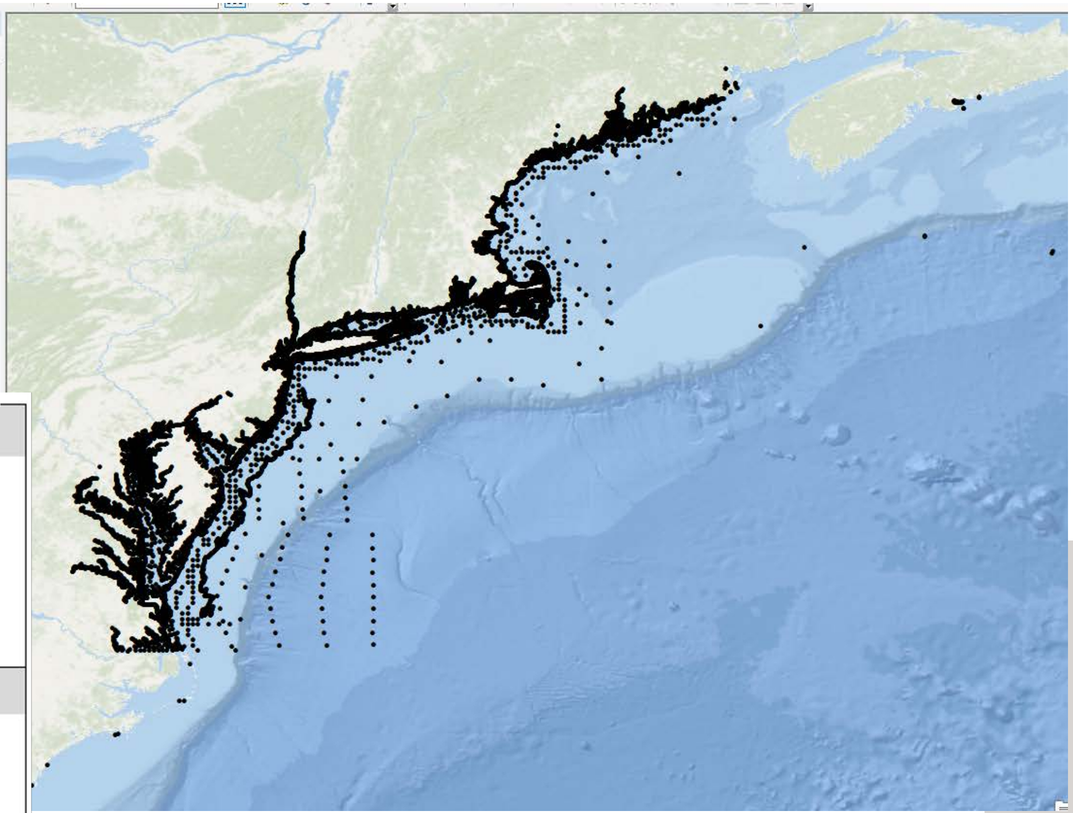
1. Open ArcMap under ArcGIS and choose **New Maps > Blank Map**.
2. Load the layers using the **Add Data** button from the Toolbar



SavePoints Layer



Points of storm surge, wave heights, and extremal statistics derived from historical and simulated storm events.



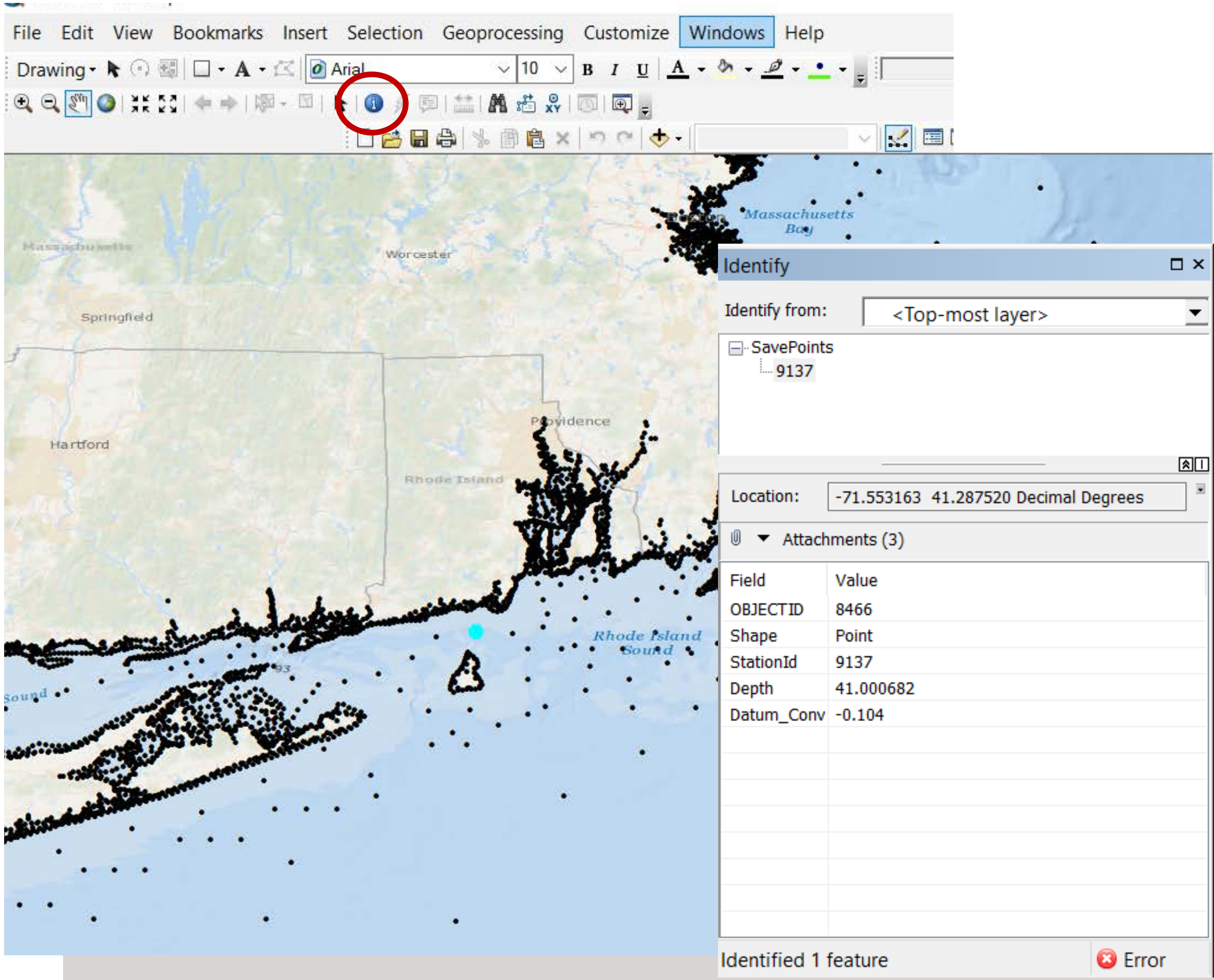
Feature Class Name: **SavePoints**	
Feature Type:	Point
Description:	NACCS save point locations
Total Number of Unique Features:	16,326
Data Status:	Complete

Line	Name	Definition	Type	Size
1	OBJECTID	Uniquely identifies a feature	OBJECTID	*
2	Shape	Geometric representation of the feature	geometry	*
3	StationId	NACCS identifier	long	6
4	Depth	Depth of seafloor at save point location	double	12, 6
5	Datum_Conv	Value used to convert from Mean Sea Level datum to NAVD88	double	12, 6
6	(attachment)	Text file with all water level and wave height data	.txt	*
7	(attachment)	Plot of water level by return period with confidence intervals and peak	.png	*
8	(attachment)	Plot of wave height by return period with confidence intervals and peak	.png	*

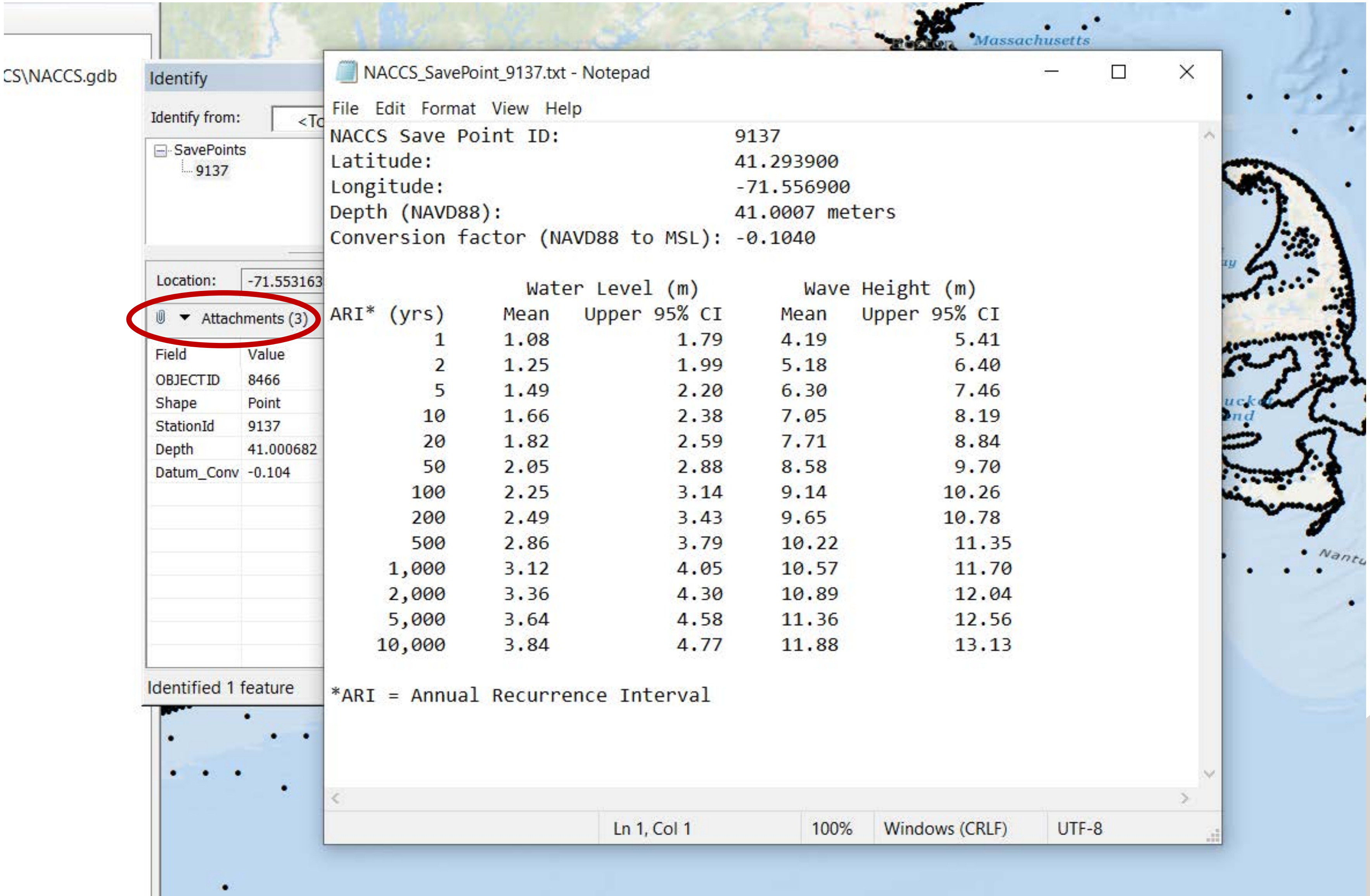
Example: SavePoint between Block Island & mainland Rhode Island

