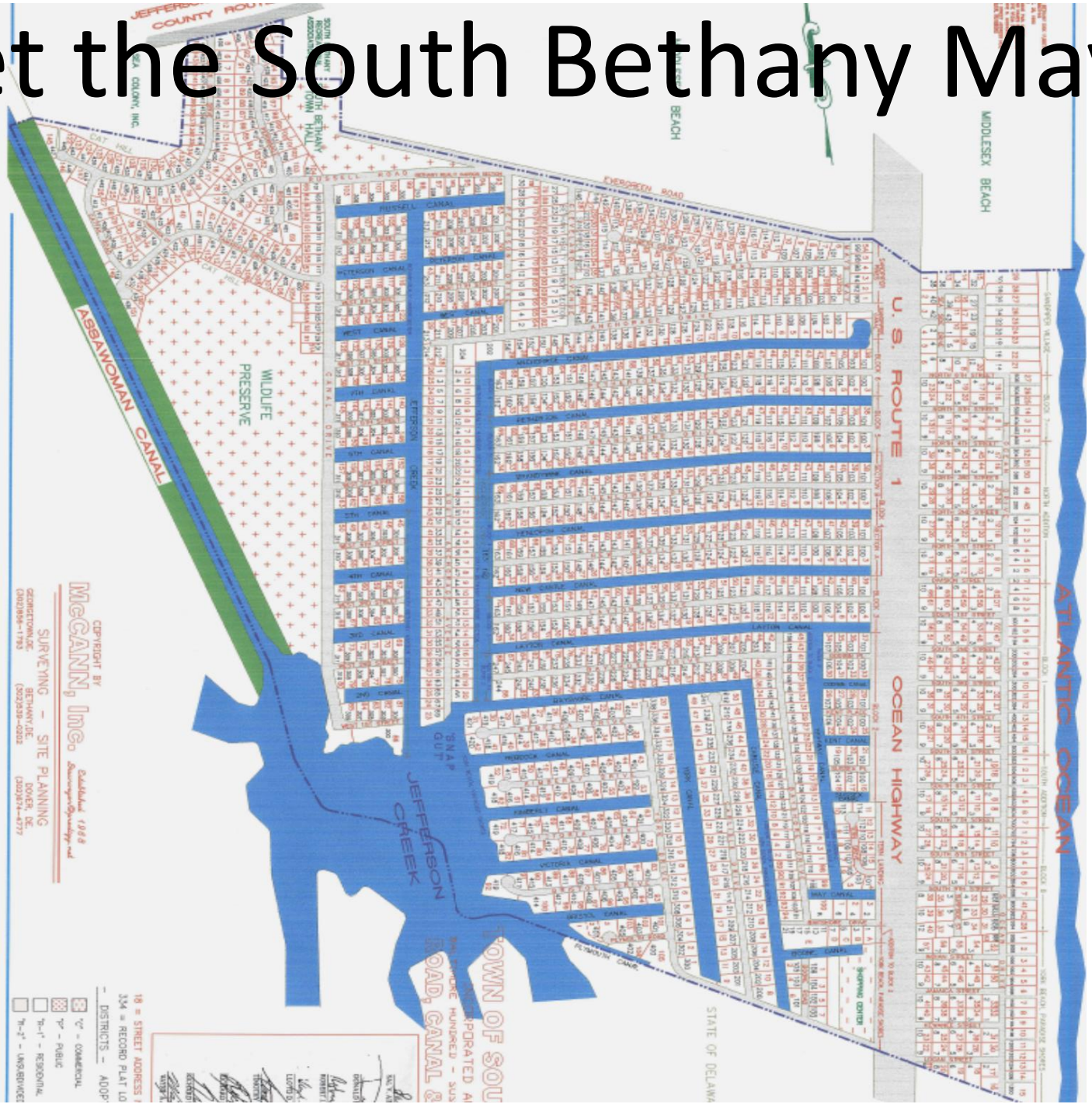
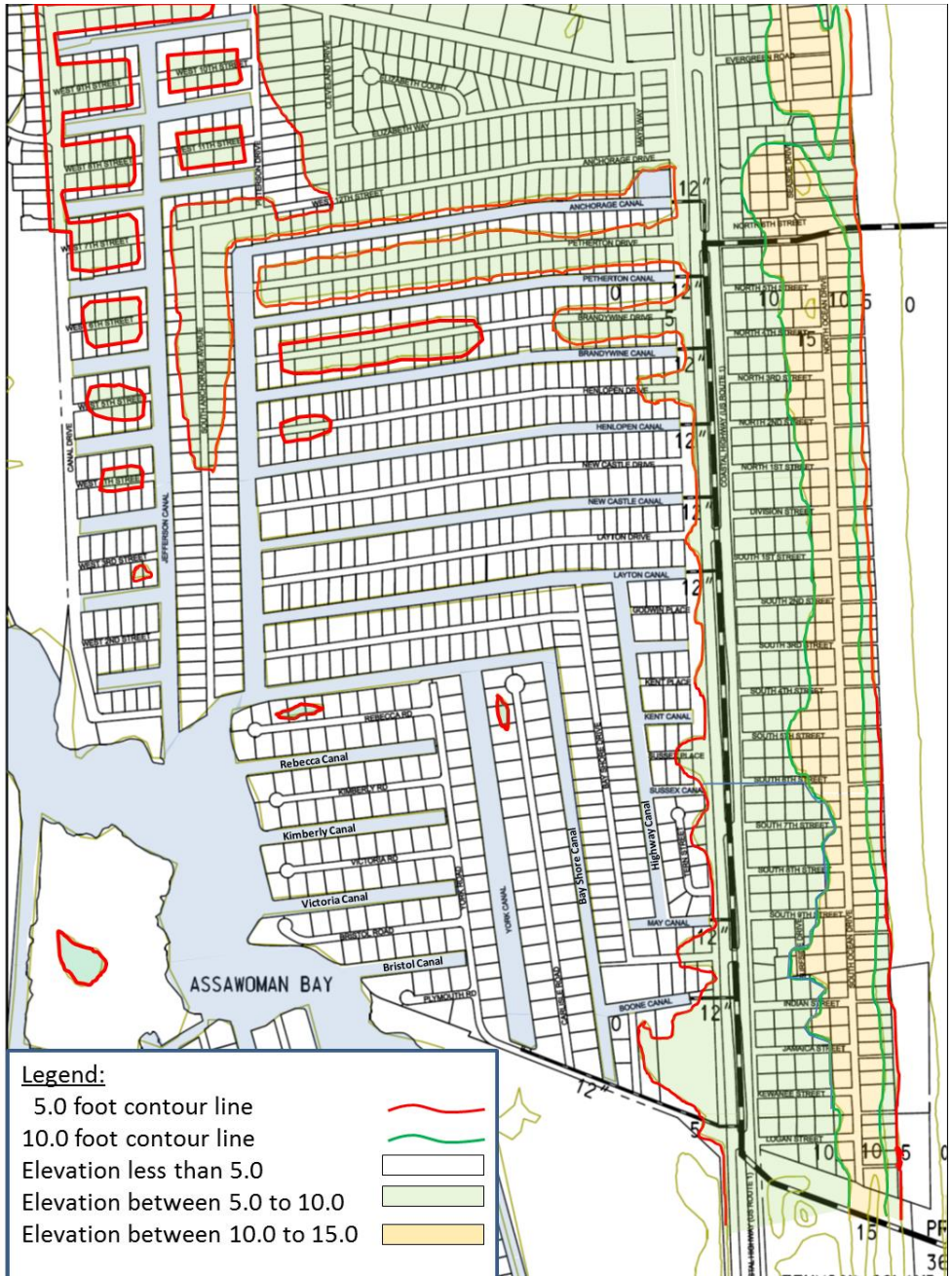
Meet the South Bethany Mayor



Sea Level Rise (SLR) & Storm Surge (SS)

- How High Is South Bethany?
- South Bethany is Very Vulnerable to Storm Surge as Demonstrated by Hurricane Sandy
- Past 100 years – Actuals
- Next 100 Years – Predictions
- Town Has Formed a SLR & SS Adaptation Committee

How High Is South Bethany? – Not Very High!



- Most areas (the white areas on the map) are less than 5 FT NGVD29
- Green areas are between 5 FT and 10 FT NGVD29
- The center of the south bound lane of Rt. 1 is at 5.8 FT NGVD29
- The center of the north bound lane is at 6.8 FT NGVD29
- Ocean Dr. is about 12.0 FT NGVD29, a little higher at the north end and a little lower at the south end.

