BERKELEY **TOWNSHIP**

TOWNSHIP HALL
Pinewald-Keswick Road
P.O. Box B
Email: RSecretary@aol.com

WATERWAYS ADVISORY COMMISSION
William E. McGrath, Chairman
Lee Gashlin, Vice Chairman
Fred Bekiarian, Secretary
Larry Borio, Commissioner
Thomas Bellinato, Commissioner
Jerome Bollettieri, Commissioner
Samuel Cammarato, Commissioner
Vito Esposito, Commissioner
Robert Nunn, Commissioner

Oct. 12, 2014

The Honorable Carmen F. Amato, Jr., Mayor
and Members of the Berkeley Township Council
Township Hall
Pinewood-Keswick Road
P.O. Box B
Bayville, NJ, 08721

Dear Mayor Amato and Members of the Township Council:

As you know, last spring our Commission prepared a Dune Assessment report on Island Beach State Park (IBSP). Our report consisted of documented measurements of water levels in Barnegat Bay during Superstorm Sandy utilizing real time tide gauge stations with satellite telemetry at the Mathis Bridge, Seaside Heights and Mantoloking, along with photographic proof of dune degradation and various breaches that occurred during the storm.

Presently, we have evaluated the following two reports on the matter:

1. "Barnegat Bay Storm Surge Elevations During Hurricane Sandy And Sources Of Flooding Within The Bay" Prepared by The Richard Stockton College of New Jersey.

2. "Island Beach State Park Breach Analysis" Prepared by Stevens Institute of Technology.

Both reports reach the same conclusion that the breaches at IBSP did not "significantly" add to the water levels in Barnegat Bay during the storm. In evaluating the reports, we have found significant mathematical errors, discrepancies and unproven assumptions. The following is a detailed analysis of each report.

Stockton College Report:

The Stockton report attempts to quantify the water surface (in square feet) in Barnegat Bay. It then attempts to compute the storm surge inflow (in cubic feet per second) at the Point Pleasant Canal, Barnegat Inlet and various breaches of the barrier island from Mantoloking to IBSP. In calculating the square foot surface area, the report utilizes acreage figures obtained from NJDEP 2007 Land Use geo-database. In converting the acreages to square feet the report erroneously uses 43,500 square feet per acre instead of the correct 43,560 sq. ft. At first glance the 60 sq. ft. mistake may seem de minimus but, when it is used as a multiplier with a 5 digit multiplicand the resultant answer is quite significant. This error was perpetuated twice on page 2 of the report with the two erroneous figures added together to further compound the mistake. This error produces a distortion of over 5.5 million square feet.

Particular attention was taken on page 8 of the report. In the paragraph entitled "Island Beach State Park Overwash Events", the report attempts to quantify the storm surge inflow from the Ocean to the Bay (in cubic feet per second).

Before we analyze this part of the report we have to define the types of flooding IBSP can be subjected to.

FEMA defines three types of flooding IBSP and all of the barrier island is, or can be subjected to. They are VE, AE and AO. VE is wave velocity flooding from a lateral direction (ocean waves). AE flooding is vertical rising water level with little or no lateral movement. AO flooding is sheet flow from a higher elevation to a lower elevation, usually 1 or 2 ft. deep (eg. ocean water running down the street to a lower level or the bay). VE and AO flooding usually leave evidence such as an alluvial fan of sand deposits (***Figure 1***)

Figure 1: Alluvial deposit of sand at mile marker 2.27

AE (vertically rising tide) flooding usually does not leave such sand deposits. In many instances an area can experience both an AO (lateral sheet flow) and AE (rising tide) flooding at the same time and place. In those instances, whole areas could be under water with little or no residual evidence after the flood has receded.

Figure 2: Residual flood water trapped in roadway 3 days after storm

Figure 2 shows residual trapped flood water in the roadway at mile marker 4.71 three days after the storm. Note that there is no alluvial deposited sand to the immediate right and left of the standing water. This is one of many areas that should have been used to calculate the cubic feet per second inflow but was not in the Stockton report.