1. Select the **Identify** button from the Toolbar.

2. Click a point on a map.



Water Level and Wave Height Annual Recurrence Intervals at 9137

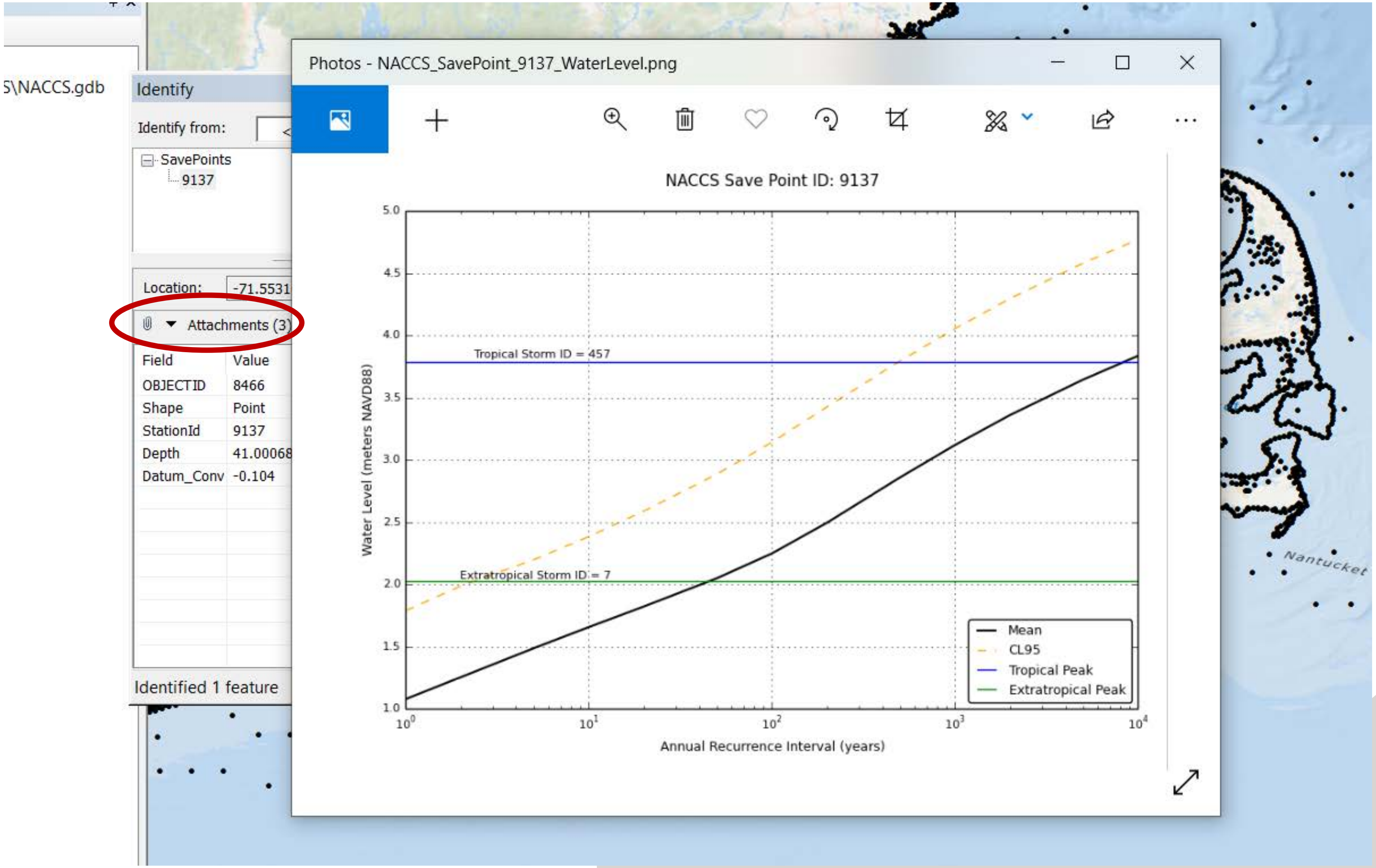


NACCS Save Point ID: 9137
Latitude: 41.293900
Longitude: -71.556900
Depth (NAVD88): 41.0007 meters
Conversion factor (NAVD88 to MSL): -0.1040

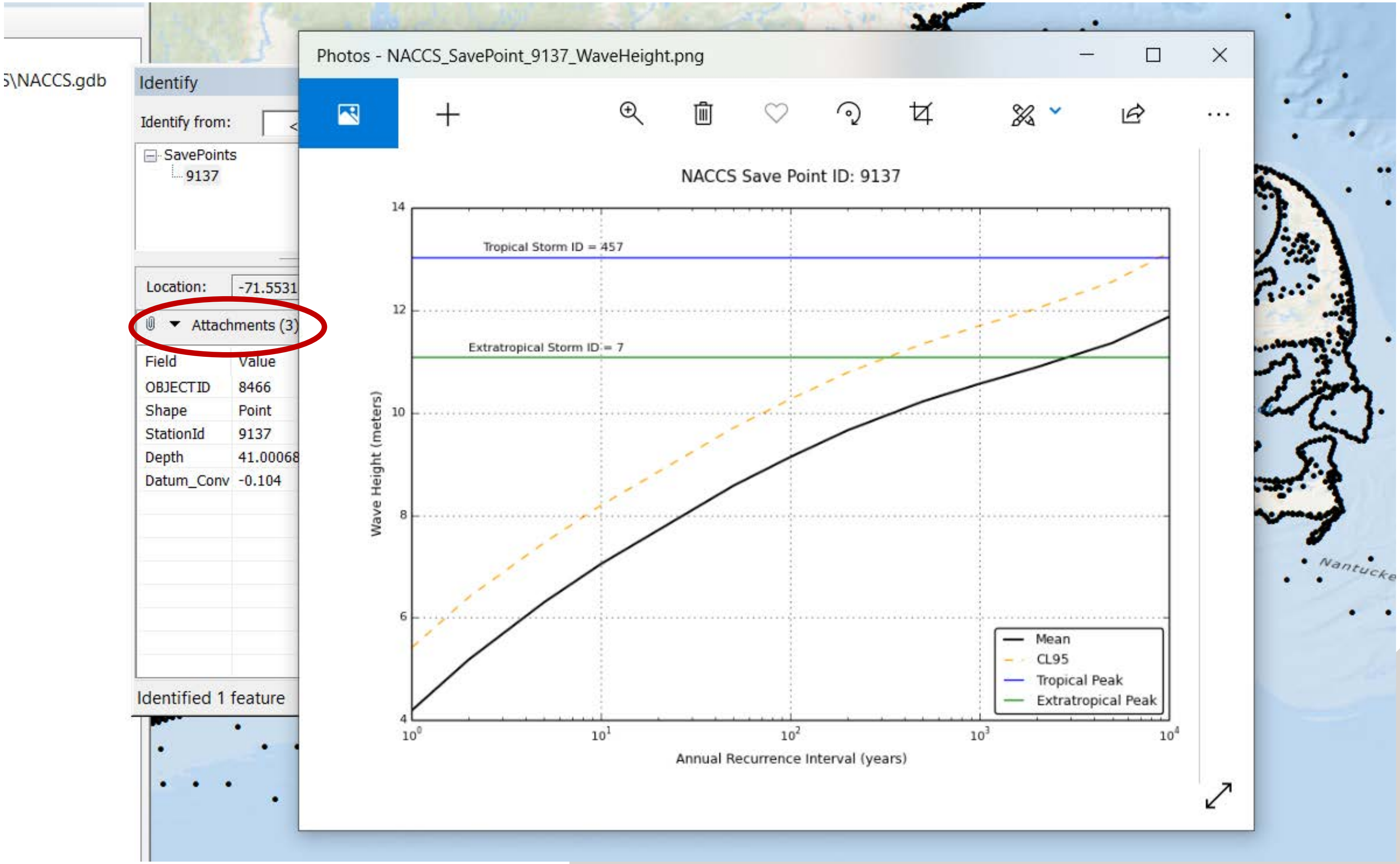
	Water Level (m)		Wave Height (m)	
ARI* (yrs)	Mean	Upper 95% CI	Mean	Upper 95% CI
1	1.08	1.79	4.19	5.41
2	1.25	1.99	5.18	6.40
5	1.49	2.20	6.30	7.46
10	1.66	2.38	7.05	8.19
20	1.82	2.59	7.71	8.84
50	2.05	2.88	8.58	9.70
100	2.25	3.14	9.14	10.26
200	2.49	3.43	9.65	10.78
500	2.86	3.79	10.22	11.35
1,000	3.12	4.05	10.57	11.70
2,000	3.36	4.30	10.89	12.04
5,000	3.64	4.58	11.36	12.56
10,000	3.84	4.77	11.88	13.13