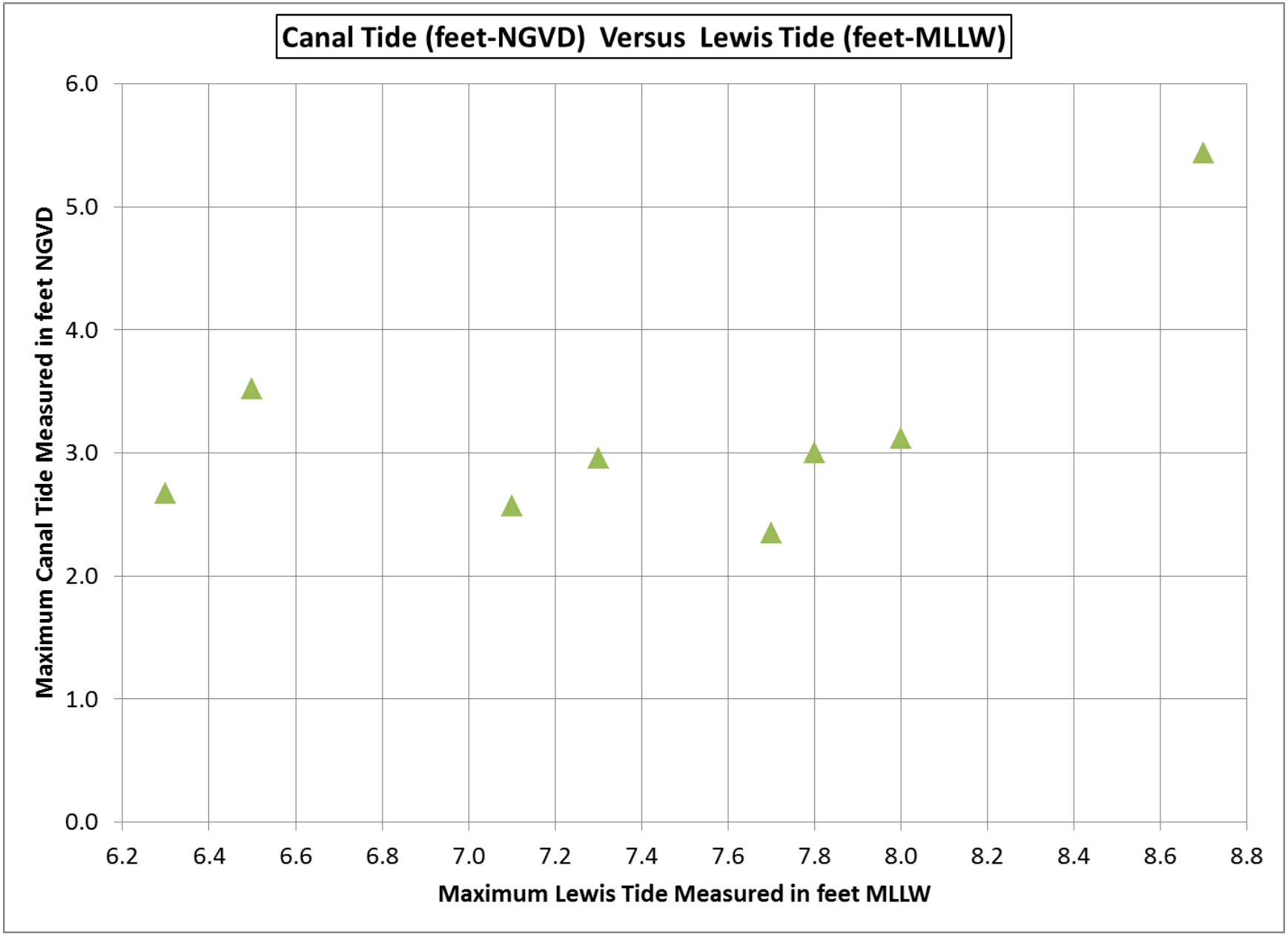
Storm Surge is What Has Flooded South Bethany Bulkhead Heights - All Less Than 5 FT NGVD29

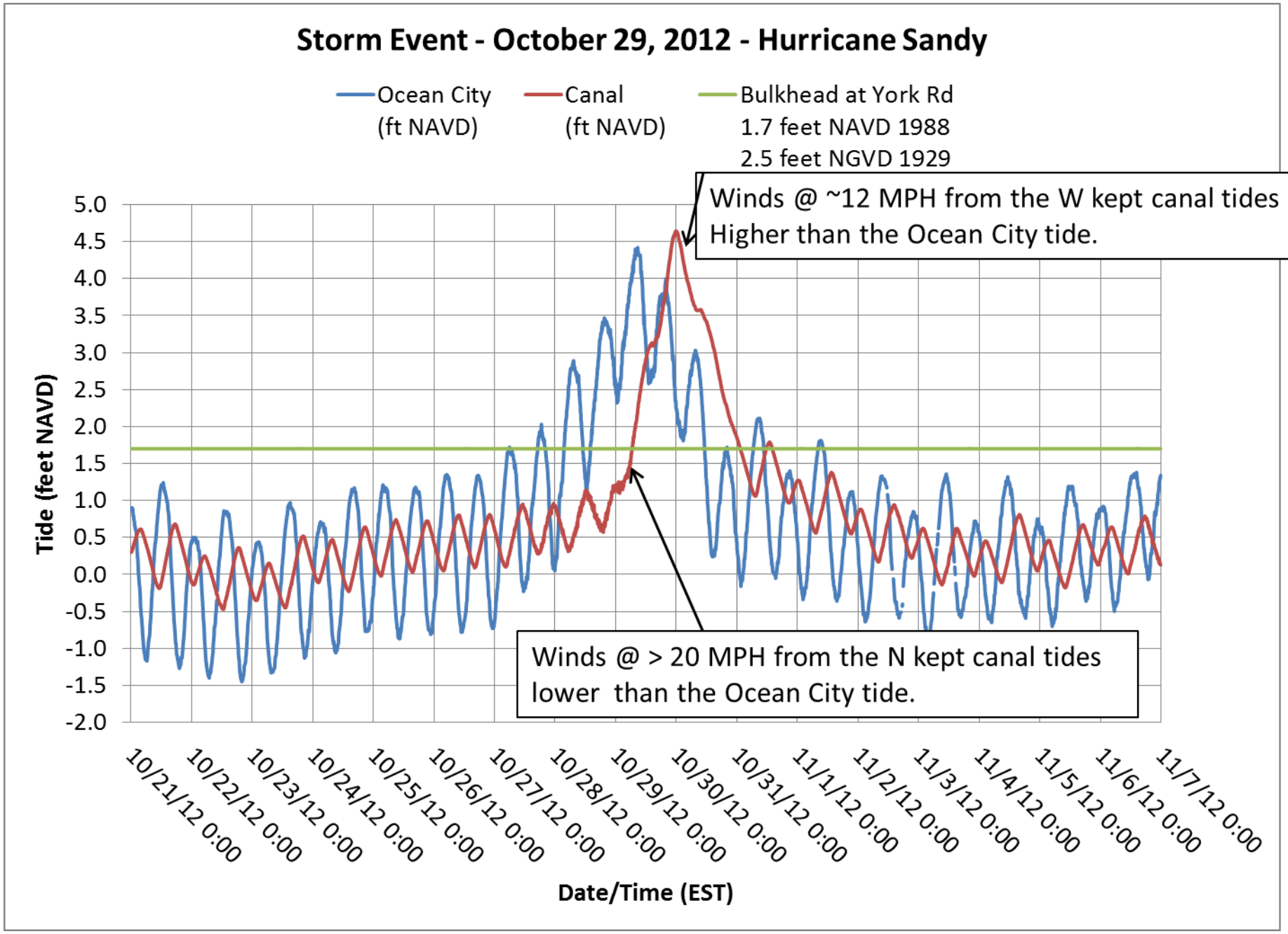
Canal End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)	Flood over Bulkhead on 10/29/2012 (feet)	When Gage is at 2.8 feet. Current value of MHHW at Lewiis
Tide Gage		**3.12**	**3.52**	**5.44**	**2.8**
W. 2nd	2.86	0.26	0.66	2.58	-0.06
W. 3rd	2.77	0.35	0.75	2.67	0.03
W. 4th	3.02	0.10	0.50	2.42	-0.22
W. 5th	3.61	-0.49	-0.09	1.83	-0.81
W. 6th	3.11	0.01	0.41	2.33	-0.31
W. 7th	3.19	-0.07	0.33	2.25	-0.39
W. 8th	3.61	-0.49	-0.09	1.83	-0.81
W. 9th	3.86	-0.74	-0.34	1.58	-1.06
W. Russell	3.36	-0.24	0.16	2.08	-0.56
E. Russell	4.00	-0.88	-0.48	1.44	-1.20
W. 10th	4.00	-0.88	-0.48	1.44	-1.20
W. 11th	3.92	-0.80	-0.40	1.52	-1.12
Anchorage	3.42	-0.30	0.10	2.02	-0.62
Petherton	4.19	-1.07	-0.67	1.25	-1.39
Brandywine	3.36	-0.24	0.16	2.08	-0.56
S. Highway	3.19	-0.07	0.33	2.25	-0.39
York	2.52	0.60	1.00	2.92	0.28
Rebeca	3.94	-0.82	-0.42	1.50	-1.14
Kimberly	2.69	0.43	0.83	2.75	0.11
Victoria	2.86	0.26	0.66	2.58	-0.06
Bristol	2.69	0.43	0.83	2.75	0.11
Boone	4.02	-0.90	-0.50	1.42	-1.22
N. Highway	2.78	0.34	0.74	2.66	0.02
W. May	3.04	0.08	0.48	2.40	-0.24
E. May	3.52	-0.40	0.00	1.92	-0.72
Layton	2.71	0.41	0.81	2.73	0.09
Henlopen					
Maximum	**4.19**				
Minimum	**2.52**				

Street End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)	Flood over Bulkhead on 10/29/2012 (feet)	When Gage is at 2.8 feet. Current value of MHHW at Lewiis
Tide Gage		**3.12**	**3.52**	**5.44**	**2.8**
Plymouth					
Bristol					
Victotia					
Kimberly					
Rebecca	3.46	-0.34	0.06	1.98	-0.66
W. Bayshore	2.88	0.24	0.64	2.56	-0.08
Layton	2.72	0.40	0.80	2.72	0.08
New Castle	3.08	0.04	0.44	2.36	-0.28
Henlopen	3.34	-0.22	0.18	2.10	-0.54
Brandywine	3.66	-0.54	-0.14	1.78	-0.86
Petherton	4.43	-1.31	-0.91	1.01	-1.63
Sussex					
Kent					
Godwin	3.19	-0.07	0.33	2.25	-0.39
107 Godwin	2.86	0.26	0.66	2.58	-0.06
W. Anchorage	3.58	-0.46	-0.06	1.86	-0.78
W. 11th	4.50	-1.38	-0.98	0.94	-1.70
W. 10th	4.51	-1.39	-0.99	0.93	-1.71
W. 9th	3.28	-0.16	0.24	2.16	-0.48
W. 8th	4.13	-1.01	-0.61	1.31	-1.33
W. 7th	4.06	-0.94	-0.54	1.38	-1.26
W. 6th	3.60	-0.48	-0.08	1.84	-0.80
W. 5th	3.68	-0.56	-0.16	1.76	-0.88
W. 4th	3.69	-0.57	-0.17	1.75	-0.89
W. 3th	3.61	-0.49	-0.09	1.83	-0.81
W. 2th	2.78	0.34	0.74	2.66	0.02
W. 1th	2.79	0.33	0.73	2.65	0.01
Maximum	**4.51**				
Minimum	**2.72**				