The Stockton report states on page 8 that *"A careful review of the entire length of the Isand Beach State Park as covered by the immediate post Sandy aerial photography shows that one overwash element moved sand into Barnegat Bay, but all others the alluvial fan of overwash sand deposited died out at the highway or prior to reaching it".*

The Stockton report on page 8 then proceeds to calculate the volume (in cubic feet) of storm surge inflow from the ocean to the bay at 4 breach sites.

Both the Stockton report and our findings agree that the peak storm surge water levels were approximately 9 feet NAVD'88 for the ocean. The Stockton report assumes 4 breach locations each with a width of 200 feet wide by 3 feet deep. This analysis has found 13 breached locations that will be detailed on subsequent pages. The Stockton report uses a 3 foot depth on a typical breach cross section using the 9 foot storm surge level minus an assumed uniform road elevation of 6 ft. NAVD'88. This analysis has accurately measured the road elevations at each breach location (13 documented herein) using a Leica GS 14 RTK GPS with a Smartnet connection to the CORS transmitter atop the Ocean County Administration Building. That produced an accuracy of plus or minus 0.06 ft. We have found that each of the road elevations range in height from a low of 3.36 ft. to a high of 6.63 ft. with the average being 4.57 ft. The 4.57 roadway height would produce a depth value of 4.43 feet as opposed to Stockton's 3 ft. value.

The formula used in the Stockton report is as follows:

600 x 4 x 60 x 60 x 2 hrs x 4 overwash sites = 69,120,000 cubic feet

The Stockton report doesn't explain what the numbers mean but we have as follows: 600 is the "assumed" cross sectional area of one breach (3ft. x 200 ft.), 4 is the feet per second flow rate (assumed not measured), times 60 is the multiplier to obtain cubic feet in one minute, then times 60 again to obtain how many cubic feet in one hour, times 2 hours, times 4 assumed breach sites.

This analysis disagrees with the cross sectional area used in the Stockton report, as we have outlined previously. This analysis also disagrees with the 4 breach site figure as this analysis has documented 13 breach sites as detailed in the following pages. The cross sectional area shown in ***Figure 3*** below displays a typical type of breach that was not accounted for in the Stockton report because the alluvial sand deposit didn't cross the roadway:

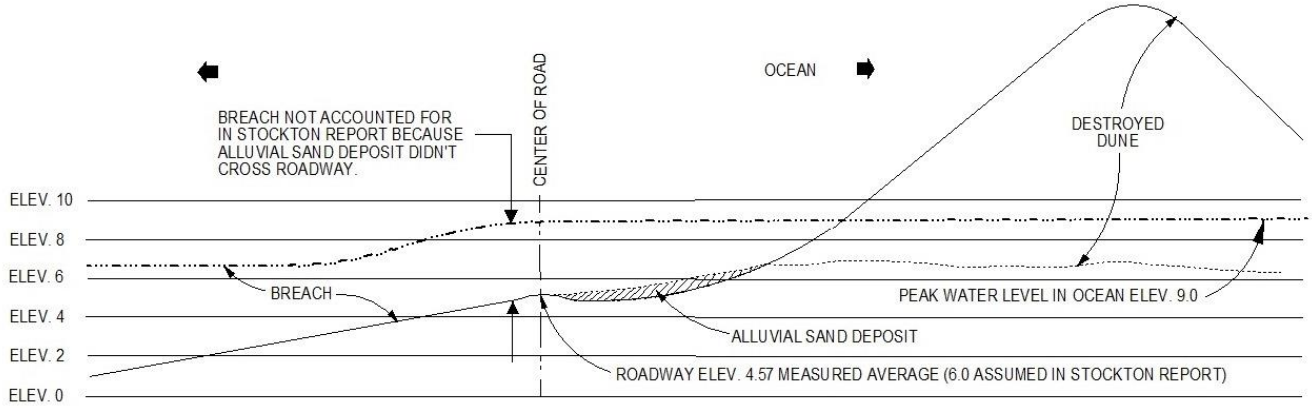

Figure 3

Figure 4: Gate house at Two Bit Road at Mile Marker 0.10

Figure 4 above is another illustration of a breach that was not counted in the Stockton report because the alluvial sand deposit didn't continue to the bay. Eye witness accounts from residents that didn't evacuate stated: "….*Trashed northern dunes at the same latitude as the Island Beach Gatehouse, water came north up Central Avenue, and then down 20th, 21st, 22nd, 23rd and 24th Avenue, meeting the bay waters when the storm pushed the bay up those streets as it spun counter clockwise……" (Berkeley Patch Newspaper 10/11/2014).*