*ARI = Annual Recurrence Interval

Annual Recurrence Interval plot of Water Level at 9137



Annual Recurrence Interval plot of Wave Height at 9137

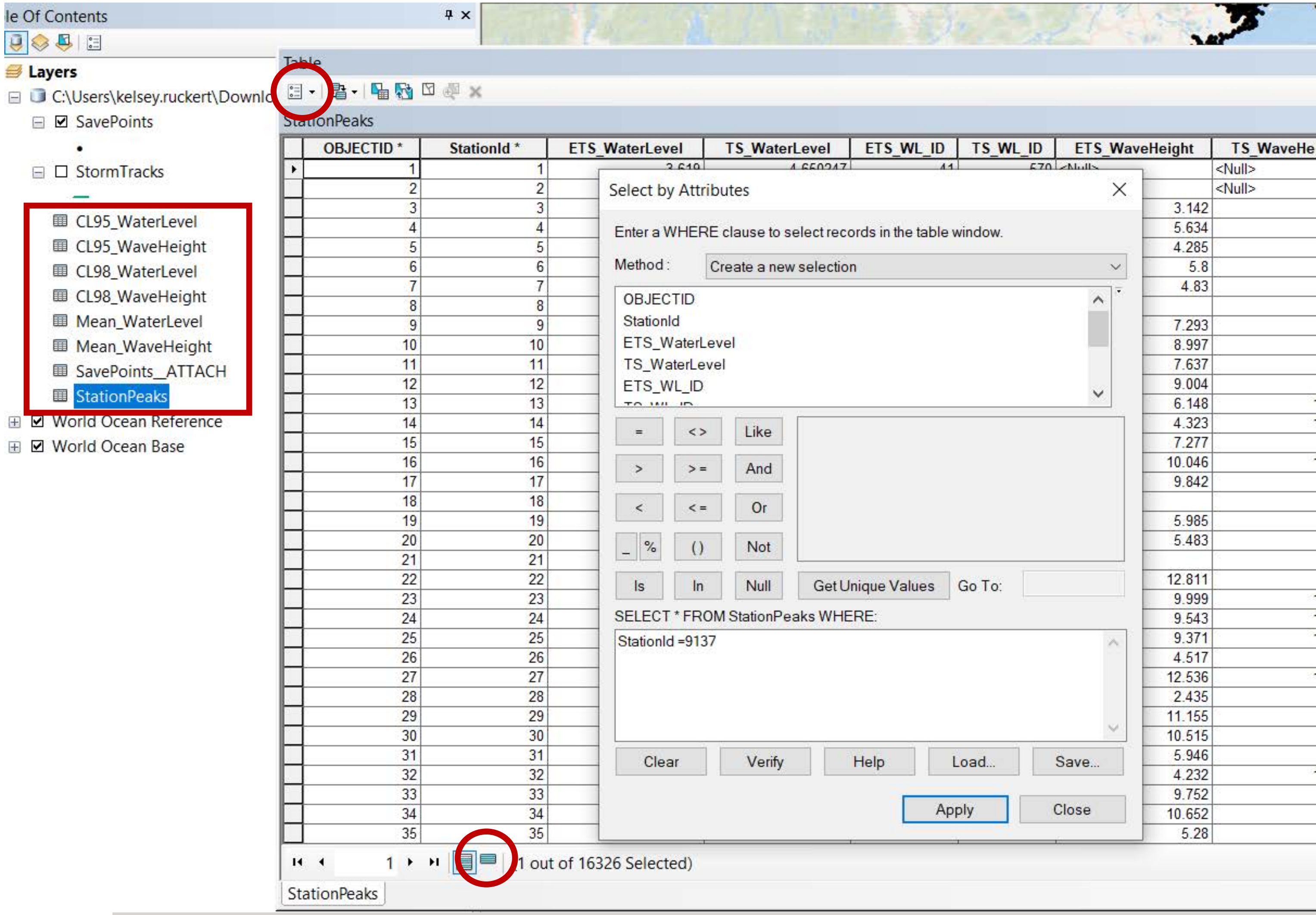


Parsing the data tables

1. Right click the table and select **Open**

2. In the popup table, click the **Table Options** button and select **Select by Attributes**

3. Create a query setting the **StationId = 9137**, click **Apply**, and click on **Show selected records**



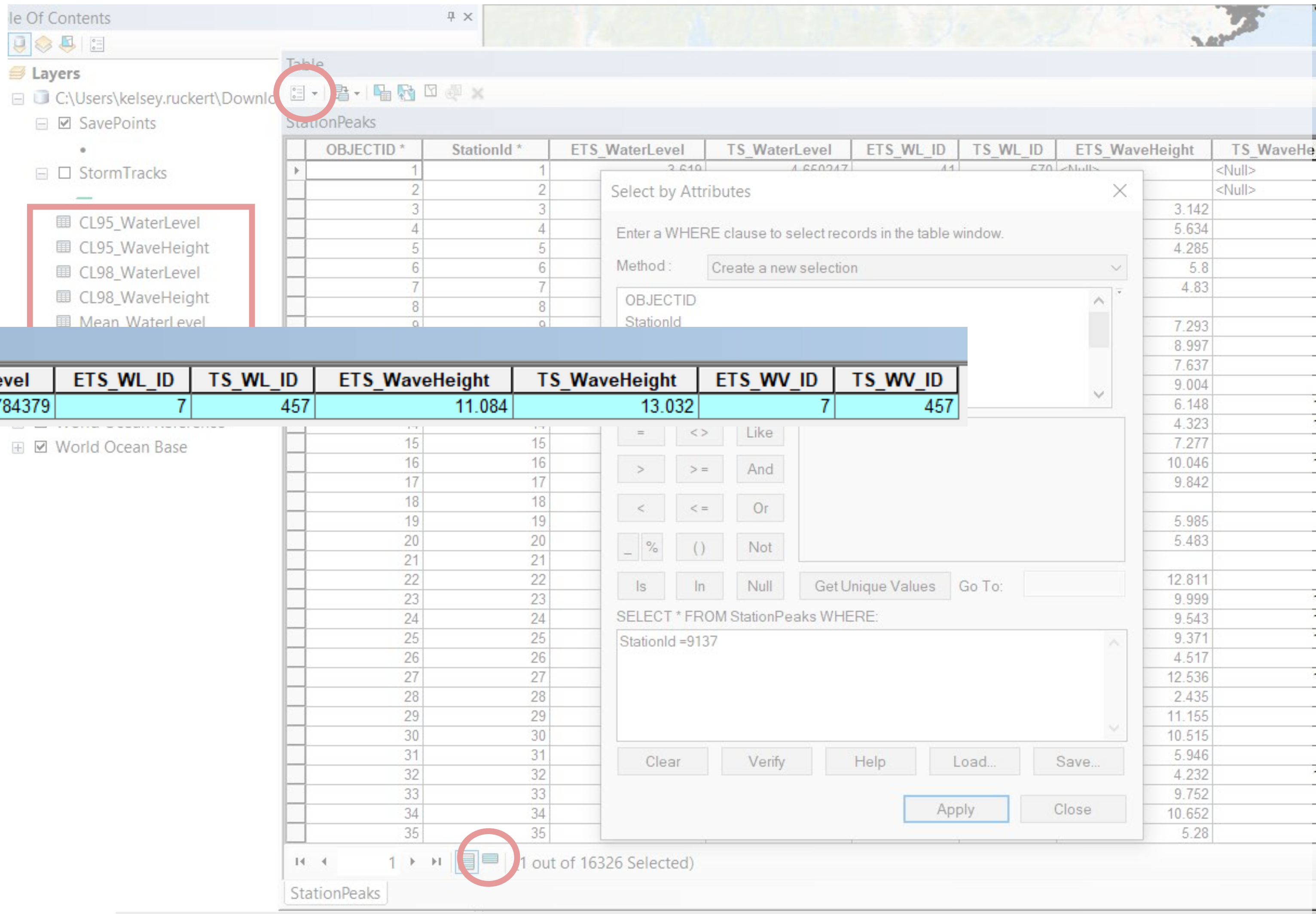
Parsing the data tables

1. Right click the table and select **Open**

2. In the popup table, click the **Ta**
select **Select by Attributes**

StationPeaks									
OBJECTID *	StationId *	ETS_WaterLevel	TS_WaterLevel	ETS_WL_ID	TS_WL_ID	ETS_WaveHeight	TS_WaveHeight	ETS_WV_ID	TS_WV_ID
8466	9137	2.023	3.784379	7	457	11.084	13.032	7	457

3. Create a query setting the **StationId = 9137**, click **Apply**, and click on **Show selected records**



Parsing the data tables

1. Right click the table and select **Open**

CL98_WaterLevel

OBJECTID *	StationId	WL_ARI_1	WL_ARI_2	WL_ARI_5	WL_ARI_10	WL_ARI_20	WL_ARI_50	WL_ARI_100	WL_ARI_200	WL_ARI_500	WL_ARI_1000	WL_ARI_2000	WL_ARI_5000	WL_ARI_10000
8466	9137	1.968136	2.185146	2.396582	2.584116	2.800589	3.112046	3.374578	3.659095	4.027734	4.289195	4.53018	4.814504	5.006381

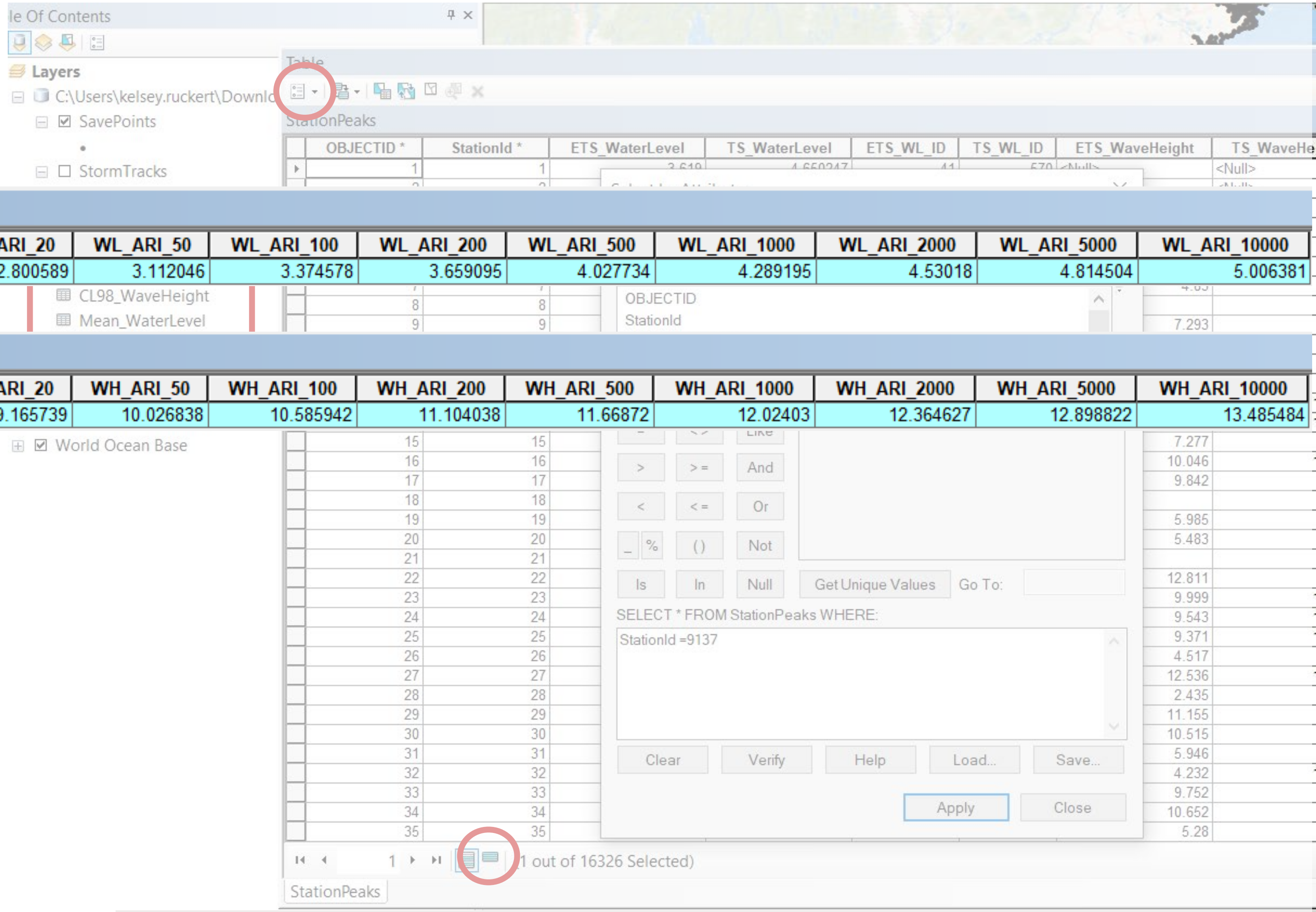
2. In the popup table, click the

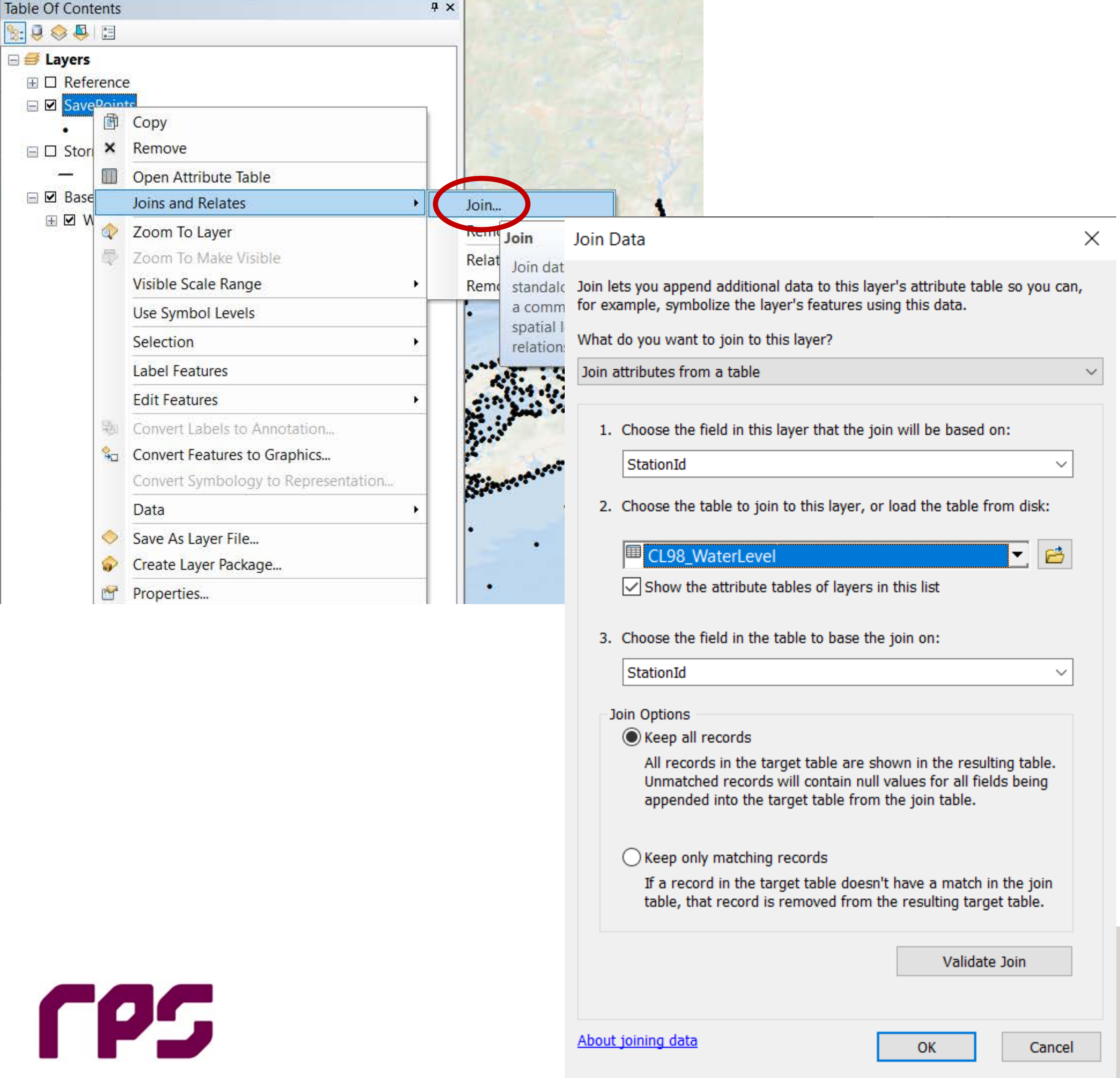
CL98_WaveHeight

OBJECTID *	StationId	WH_ARI_1	WH_ARI_2	WH_ARI_5	WH_ARI_10	WH_ARI_20	WH_ARI_50	WH_ARI_100	WH_ARI_200	WH_ARI_500	WH_ARI_1000	WH_ARI_2000	WH_ARI_5000	WH_ARI_10000
8466	9137	5.775214	6.743754	7.788907	8.517414	9.165739	10.026838	10.585942	11.104038	11.66872	12.02403	12.364627	12.898822	13.485484