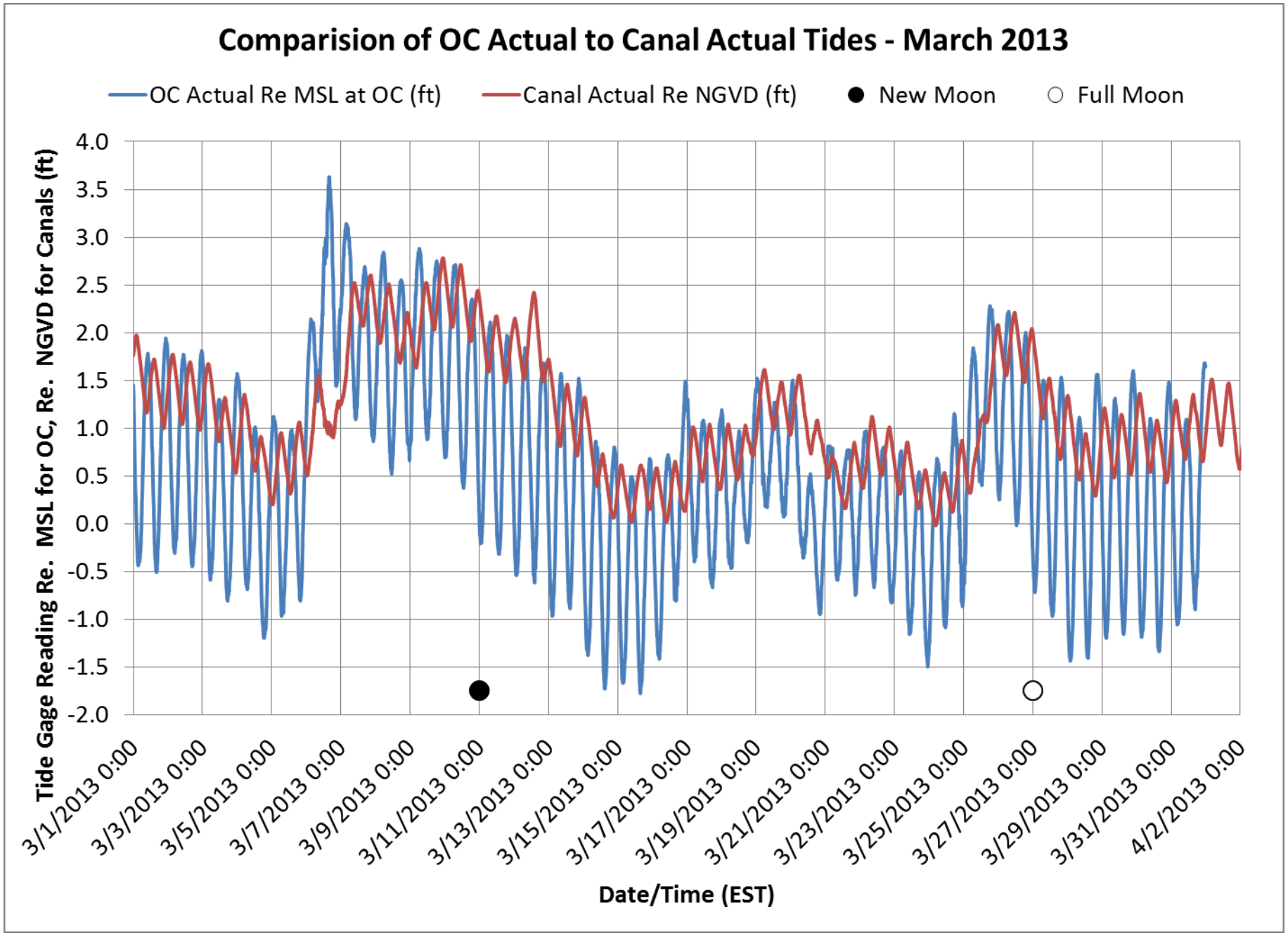
Ocean Tide Is Only One Contributor To The Canal Tide

Wind Is A Significant Contributor To The Tides Seen In Our Canals




Storm Event - October 29, 2012 - Hurricane Sandy
Ocean City (ft NAVD)
Canal (ft NAVD)
Bulkhead at York Rd
1.7 feet NAVD 1988
2.5 feet NGVD 1929
Winds @ ~12 MPH from the W kept canal tides Higher than the Ocean City tide.
Winds @ > 20 MPH from the N kept canal tides lower than the Ocean City tide.
Tide (feet NAVD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
10/21/12 0:00
10/22/12 0:00
10/23/12 0:00
10/24/12 0:00
10/25/12 0:00
10/26/12 0:00
10/27/12 0:00
10/28/12 0:00
10/29/12 0:00
10/30/12 0:00
10/31/12 0:00
11/1/12 0:00
11/2/12 0:00
11/3/12 0:00
11/4/12 0:00
11/5/12 0:00
11/6/12 0:00
11/7/12 0:00
Date/Time (EST)

"South Bethany Relieved Damage Not Worse,
Ground-level houses on west flooded, but none are floating"
News Journal October 31, 2012 - Photo by Robert Craig

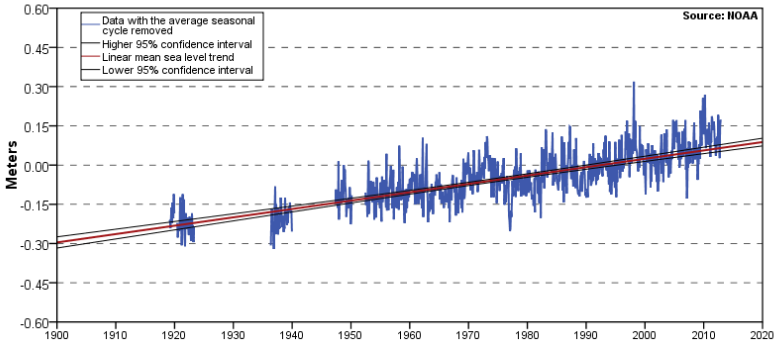

Comparision of OC Actual to Canal Actual Tides - March 2013
OC Actual Re MSL at OC (ft)
Canal Actual Re NGVD (ft)
New Moon
Full Moon
Tide Gage Reading Re. MSL for OC, Re. NGVD for Canals (ft)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
3/1/2013 0:00
3/3/2013 0:00
3/5/2013 0:00
3/7/2013 0:00
3/9/2013 0:00
3/11/2013 0:00
3/13/2013 0:00
3/15/2013 0:00
3/17/2013 0:00
3/19/2013 0:00
3/21/2013 0:00
3/23/2013 0:00
3/25/2013 0:00
3/27/2013 0:00
3/29/2013 0:00
3/31/2013 0:00
4/2/2013 0:00
Date/Time (EST)

Over The Last 100 Years Sea Level Has Risen, Locally, About 1.40 feet

Mean Sea Level Trend
8557380 Lewes, Delaware

1.05 feet in 100 years

Lewes, DE 3.20 +/- 0.28 mm/yr

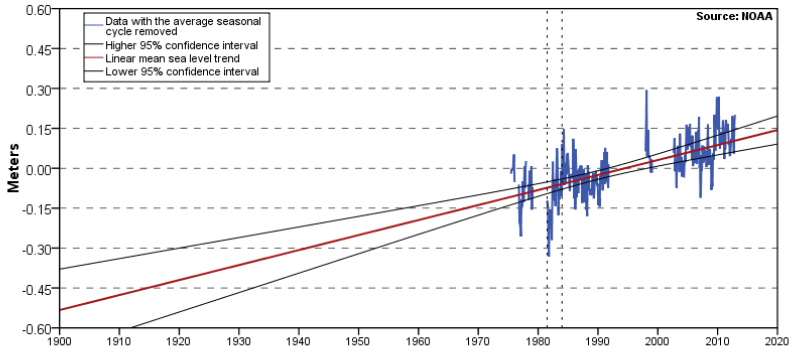


The mean sea level trend is 3.20 millimeters/year with a 95% confidence interval of +/- 0.28 mm/yr based on monthly mean sea level data from 1919 to 2006 which is equivalent to a change of 1.05 feet in 100 years.

Mean Sea Level Trend
8570283 Ocean City, Maryland

1.80 feet in 100 years

Ocean City, MD 5.48 +/- 1.67 mm/yr

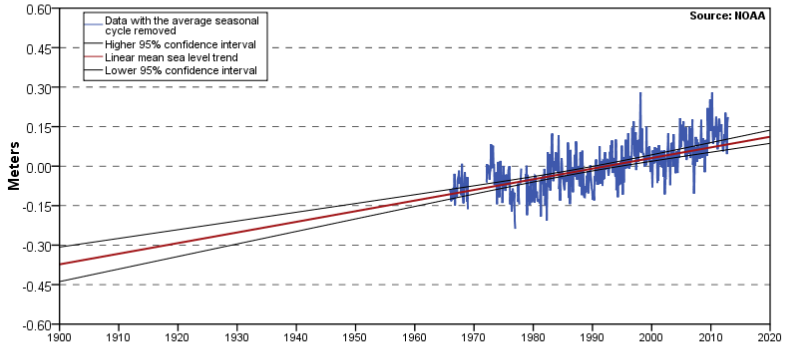


The mean sea level trend is 5.48 millimeters/year with a 95% confidence interval of +/- 1.67 mm/yr based on monthly mean sea level data from 1975 to 2006 which is equivalent to a change of 1.80 feet in 100 years.

Mean Sea Level Trend
8536110 Cape May, New Jersey

1.33 feet in 100 years

Cape May, NJ 4.06 +/- 0.74 mm/yr

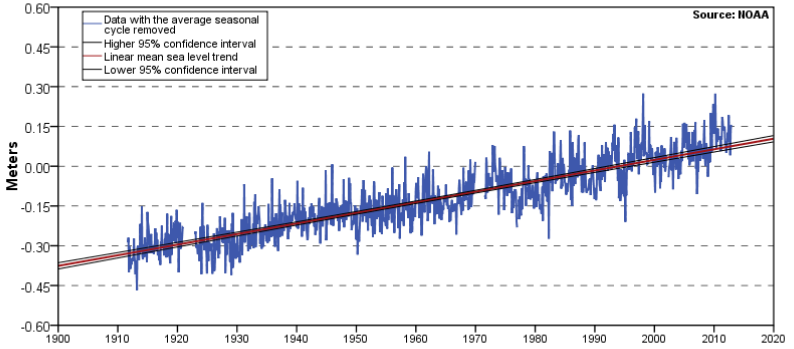


The mean sea level trend is 4.06 millimeters/year with a 95% confidence interval of +/- 0.74 mm/yr based on monthly mean sea level data from 1965 to 2006 which is equivalent to a change of 1.33 feet in 100 years.

Mean Sea Level Trend
8534720 Atlantic City, New Jersey

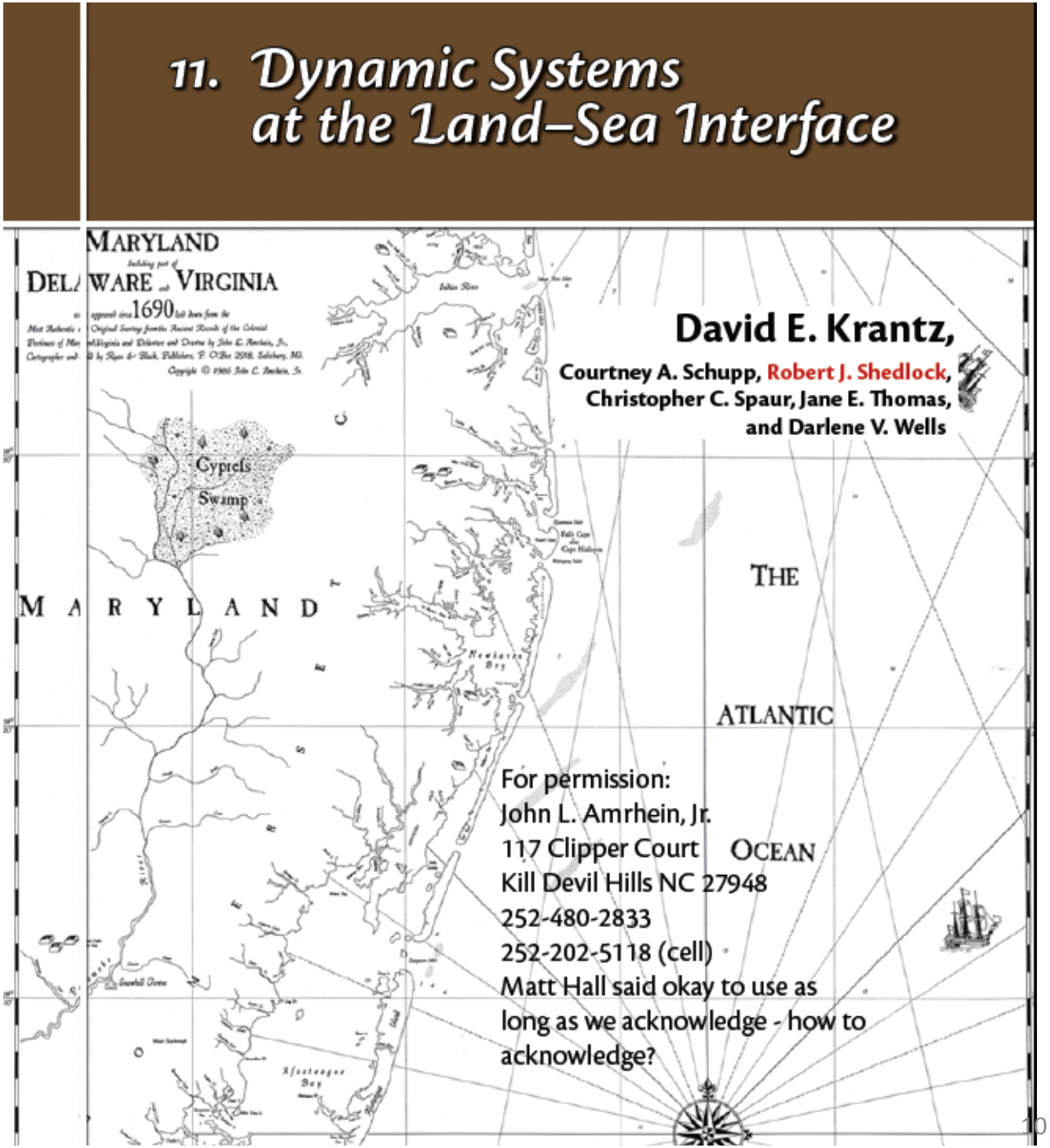
1.31 feet in 100 years

Atlantic City, NJ 3.99 +/- 0.18 mm/yr

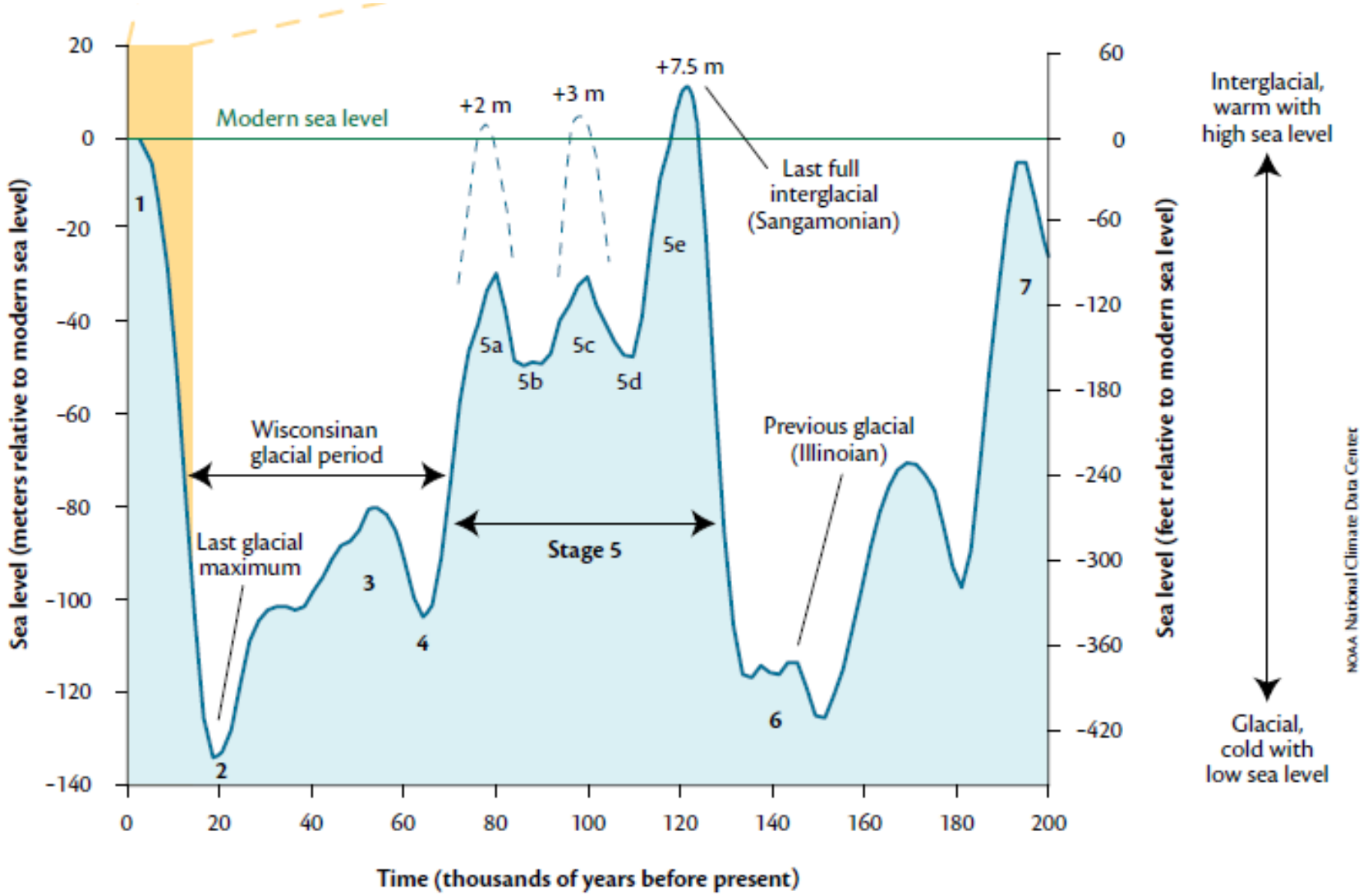


The mean sea level trend is 3.99 millimeters/year with a 95% confidence interval of +/- 0.18 mm/yr based on monthly mean sea level data from 1911 to 2006 which is equivalent to a change of 1.31 feet in 100 years.