select **Select by Attributes**

3. Create a query setting the **StationId = 9137**, click **Apply**, and click on **Show selected records**

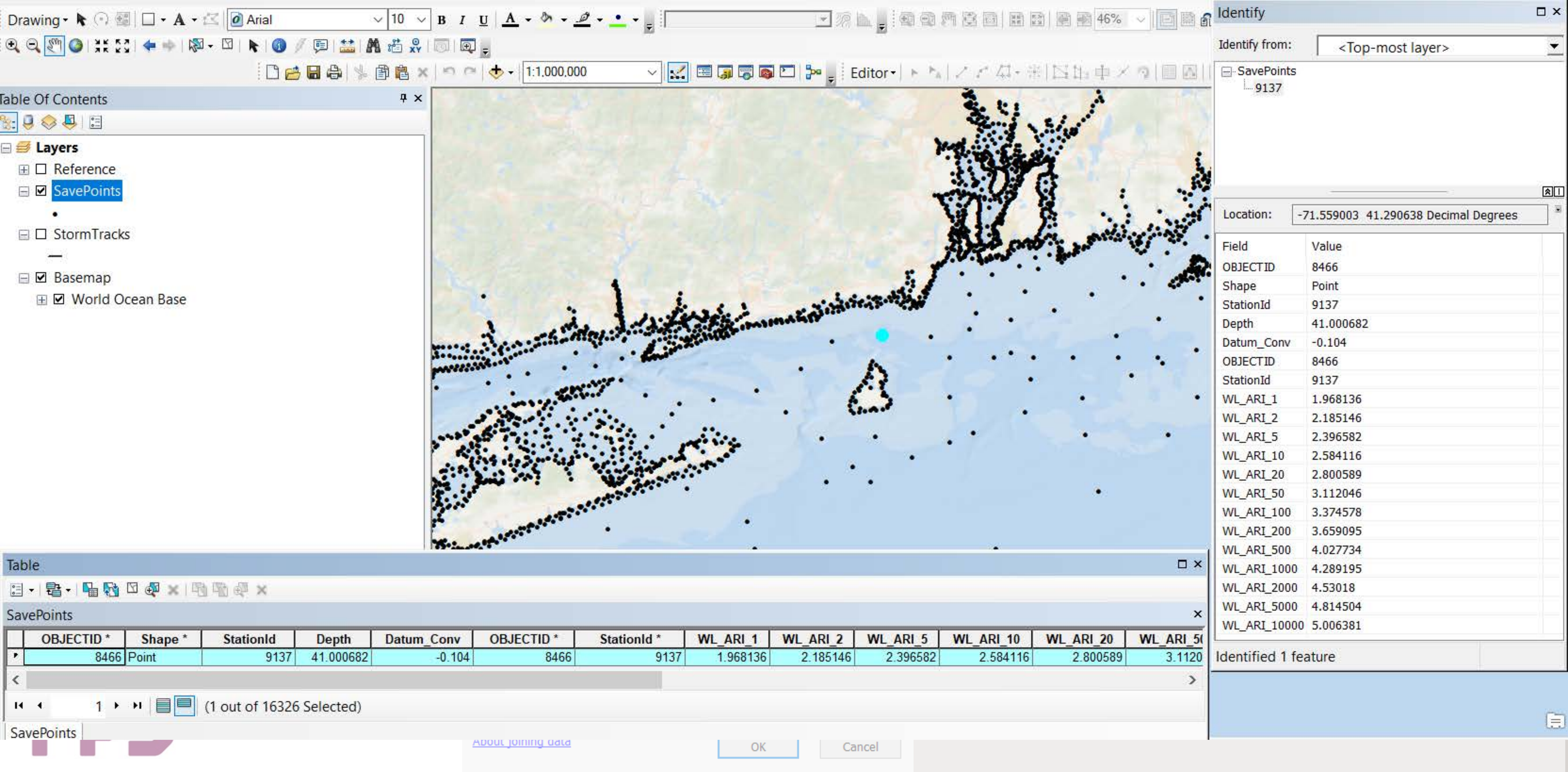




Joins and Relates

1. Right click **SavePoints**, select **Joins and Relates**, and select **Join**
2. In the popup table, select **StationId** as the field to be joined by and select the **CL98_WaterLevel** or another table to join to SavePoints
3. Choose whether to keep all records or only matching records and click **OK**

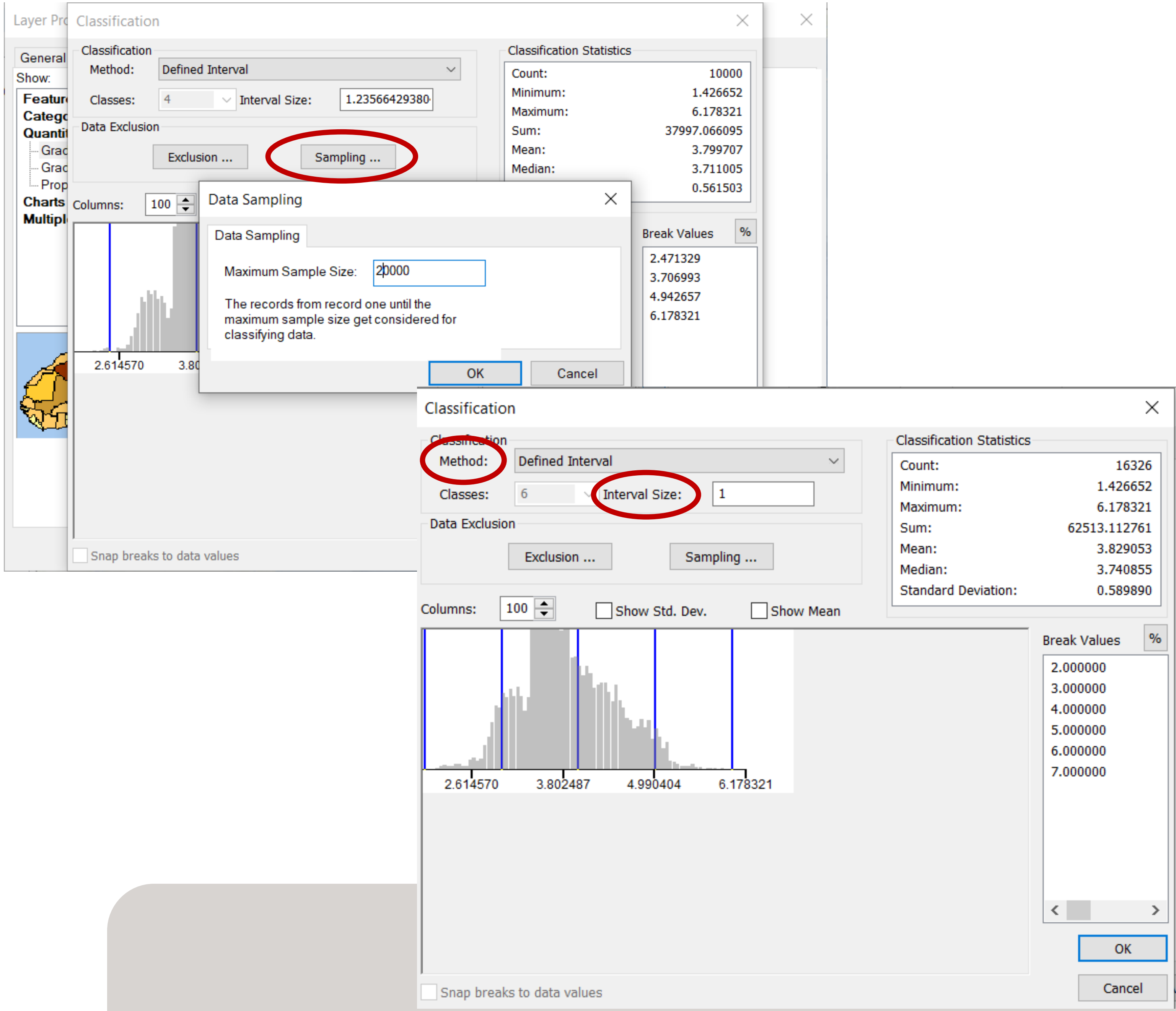
Joins and Relates



Display 100-yr values across all SavePoints

Example: 98% 100-yr water levels

1. In the Classification popup, click **Sampling…** and increase the maximum sample size to greater than the amount of points (e.g., 20000)
2. Set the **Method** to Defined Interval, specify the **Interval Size**, and click **OK**

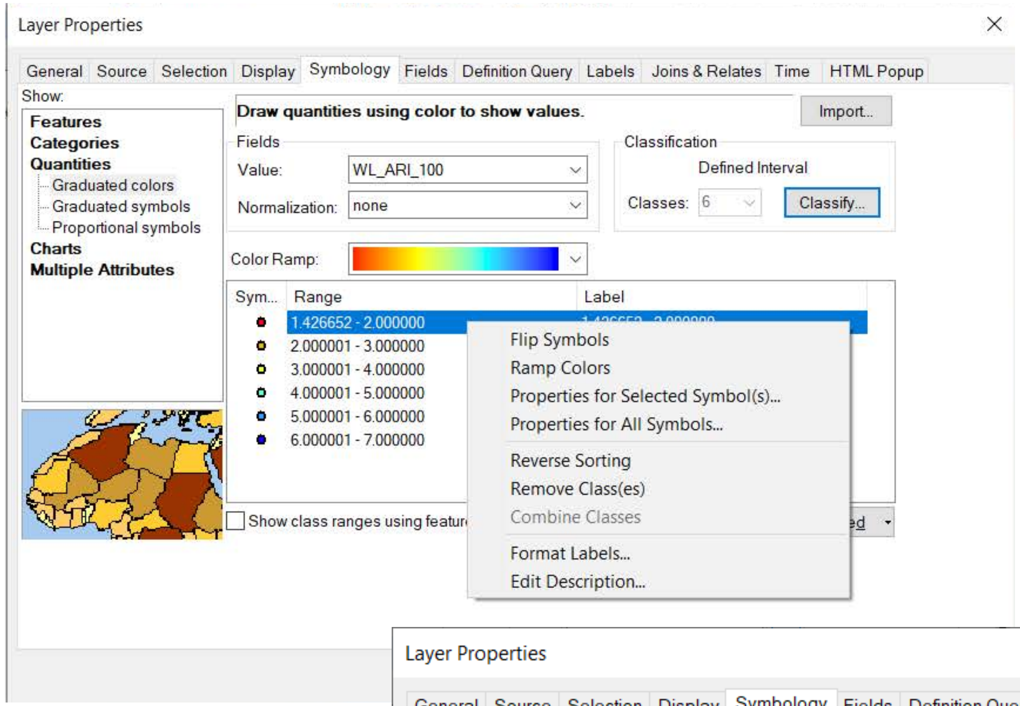


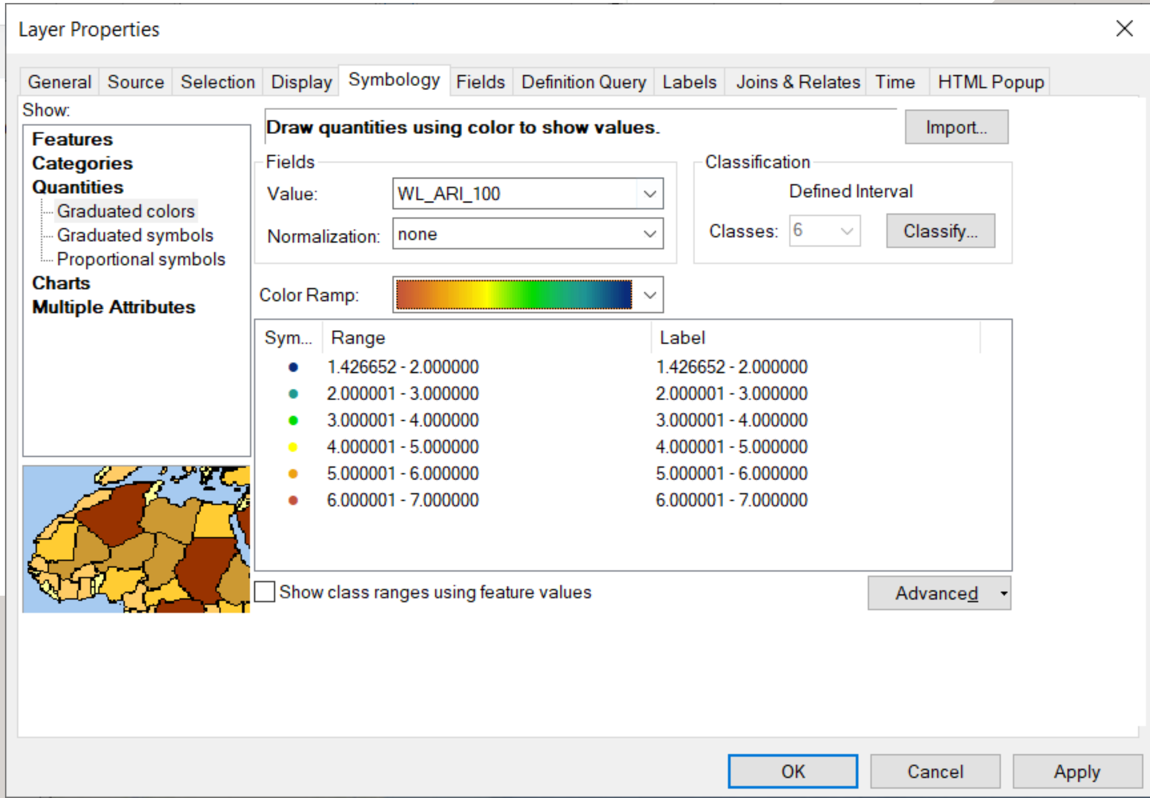
Display 100-yr values across all SavePoints