The next slide I found on the internet from *Dynamic Systems at the Land – Sea Interface* by David E. Krantz

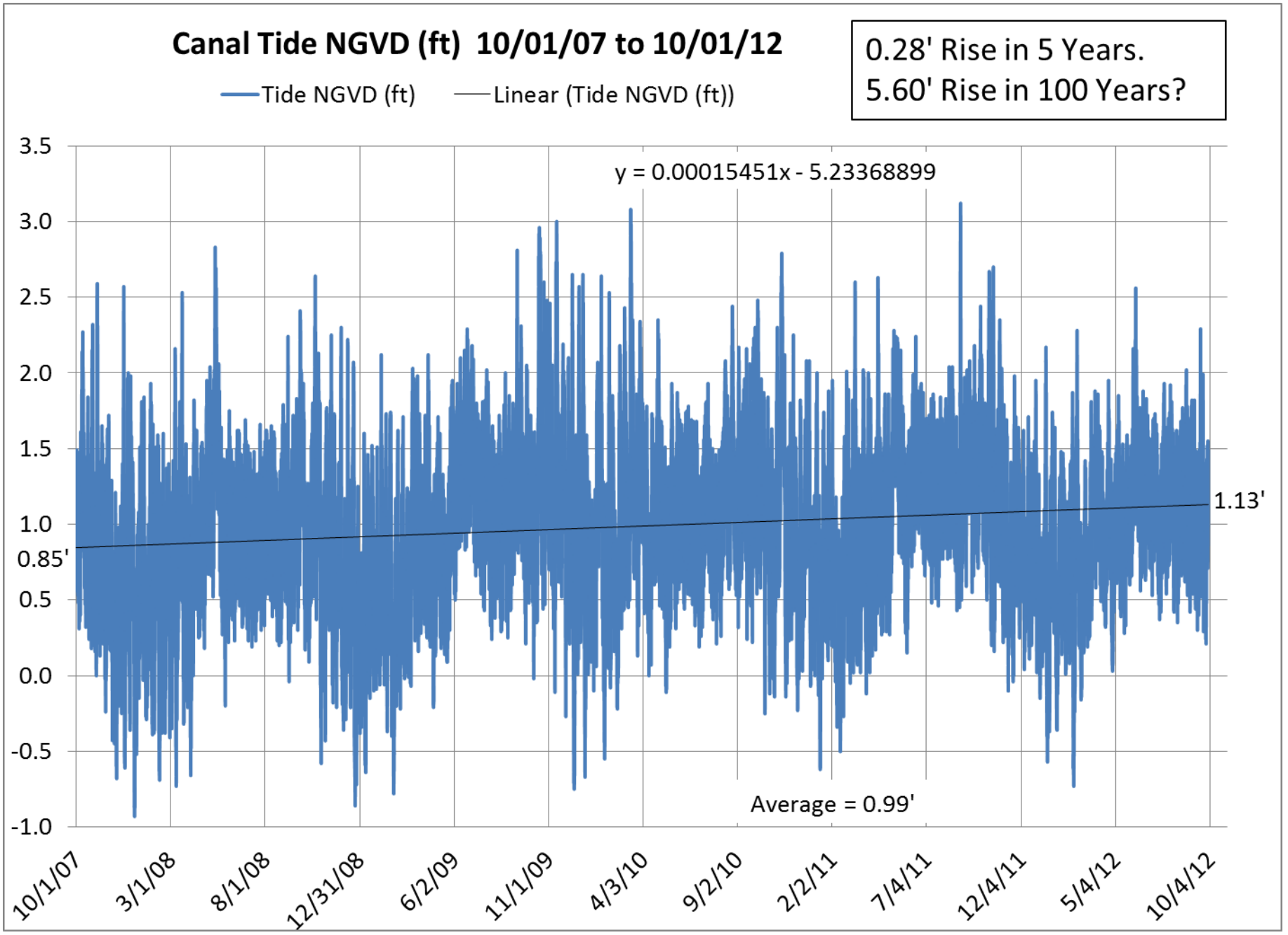


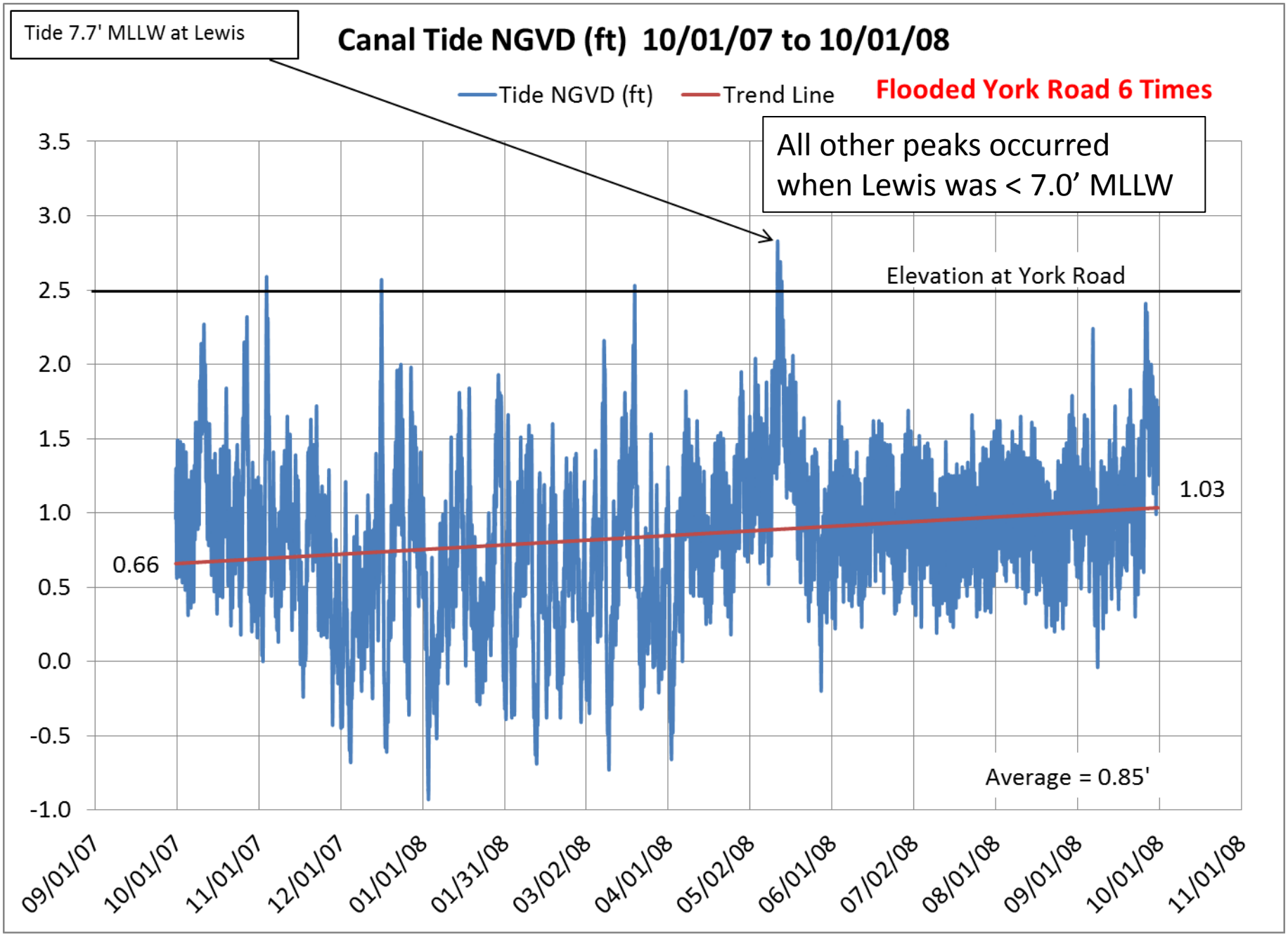
We Are Coming Out Of An Ice Age

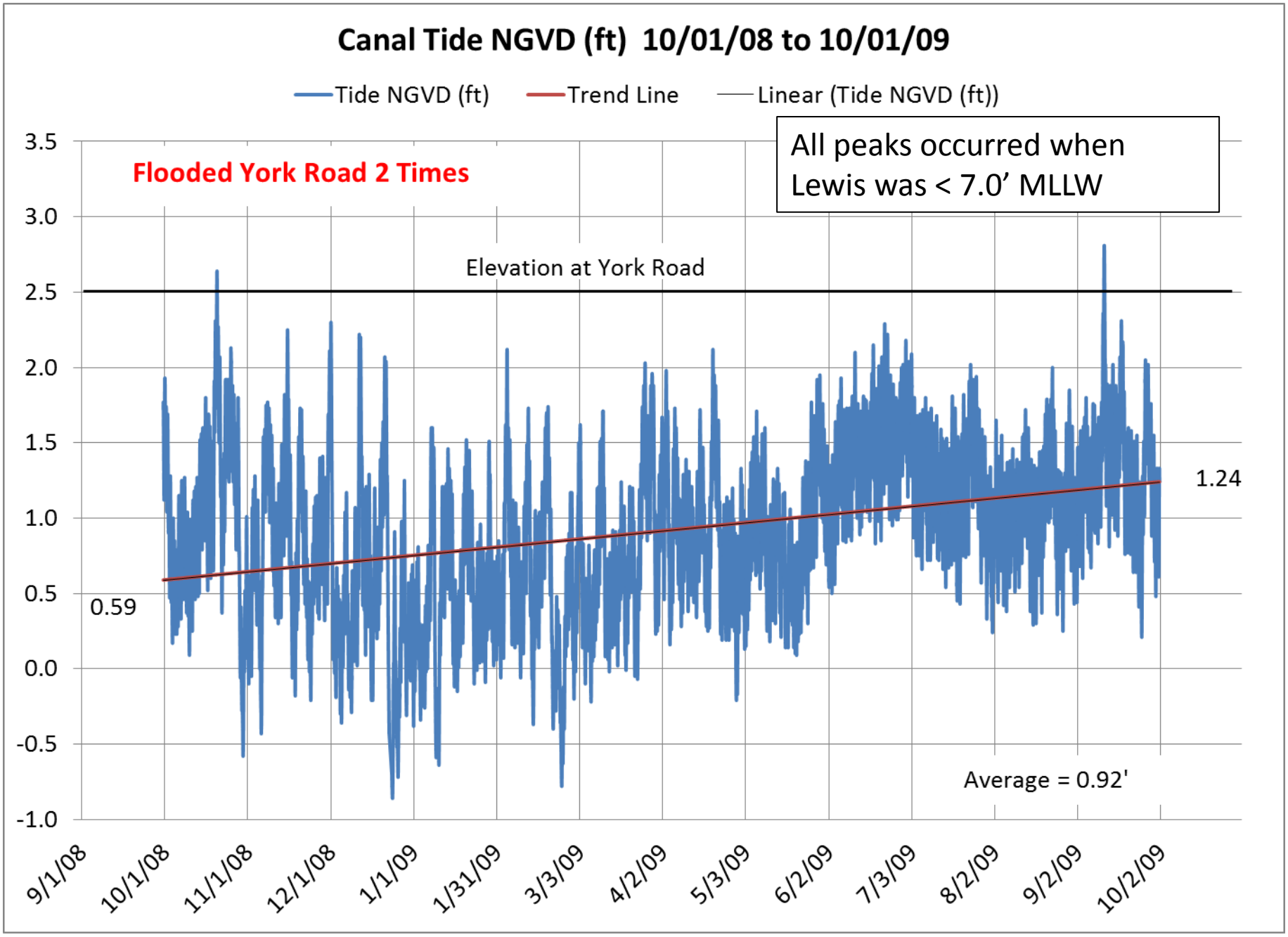


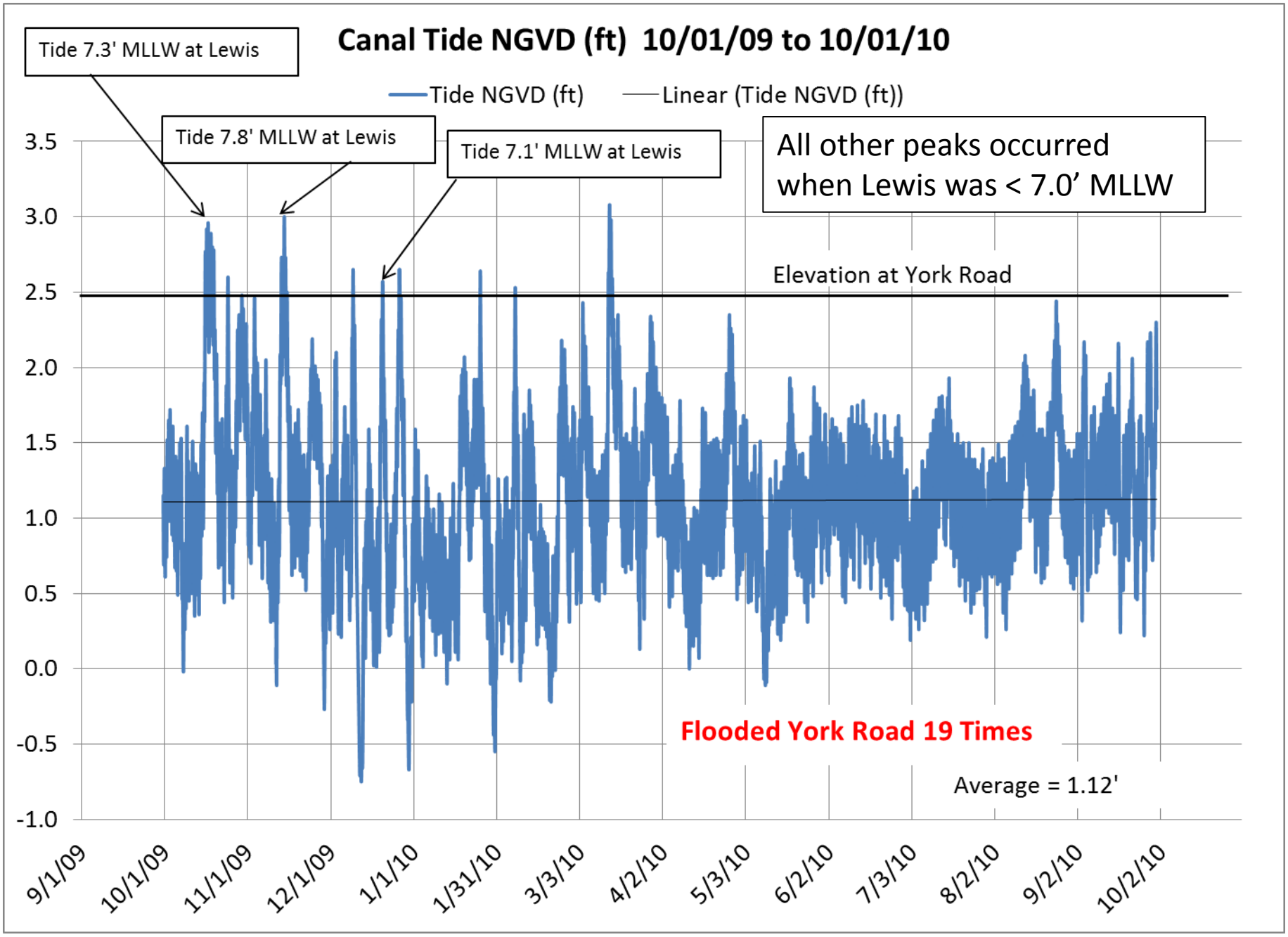
Sea level fluctuations globally and locally along the Mid-Atlantic coast over the past 200,000 years. The lower panel shows global ice volume converted to sea level relative to present.