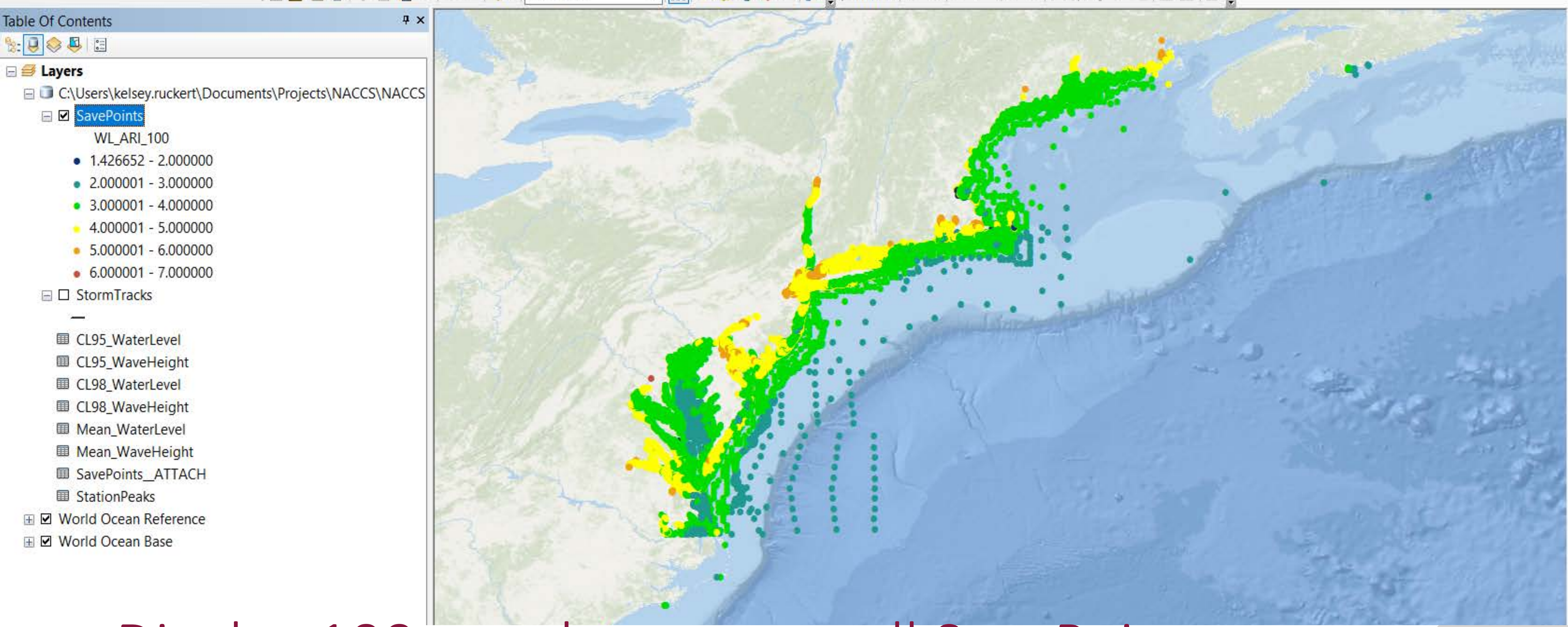
Example: 98% 100-yr water levels

1. Right clicking a range value will show a drop-down menu that can be used to modify symbols and colors

2. Click **OK** once satisfied with the ranges and styling



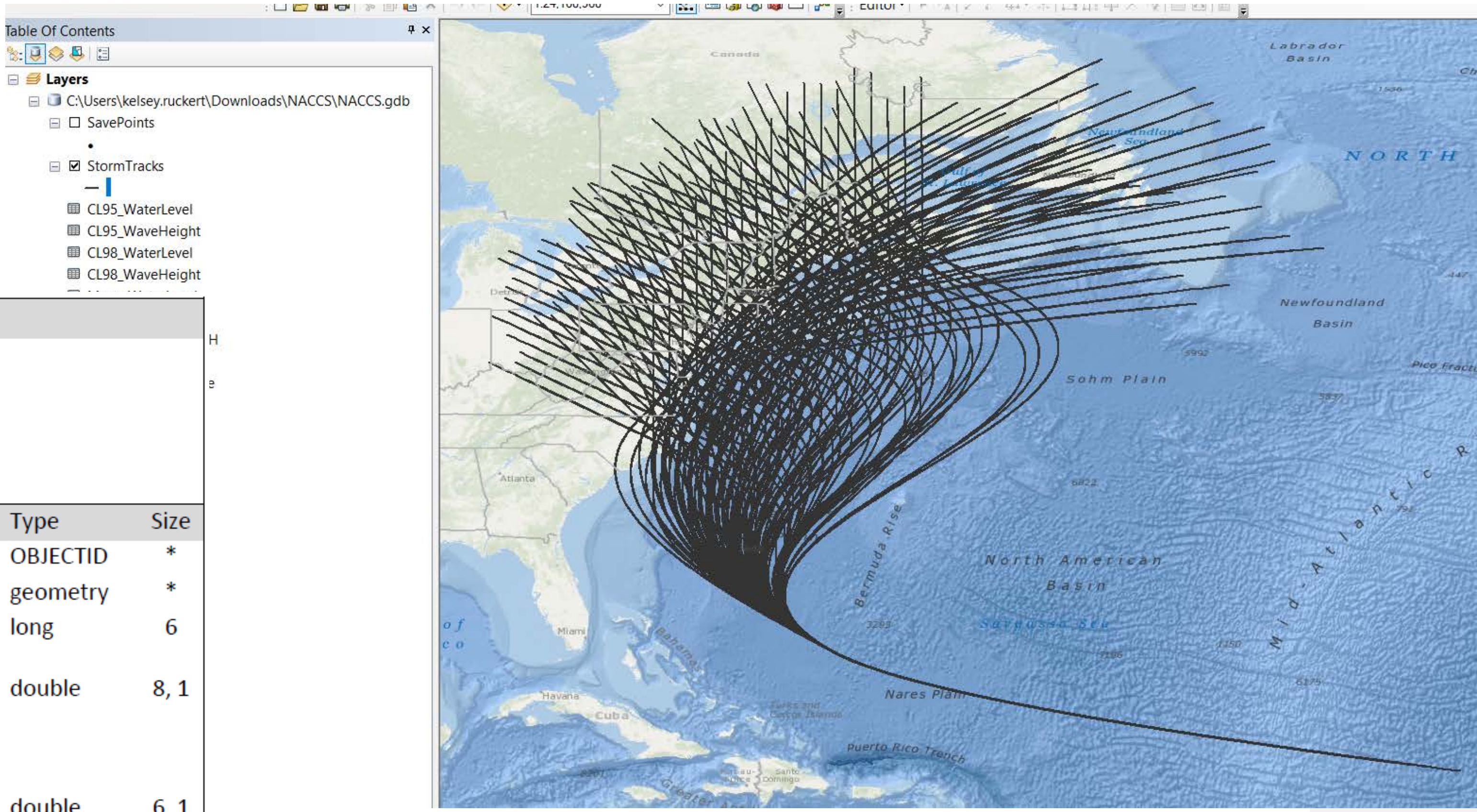




Display 100-yr values across all SavePoints:

98% 100-yr water levels

StormTracks Layer



Feature Class Name: **StormTracks**

Feature Type:	Polyline
Description:	Synthetic tropical storm tracks
Total Number of Unique Features:	1,050
Data Status:	Complete

Line	Name	Definition	Type	Size
1	OBJECTID	Uniquely identifies a feature	OBJECTID	*
2	Shape	Geometric representation of the feature	geometry	*
3	StormId	Original numerical storm identifier from source material	long	6
4	C_Pressure	Central Pressure Deficit (hPa) - difference between the central pressure of the storm and peripheral barometric pressure (controls the intensity of hurricanes)	double	8, 1
5	Heading	Heading Direction - track direction (degrees clockwise from north) at the point of landfall	double	6, 1
6	Radius_Max_Wind	Radius of Maximum Wind – distance (km) from the center of a tropical cyclone to the location of the cyclone's maximum winds (generally found at the inner edge of the eyewall)	double	8, 1
7	Ref_Lat	Reference Latitude (deg) – latitude of storm landfall point (for landfalling storms) or latitude where the storm exits the impact region (for bypassing storms)	double	6, 2
8	Ref_Lon	Reference Longitude (deg) - longitude of storm landfall point (for landfalling storms) or longitude where the storm exits the impact region (for bypassing storms)	double	6, 2
9	Trans_Speed	Translational Speed - storm forward speed (km/h) as it approaches the coast	double	6, 1

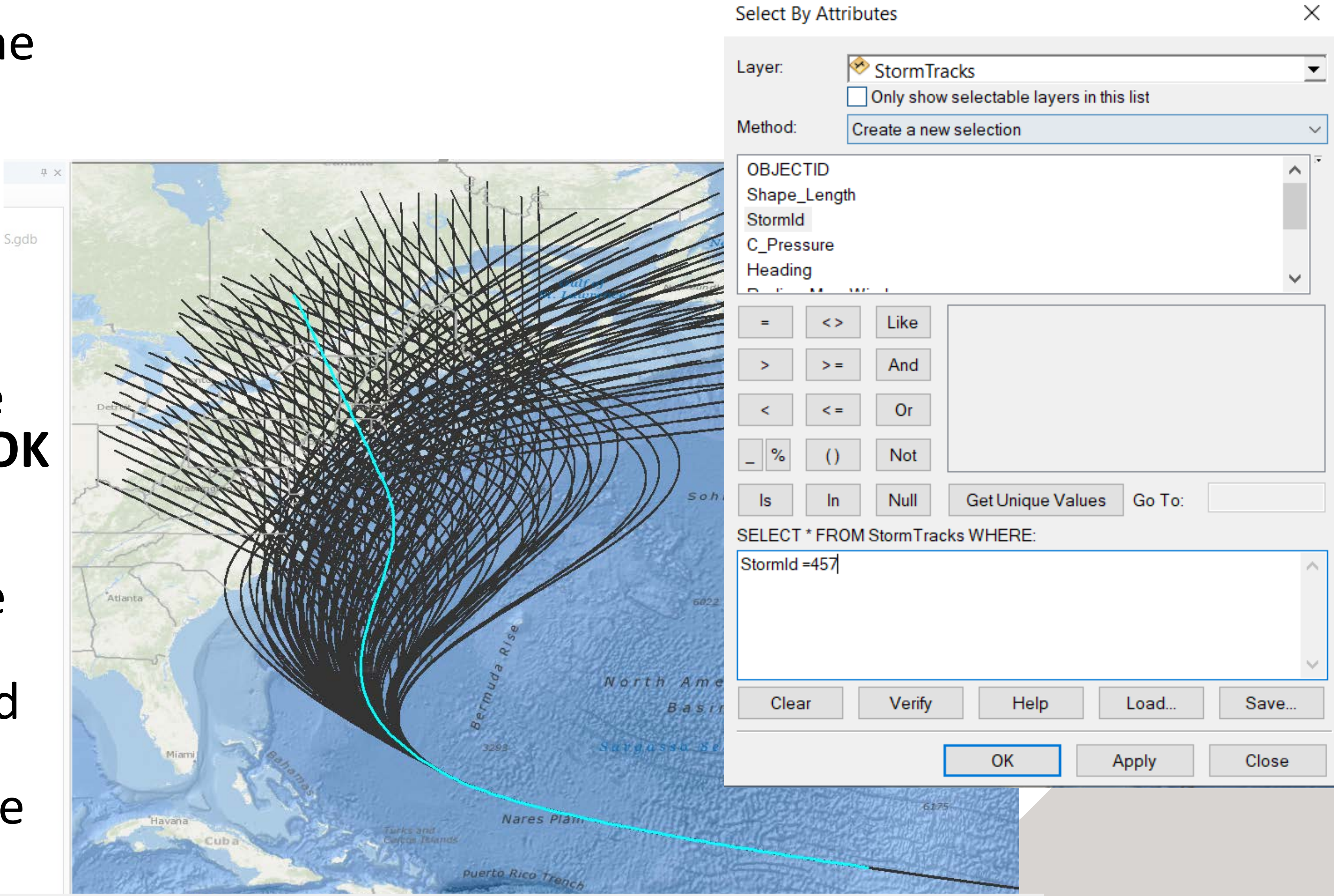
A set of simulated storm events from which storm surge, wave heights, and extremal statistics were derived.

Extracting the tropical peak storm from StormTracks

1. Click on **Selection** from the Toolbar and **Select By Attributes…**

2. In the popup, select StormTracks as the Layer, create a query setting the **StormId = 457**, and click **OK**

3. Right click the layer in the Table of Contents, select **Open Attribute Table**, and click on **Show selected records** in the popup table



StormTracks

OBJECTID *	Shape *	Shape_Length	StormId	C_Pressure	Heading	Radius_Max_Wind	Ref_Lat	Ref_Lon	Trans_Speed
457	Polyline	46.371855	457	88	-20	58	40.96	-72.12	34

Case Study: Prescott Park, NH

Prescott Park - Master Plan - Project Area (includes highlighted parcels)

Prescott Park (downtown Portsmouth, NH)

Purpose: Identify areas of Prescott Park that are vulnerable to flooding

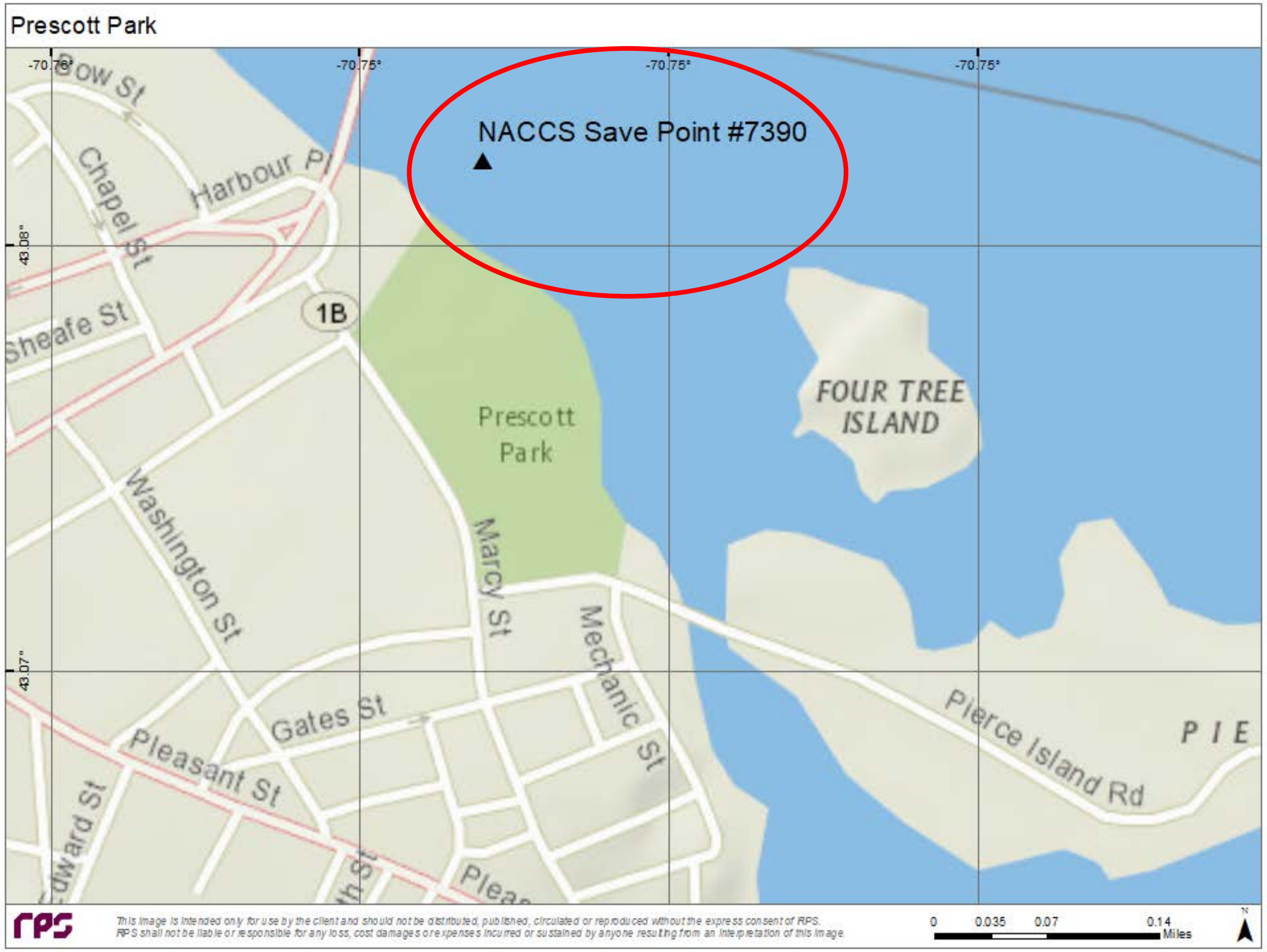
- access to the Piscataqua River
- open space and outdoor arts venue
- 10+ acres of waterfront property

Method: Bathtub modeling approach

- Variety of storm and SLR scenarios

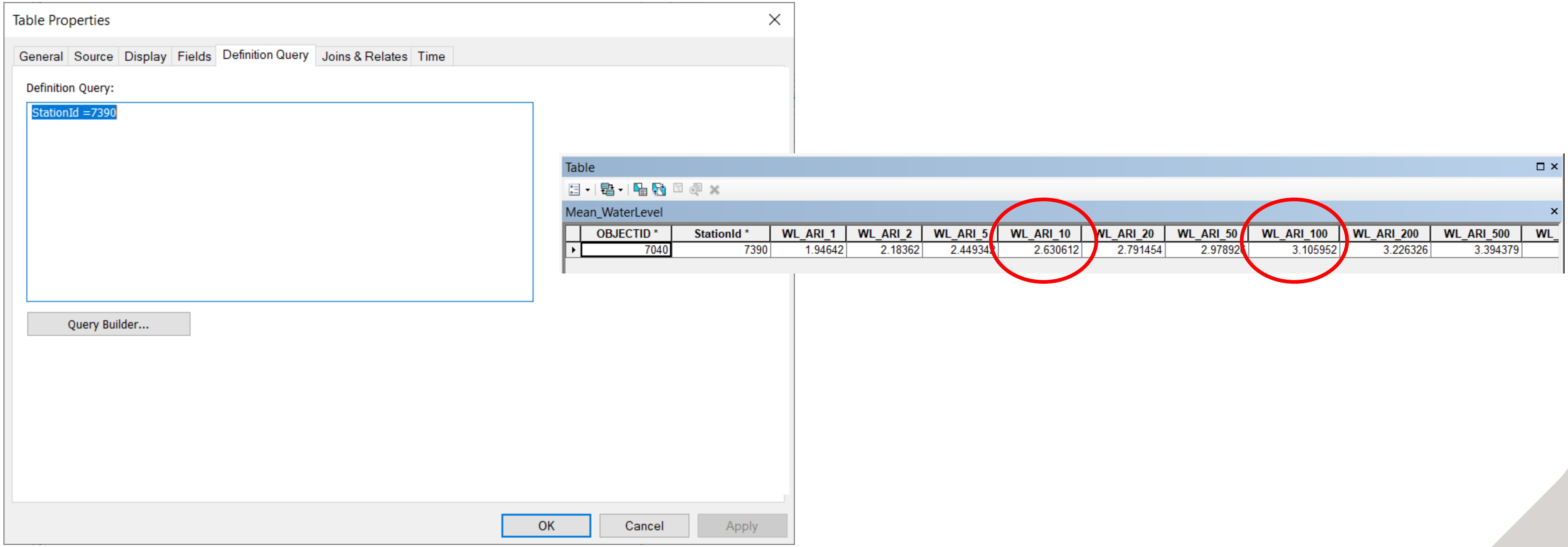
Prescott Park - Approach

- NROC NACCS database was investigated for this study:
  - **Base Conditions + 96 Random Tides**
  - Nearest NACCS save point (#7390) used.
- Both the mean and the 95th percentile were investigated.
- A scenario of no SLR (present conditions) and SLR of 2 ft were used in this study.



Prescott Park – Accessing the data

Base Conditions + 96 Random Tide Phases (NROC ArcGIS geodatabase)



Prescott Park – 8 scenarios

ID	SLR		Storm Water Level	Base + 96 Random Tide Phases			
				Mean Confidence Level		95th Percentile Confidence Level	
				NACCS Water Level (ft. NAVD88)	Water Level + RSLR (ft. NAVD88)	NACCS Water Level – 95th % (ft. NAVD88)	Water Level + RSL (ft. NAVD88)
1	Present Day	0 ft.	10-yr	8.6	**8.6**	10.8	**10.8**
2	Present Day	0 ft.	100-yr	10.2	**10.2**	12.5	**12.5**
3	Year 2050 **high** SLR	2 ft.	10-yr	8.6	**10.6**	10.8	**12.8**
4	Year 2050 **high** SLR	2 ft.	100-yr	10.2	**12.2**	12.5	**14.5**

Prescott Park – Results

Created a series of figures corresponding to each of the eight scenarios

Figures illustrate the predicted extent and depth (in feet) of inundation in and around Prescott Park for each scenario.

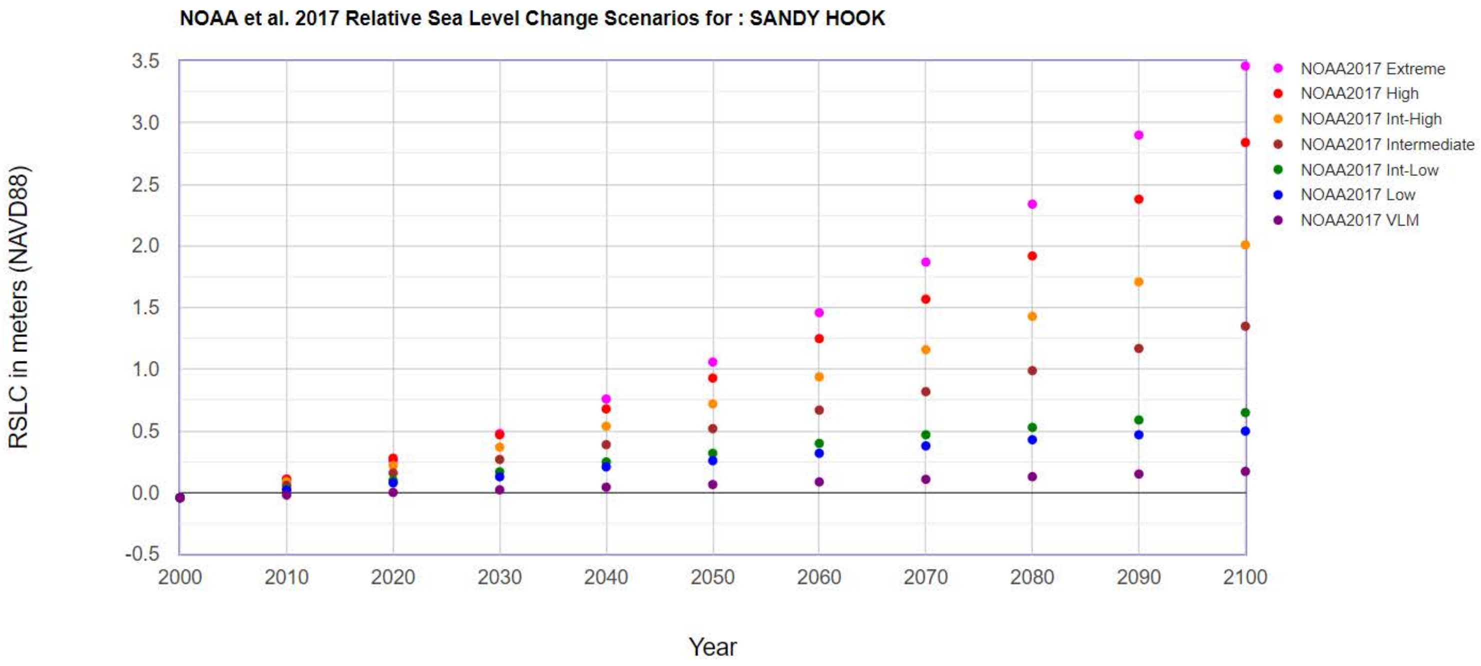
All figures were created with the same color scale for consistency with the maximum inundation depth for each scenario noted in the upper right corner.