[25]. Dashed blue lines indicate local elevations on Delmarva of sea level highstands associated with substages 5a and 5c. The upper panel shows the rise in sea level over the last 14,000 years for the Delaware coast from radiocarbon dates of peats and wood.[36]

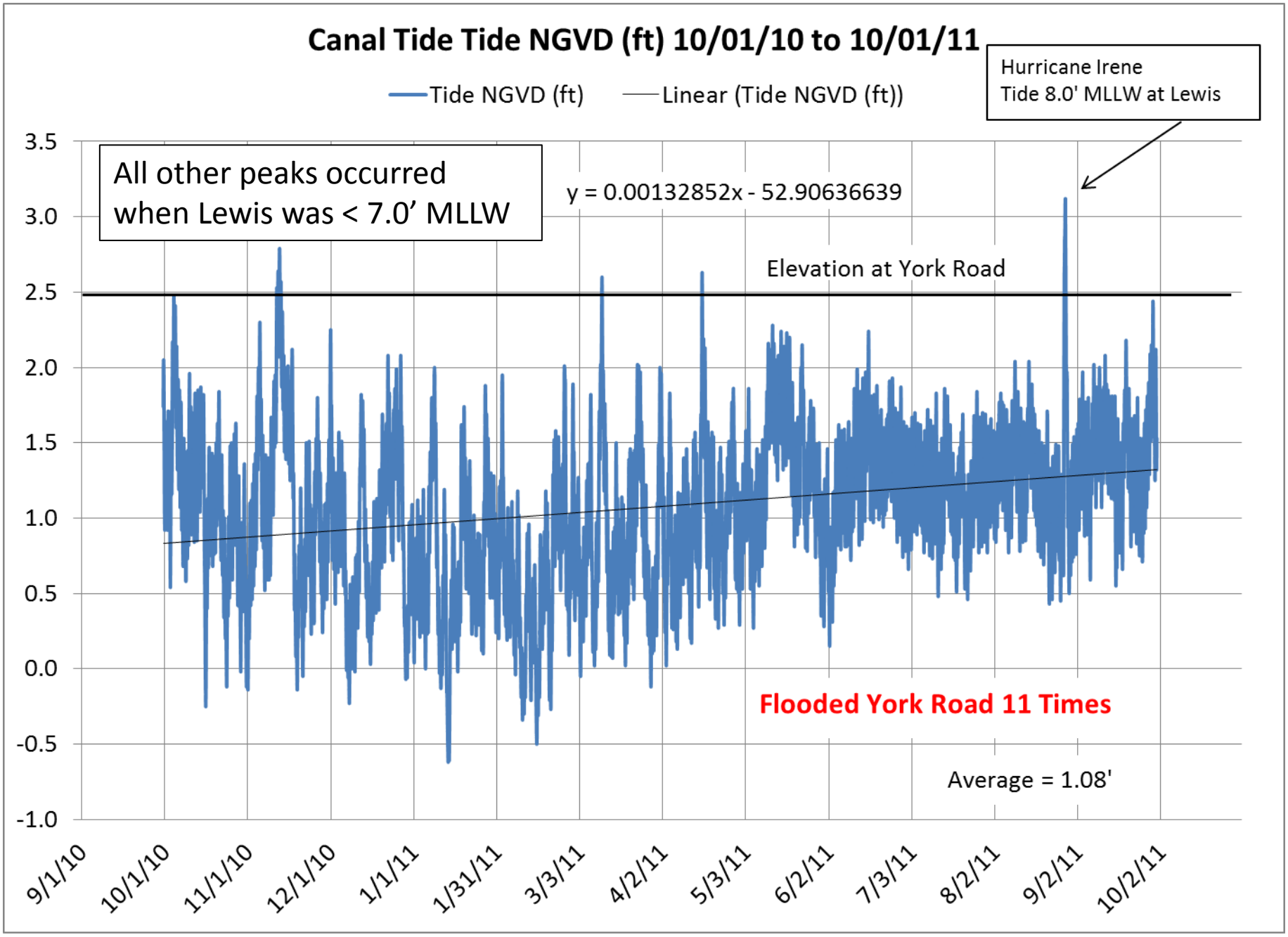
The West Side Is Most Concerned With Canal Level Not Sea Level

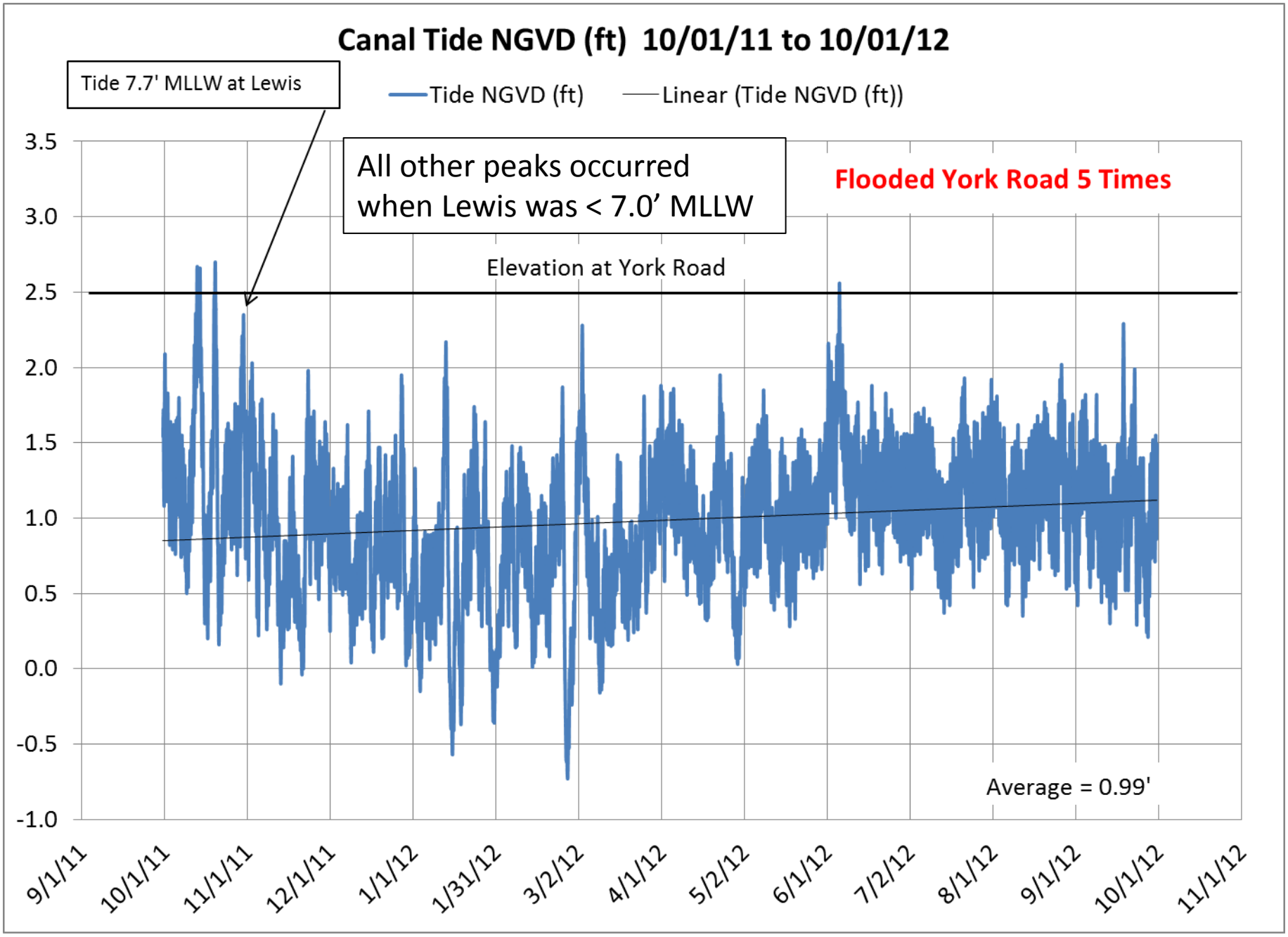

Canal Tide NGVD (ft) 10/01/07 to 10/01/12
Tide NGVD (ft)
Linear (Tide NGVD (ft))
0.28' Rise in 5 Years.
5.60' Rise in 100 Years?
y = 0.00015451x - 5.23368899
3.5
3.0
2.5
2.0
1.5
1.0
0.85'
0.5
0.0
-0.5
-1.0
1.13'
Average = 0.99'
10/1/07
3/1/08
8/1/08
12/31/08
6/2/09
11/1/09
4/3/10
9/2/10
2/2/11
7/4/11
12/4/11
5/4/12
10/4/12


Tide 7.7' MLLW at Lewis
Canal Tide NGVD (ft) 10/01/07 to 10/01/08
Tide NGVD (ft)
Trend Line
Flooded York Road 6 Times
All other peaks occurred when Lewis was < 7.0' MLLW
Elevation at York Road
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0.66
1.03
Average = 0.85'
09/01/07
10/01/07
11/01/07
12/01/07
01/01/08
01/31/08
03/02/08
04/01/08
05/02/08
06/01/08
07/02/08
08/01/08
09/01/08
10/01/08
11/01/08


Canal Tide NGVD (ft) 10/01/08 to 10/01/09
Tide NGVD (ft)
Trend Line
Linear (Tide NGVD (ft))
All peaks occurred when Lewis was < 7.0' MLLW
Flooded York Road 2 Times
Elevation at York Road
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0.59
1.24
Average = 0.92'
9/1/08
10/1/08
11/1/08
12/1/08
1/1/09
1/31/09
3/3/09
4/2/09
5/3/09
6/2/09
7/3/09
8/2/09
9/2/09
10/2/09


Canal Tide NGVD (ft) 10/01/09 to 10/01/10
Tide 7.3' MLLW at Lewis
Tide 7.8' MLLW at Lewis
Tide 7.1' MLLW at Lewis
Tide NGVD (ft)
Linear (Tide NGVD (ft))
All other peaks occurred when Lewis was < 7.0' MLLW
Elevation at York Road
Flooded York Road 19 Times
Average = 1.12'
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
9/1/09
10/1/09
11/1/09
12/1/09
1/1/10
1/31/10
3/3/10
4/2/10
5/3/10
6/2/10
7/3/10
8/2/10
9/2/10
10/2/10


Canal Tide Tide NGVD (ft) 10/01/10 to 10/01/11
Tide NGVD (ft)
Linear (Tide NGVD (ft))
Hurricane Irene
Tide 8.0' MLLW at Lewis
All other peaks occurred when Lewis was < 7.0' MLLW
y = 0.00132852x - 52.90636639
Elevation at York Road
Flooded York Road 11 Times
Average = 1.08'
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
9/1/10
10/1/10
11/1/10
12/1/10
1/1/11
1/31/11
3/3/11
4/2/11
5/3/11
6/2/11
7/3/11
8/2/11
9/2/11
10/2/11


Canal Tide NGVD (ft) 10/01/11 to 10/01/12
Tide 7.7' MLLW at Lewis
Tide NGVD (ft)
Linear (Tide NGVD (ft))
All other peaks occurred when Lewis was < 7.0' MLLW
Flooded York Road 5 Times
Elevation at York Road
Average = 0.99'
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
9/1/11
10/1/11
11/1/11
12/1/11
1/1/12
1/31/12
3/2/12
4/1/12
5/2/12
6/1/12
7/2/12
8/1/12
9/1/12
10/1/12
11/1/12

The next two pages are from

Global Mean SLR Scenarios

We have very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100.

Table ES-1. Global SLR Scenarios

Scenario	SLR by 2100 (m)*	SLR by 2100 (ft)*
Highest	2.0	6.6
Intermediate-High	1.2	3.9
Intermediate-Low	0.5	1.6
Lowest	0.2	0.7

* Using mean sea level in 1992 as a starting point.