Base + 96 Random Tide Phases Mean Confidence Level

The bathtub approach: Creating an inundation map surrounding Rockaway park, NY

Datasets

- Topobathy Digital Elevation Model (DEM)
  - Coastal National Elevation Database (CoNed)
    - Hurricane Sandy Region (New Jersey and Delaware)
    - New England

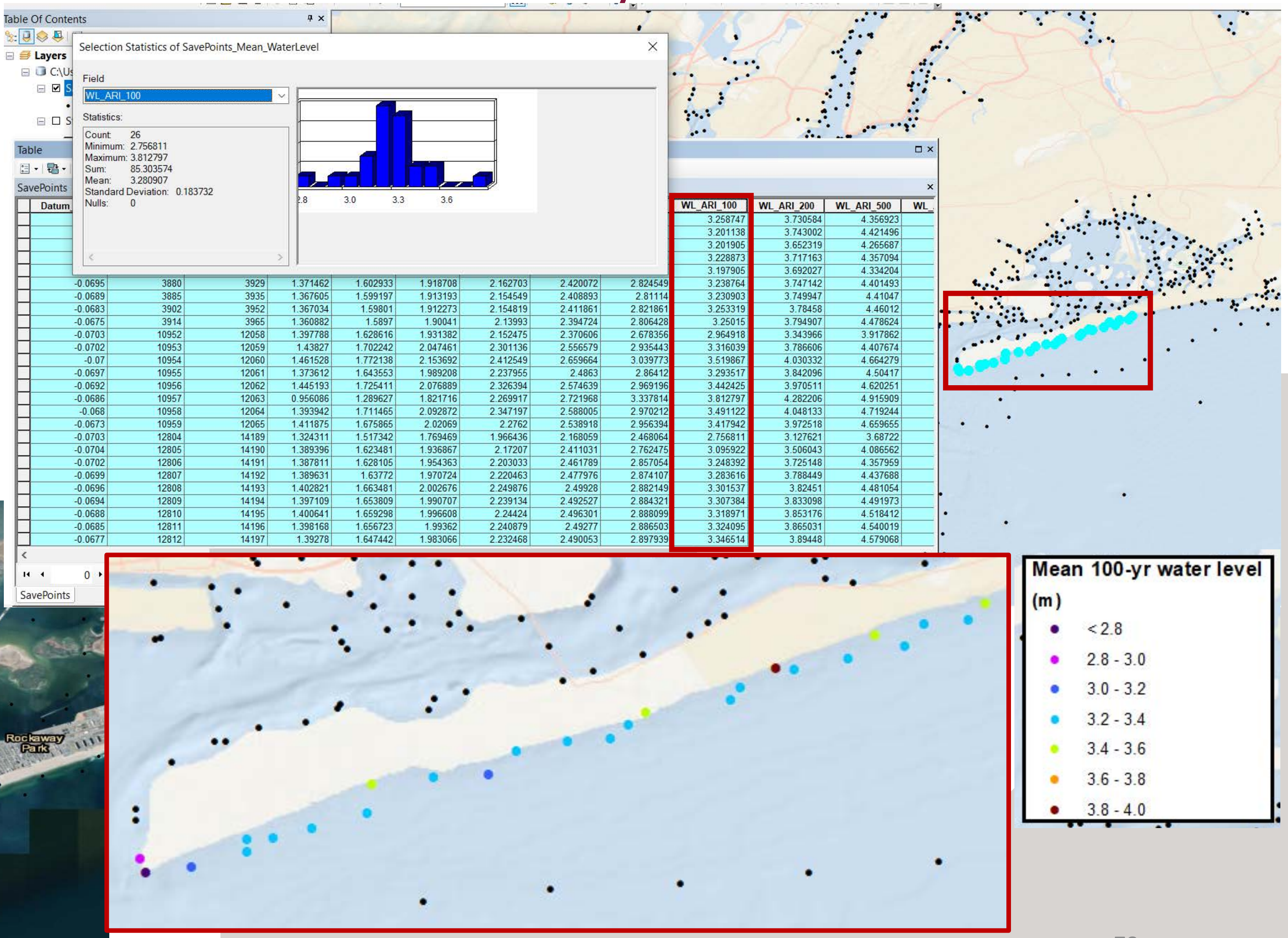


- NROC NACCS geodatabase
  - Mean 100-year water level
- Sweet et al., 2017 relative sea-level change (RSLC) at Sandy Hook tide station
  - Intermediate scenario in the year 2050 (**0.52 m** relative to 1992)

Selection of NROC NACCS Mean 100-year water level

SavePoints along Rockaway Park:

- 2.8 – 3.8 m with a mean of 3.3 m
- ID 14196: Mean 100-yr WL: **3.32 m**

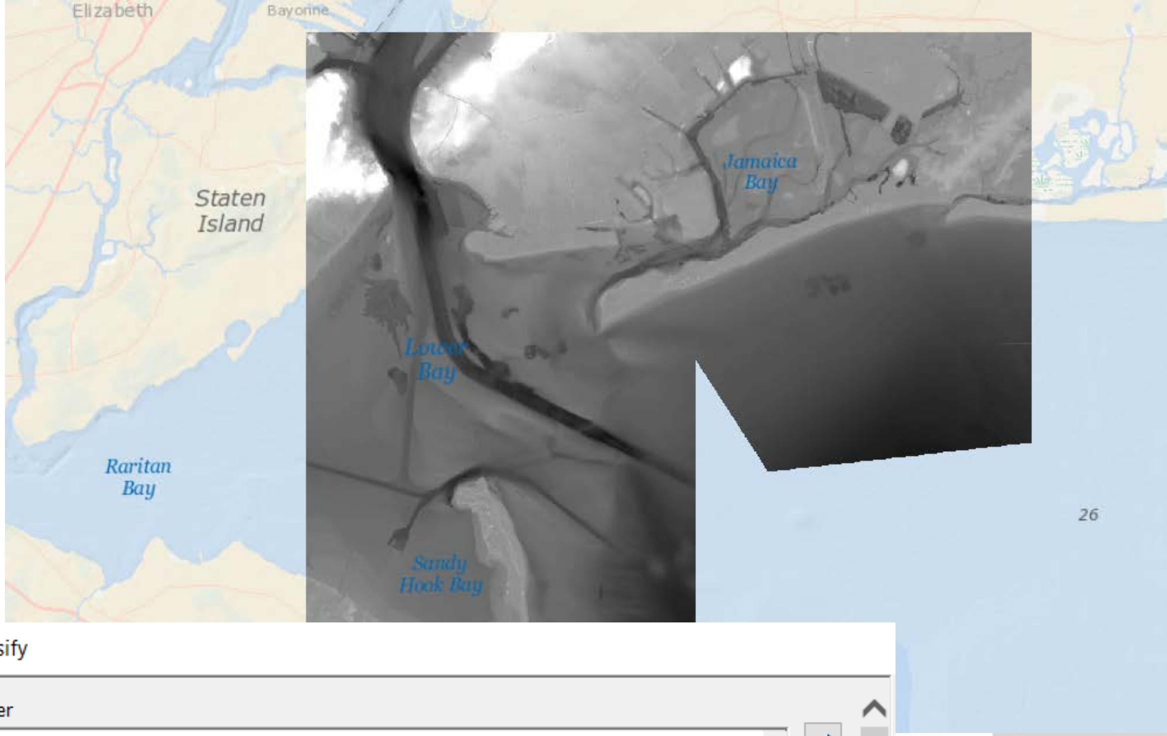


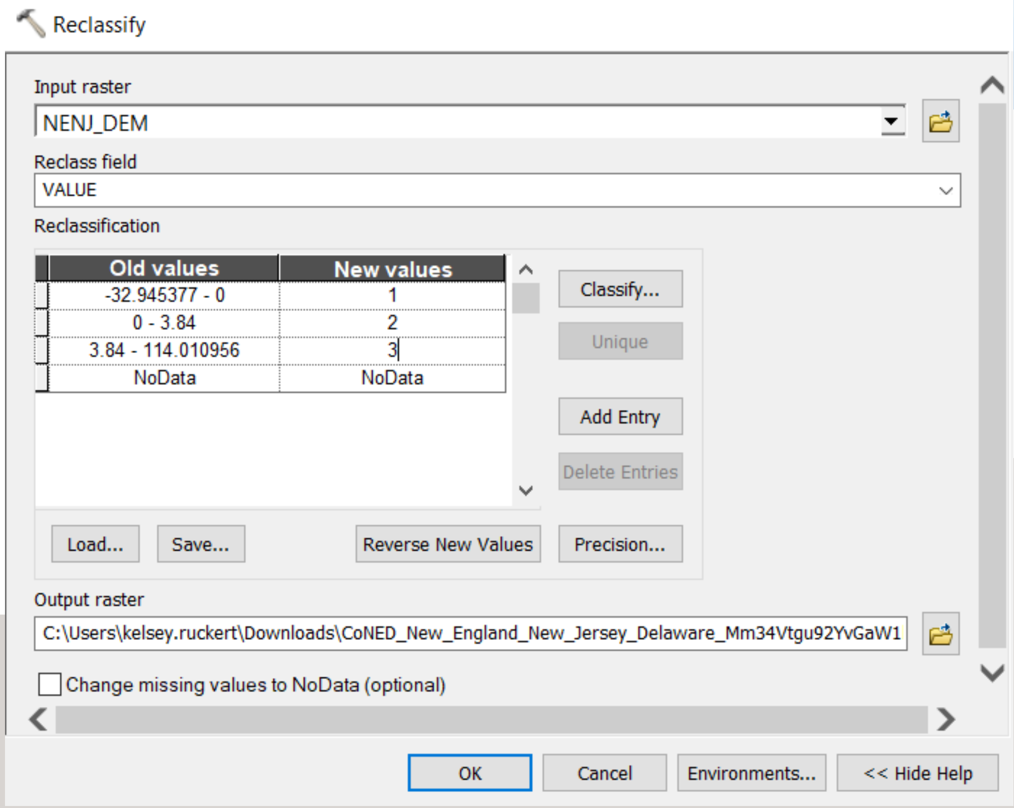
Datum_									WL_ARI_100	WL_ARI_200	WL_ARI_500	WL_
									3.258747	3.730584	4.356923	
									3.201138	3.743002	4.421496	
									3.201905	3.652319	4.265687	
									3.228873	3.717163	4.357094	
									3.197905	3.692027	4.334204	
-0.0695	3880	3929	1.371462	1.602933	1.918708	2.162703	2.420072	2.824549	3.238764	3.747142	4.401493	
-0.0689	3885	3935	1.367605	1.599197	1.913193	2.154549	2.408893	2.81114	3.230903	3.749947	4.41047	
-0.0683	3902	3952	1.367034	1.59801	1.912273	2.154819	2.411861	2.821861	3.253319	3.78458	4.46012	
-0.0675	3914	3965	1.360882	1.5897	1.90041	2.13993	2.394724	2.806428	3.25015	3.794907	4.478624	
-0.0703	10952	12058	1.397788	1.628616	1.931382	2.152475	2.370606	2.678356	2.964918	3.343966	3.917862	
-0.0702	10953	12059	1.43827	1.702242	2.047461	2.301136	2.556579	2.935443	3.316039	3.786606	4.407674	
-0.07	10954	12060	1.461528	1.772138	2.153692	2.412549	2.659664	3.039773	3.519867	4.030332	4.664279	
-0.0697	10955	12061	1.373612	1.643553	1.989208	2.237955	2.4863	2.86412	3.293517	3.842096	4.50417	
-0.0692	10956	12062	1.445193	1.725411	2.076889	2.326394	2.574639	2.969196	3.442425	3.970511	4.620251	
-0.0686	10957	12063	0.956086	1.289627	1.821716	2.269917	2.721968	3.337814	3.812797	4.282206	4.915909	
-0.068	10958	12064	1.393942	1.711465	2.092872	2.347197	2.588005	2.970212	3.491122	4.048133	4.719244	
-0.0673	10959	12065	1.411875	1.675865	2.02069	2.2762	2.538918	2.956394	3.417942	3.972518	4.659655	
-0.0703	12804	14189	1.324311	1.517342	1.769469	1.966436	2.168059	2.468064	2.756811	3.127621	3.68722	
-0.0704	12805	14190	1.389396	1.623481	1.936867	2.17207	2.411031	2.762475	3.095922	3.506043	4.086562	
-0.0702	12806	14191	1.387811	1.628105	1.954363	2.203033	2.461789	2.857054	3.248392	3.725148	4.357959	
-0.0699	12807	14192	1.389631	1.63772	1.970724	2.220463	2.477976	2.874107	3.283616	3.788449	4.437688	
-0.0696	12808	14193	1.402821	1.663481	2.002676	2.249876	2.49928	2.882149	3.301537	3.82451	4.481054	
-0.0694	12809	14194	1.397109	1.653809	1.990707	2.239134	2.492527	2.884321	3.307384	3.833098	4.491973	
-0.0688	12810	14195	1.400641	1.659298	1.996608	2.24424	2.496301	2.888099	3.318971	3.853176	4.518412	
-0.0685	12811	14196	1.398168	1.656723	1.99362	2.240879	2.49277	2.886503	3.324095	3.865031	4.540019	
-0.0677	12812	14197	1.39278	1.647442	1.983066	2.232468	2.490053	2.897939	3.346514	3.89448	4.579068	