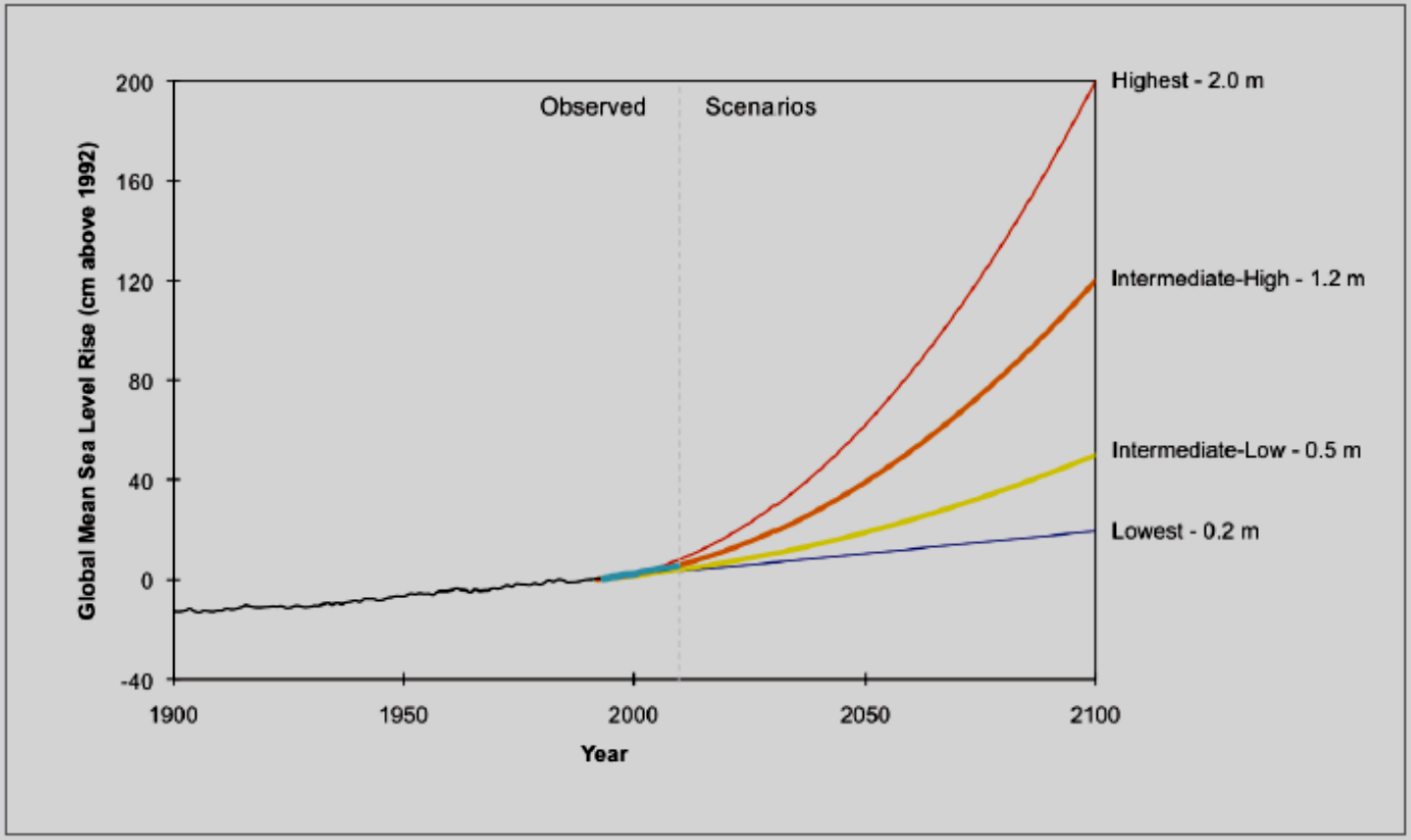
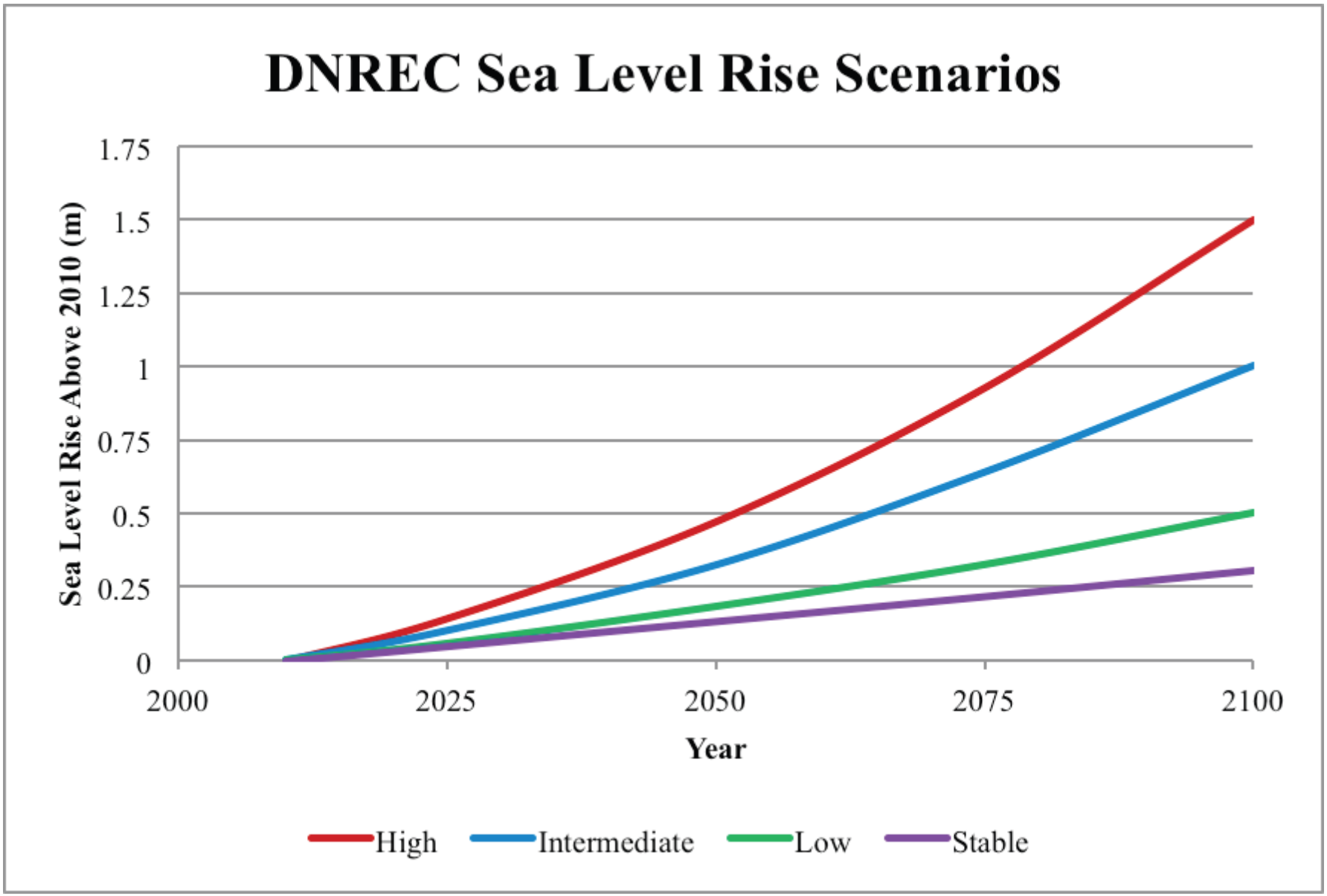


Figure ES 1. Global mean sea level rise scenarios. Present Mean Sea Level (MSL) for the US coasts is determined from the National Tidal Datum Epoch (NTDE) provided by NOAA. The NTDE is calculated using tide gauge observations from 1983 – 2001. Therefore, we use 1992, the mid-point of the NTDE, as a starting point for the projected curves. The Intermediate-High Scenario is an average of the high end of ranges of global mean SLR reported by several studies using semi-empirical approaches. The Intermediate Low Scenario is the global mean SLR projection from the IPCC AR4 at the 95% confidence interval.

Four Charts From *Preparing For Tomorrow's High Tide*



Predicted Flooding Of Roads

Arial View of South Bethany

Average Tide
about 1.0’ NGVD

Five Charts From
http://www.dnrec.delaware.gov/Pages/SLRMaps.aspx

Arial View of South Bethany

Current Mean Higher High Water (MHHW) at Lewis about **2.8' NGVD**

York Rd is flooded.
Slight flooding on Layton and New Castle.

Arial View of South Bethany

Current Mean Higher High Water (MHHW) at Lewis combined with
0.5 meter sea level rise
about **4.4' NGVD**

Significant flooding in south part of South Bethany west of Route 1.

No flooding on Route 1.

This is 1.0 feet less than the tide that was seen during Hurricane Sandy.

Arial View of South Bethany

Current Mean Higher High Water (MHHW) at Lewis combined with **1.0 meter** sea level rise about 6.1’ NGVD

Almost all of South Bethany west of Route 1 is flooded. McCabe parking lot is still dry.

Southbound lane (elevation 5.8’ NGVD) of Route 1 is flooded. Northbound lane (elevation 6.8’ NGVD) is still dry.

This is 0.7 feet more than the tide that was seen during Hurricane Sandy.

It Is A Fact – Sea Level Is Rising.
What Strategies Will South Bethany Use To Adapt To Sea Level Rise?

- Ostrich Strategy – Sea Level is not rising – Do nothing.
- Protection Strategies – Actions that would keep rising waters out of a specific area. Examples for South Bethany include;
  - Raising bulkheads to restrain canal water
  - Adding bulkheads to restrain Little Assawoman Bay and Assawoman Canal
  - Pumps to remove storm water
  - Continued beach replenishment to build up dunes and beach
- Accommodation Strategies – Actions that allow continued use of area or structure without shoreline structures. Examples for South Bethany include;
  - Raising Buildings
  - Raising roads
  - Raising land – To raise a 5,000 ft^2 lot 1 foot requires 185 yd^3 of soil.
- Retreat Strategies – Actions that plan for the eventual removal of structures. This is a non starter for South Bethany.

Quote below is from http://www.wetlandswatch.org/Home.aspx

A "TOOLKIT" FOR SEA LEVEL RISE ADAPTATION IN VIRGINIA

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Many legal and financial disincentives complicate the process of getting individual landowners and local governments to start sea level adaptation work today. Most of these adaptation measures depend on changes to current shoreline land use expectations that limit development and redevelopment options. Local governments are reluctant to place conditions on the development and redevelopment of private shoreline land today, and forego the increased property tax revenues that may come from the higher uses of these shoreline properties, frequently the highest value segment of a locality's property tax base. Similarly, private landowners are resistant to restrict their development and redevelopment options in order to adapt to future sea level rise impacts without fair compensation for the loss of expected return from an unrestricted land use.

The asymmetry of asking localities and individuals to forego present economic gain based upon a potential sea level rise impact coming decades in the future is the main factor hindering adaptation strategy development today. This resistance can even hinder detailed local government planning efforts as these plans begin to identify individual parcels of land that will be at risk from inundation, diminishing their market value. Finding ways to overcome the conflict between current economic incentives and long-range sea level rise adaptation needs is a major challenge to be overcome if we are to start adaptation planning and implementation today.

Discussion of South Bethany Sea Level Rise (SLR) Potential Adaptation Options

- **AVOID** – This is no longer an option. We are already here. There are only about 80 lots that have not been developed.
- **RETREAT** – I am assuming that the state will do what is required to accommodate SLR so that Route 1 remains open from Lewes to Fenwick Island (FI). They have already raised part of Route 54 near FI to accommodate flooding. This will be a viable option for homeowners in South Bethany (SB) who are not willing to pay the cost for PROTECTION and/or ACCOMMODATION. I believe that SB as a Town would not select RETREAT as an option.
- **ACCOMMODATE** – Home owners can raise their homes, driveways, lots. The Town can raise their roads. The Comprehensive Development Plan (CDP) should be updated to include SB's plans to ACCOMMODATE SLR.
- **PROTECT** – The town and homeowners can raise the bulkheads. The Town can raise roads like Canal Drive, York Road and York Drive to provide a barrier. Their still would be some properties that would be very hard to PROTECT. The CDP should be updated to include SB's plants to PROTECT against SLR. If protect is the strategy we must figure out what we are going to do with rainfall. See map below. Only some of the raised bulkheads are shown. All must be raised. There may not currently be any bulkheads where some are shown in black. Not all properties are shown protected.

Sea Level Rise (SLR) and Storm Surge (SS) Adaptation Committee

Mission Statement

Given the increasing information about future concerns that coastal communities like South Bethany may face from Sea Level Rise and Storm Surge, as demonstrated by Hurricane Sandy in October 2013, the SLR & SS Adaptation Committee will:

- Conduct a SLR & SS Vulnerability Assessment that will identify homes, infrastructure and community spaces that may be at risk for SRL & SS.
- Gather relevant data and expertise to understand the possible hazards and costs associated with SLR & SS;
- Identify potential adaptation options;
- Evaluate adaptation options;
- Recommend adaptation options;
- Develop a proactive reasonable response based on information and research;

with the overall goal being the future protection of both the property owners' and the Town's assets.