Reclassify values

NACCS 100-year water level + RSLC in 2050 = 3.84 m

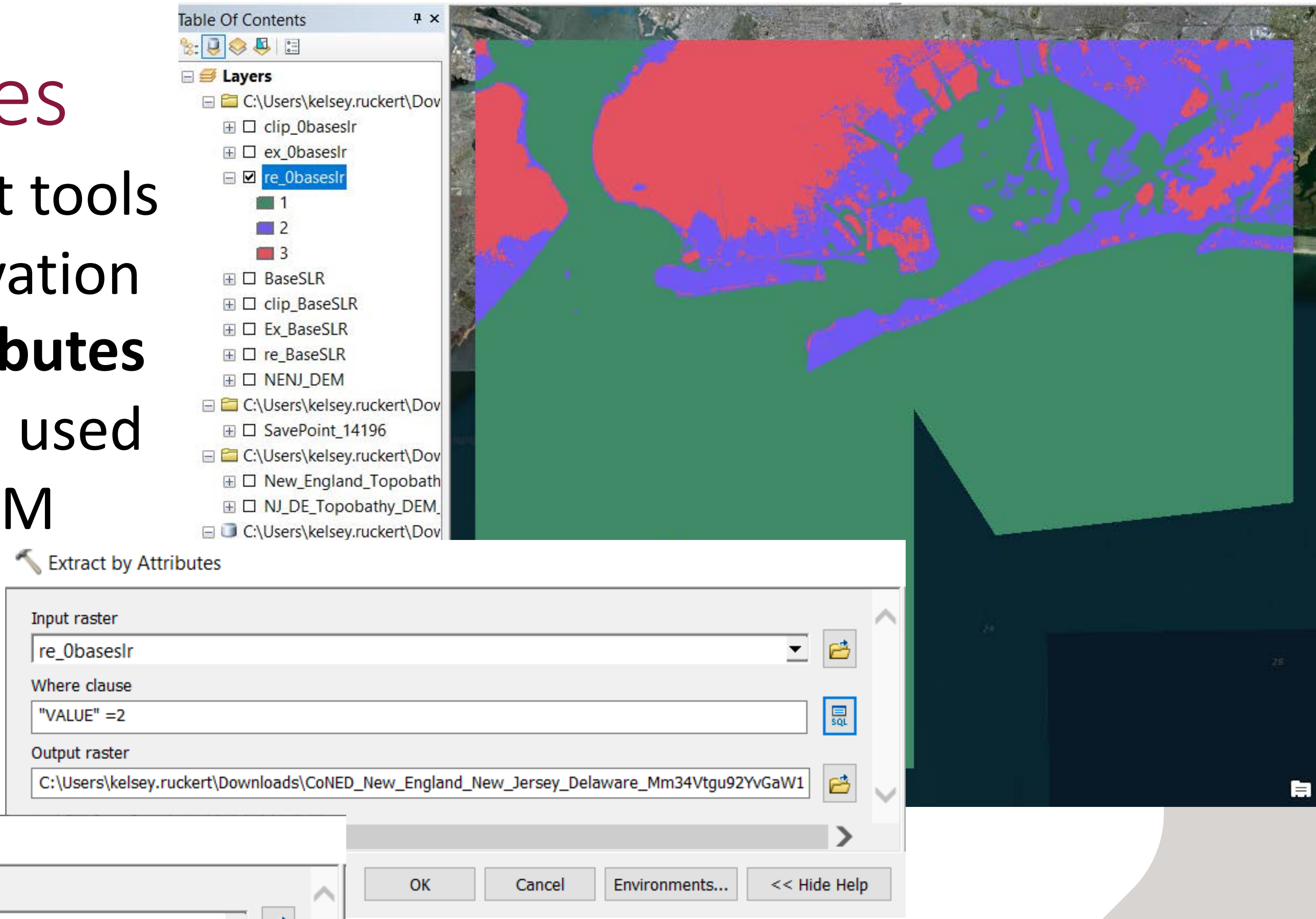
Old values	New values
-32.945377 - 0	1
0 - 3.84	2
3.841 - 114.010956	3
NoData	NoData

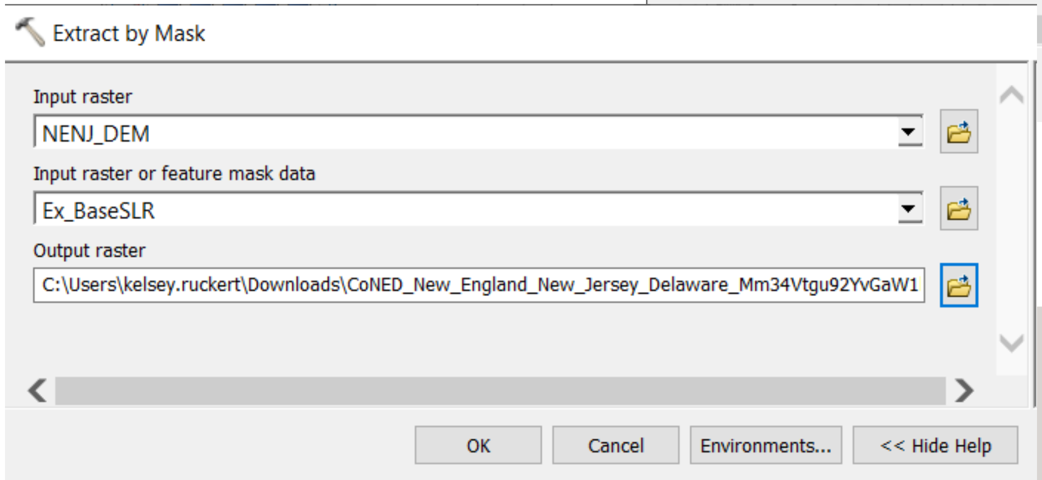




Extract Elevation Ranges

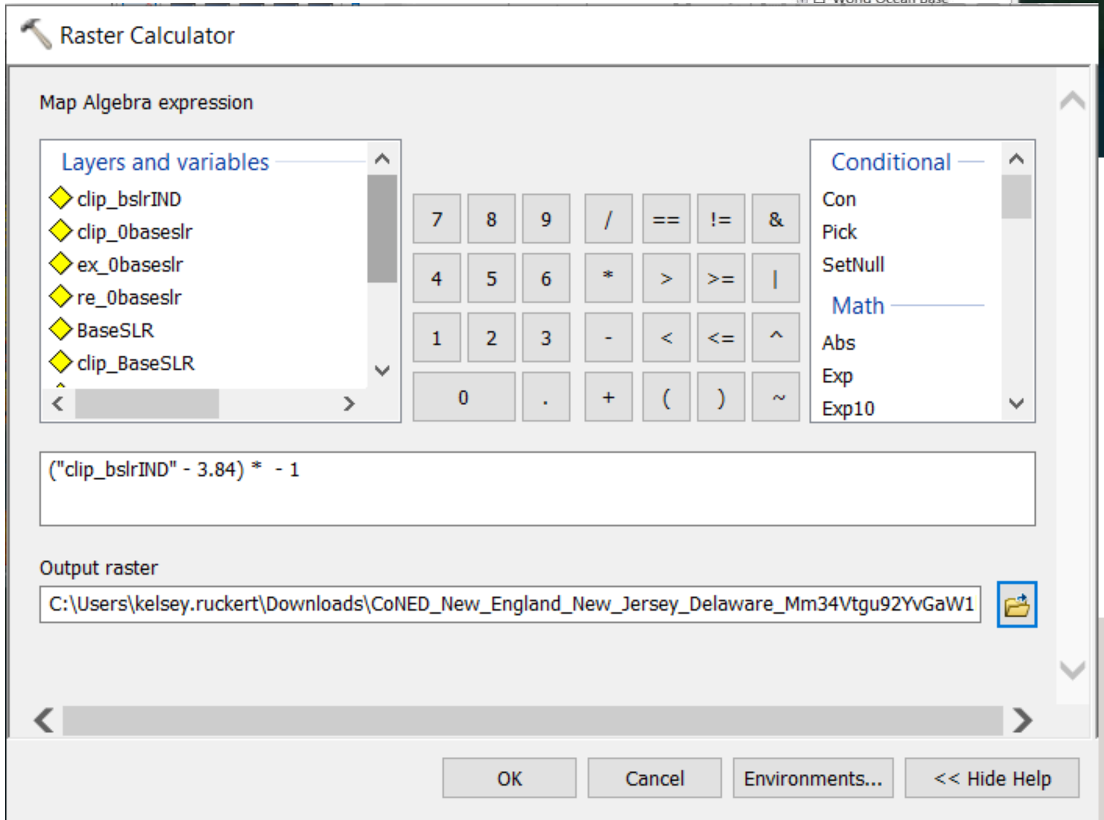
Using the Spatial Analyst extract tools you can extract the specific elevation ranges with the **Extract by Attributes** tool. The resulting raster can be used as a mask to clip the original DEM with the **Extract by Mask** tool.



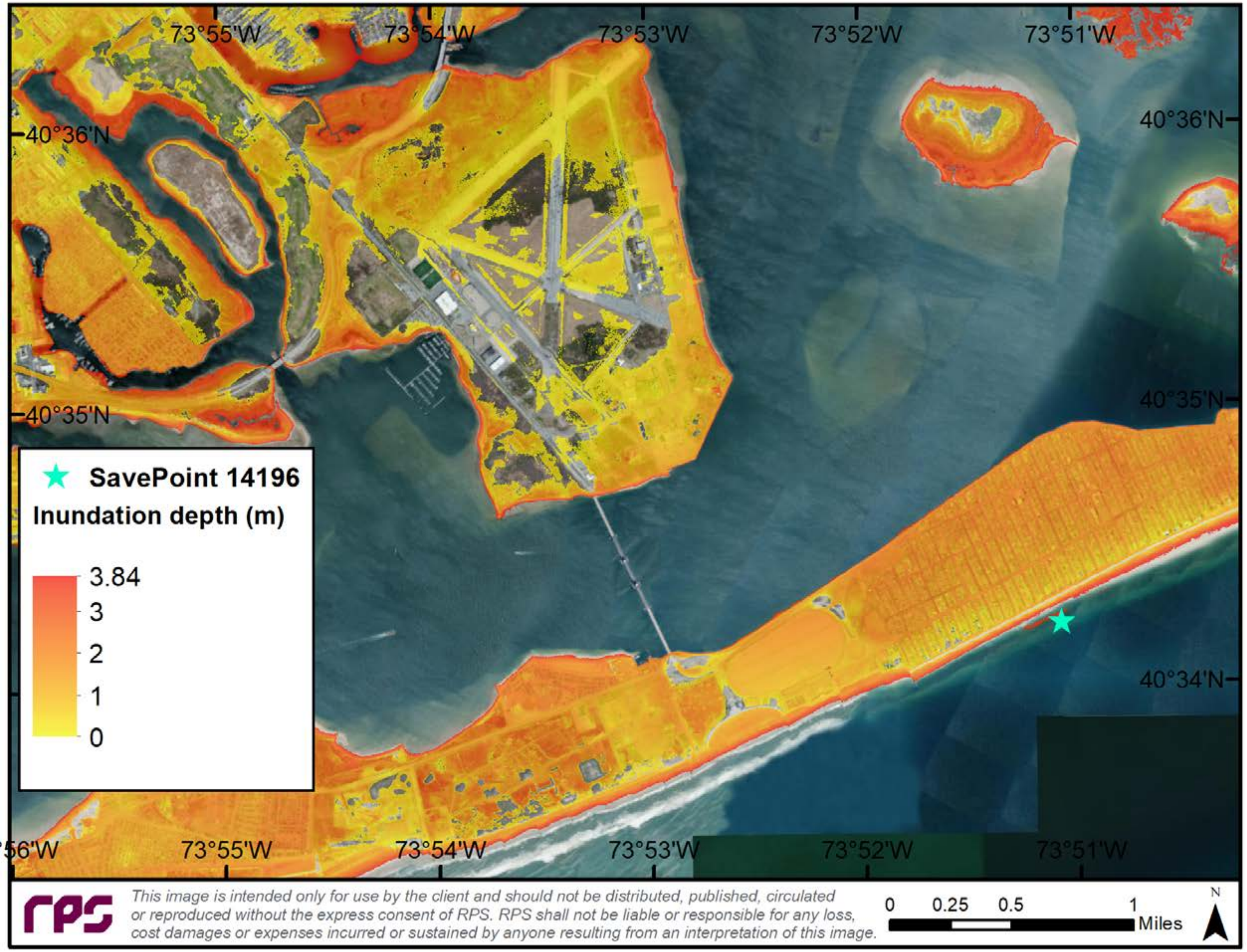


Convert elevation to inundation

To convert the raster to inundation depth, use the **Raster Calculator** to subtract the clipped raster by the flood level (3.84 m) and multiply by -1



Predicted extent and depth of inundation from 100-yr + SLR



Final Note

Locations to access the data:

- USACE Coastal Hazards System Portal
- Northeast Ocean Data, Data Explorer
- NACCSapi
- NROC ArcGIS Server
- NROC ArcGIS geodatabase

THANK YOU!

Questions?

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