The Stockton report stipulates 4 breach points with an assumed (not measured) generic width of 200 feet and an assumed (not measured) depth of 3 feet. This analysis documents 13 breach points similar to ***Figure 4*** above with photographic evidence. The widths that vary up to 400 feet wide as measured on the aerial photograph.

The following is a listing of the 13 documented breach locations along with photographic proof, measured (not assumed) road elevations and documented water depth:

MILE MARKER 0.10 (Gatehouse / Two Bit Road)

(Photo Shown in Figure 4)

Road Elevation 4.14 ft. NAVD'88, Water depth 4.9 feet above roadway (3 ft. Stockton report)

MILE MARKER 2.27

(Photo in Shown in Figure 1)

Road Elevation 6.03 ft. NAVD'88, Water depth 3.0 ft. above roadway (Same as Stockton report)

MILE MARKER 3.13

Road Elevation 6.63ft.NAVD’88, Water depth 2.4 ft. above roadway (3ft. Stockton report)

MILE MARKER 3.50

Road Elevation 4.00 NAVD’88, Water depth 5.0 ft. above roadway (3 ft. Stockton report)

MILE MARKER 3.71

Road Elevation 3.36 ft. NAVD'88, Water depth 5.6 ft. above roadway (3 ft. Stockton report)

MILE MARKER 4.41

Road Elevation 3.41 ft. NAVD'88, Water depth 5.6 ft. above roadway (3 ft. Stockton report)

MILE MARKER 4.71

Road Elevation 4.06 ft. NAVD'88, Water depth 4.9 ft. above roadway (3 ft. Stockton report)

MILE MARKER 5.05 (Tice's Shoal)

Road Elevation 3.82 ft. NAVD'88, Water depth 5.2 ft. above roadway (3 ft. Stockton report)

MILE MARKER 5.62

Road Elevation 5.46 ft. NAVD'88, Water depth 3.5 ft. above roadway (3 ft. Stockton report)

MILE MARKER 5.87

Road Elevation 4.17 ft. NAVD'88, Water depth 4.8 ft. above roadway (3 ft. Stockton report)

MILE MARKER 6.50

Road Elevation 4.70 ft. NAVD'88, Water depth 4.3 ft. above roadway (3 ft. Stockton report)

MILE MARKER 8.22

Road Elevation 4.36 ft. NAVD'88, Water depth 4.6 ft. above roadway (3 ft. Stockton report)

MILE MARKER 8.30

Road Elevation 5.24 ft. NAVD'88, Water depth 3.8 ft. above roadway (3 ft. Stockton report)

As stated previously the width of each breach varies widely up to 400 ft. or more. The Stockton report assumes a uniform width of 200 ft. for only four breaches. Each actual breach width would depend on the freeboard of all ground elevations below elevation 9 ft. NAVD'88 (Ocean storm surge level during peak).

The Stockton report uses a peak duration of 2 hours. This was confirmed by examining the data produced by the tide guage on the Mathis Bridge between midnight 10/29/2012 and 4 am 10/30/2012.
The data indicates a sustained peak surge for a 2 hour period from 1 am 10/30/2012 to 3 am 10/30/2012. The water level varied very little during that 2 hour time period. What the Stockton report excludes from the calculation is the cubic feet per section flow during the run-up period to peak and the c/f/s flow during the ebbing from peak.

To accurately determine the total cubic feet of water that entered Barnegat Bay from the breaches in IBSP, one would have to quantify the width of each breach below ground elevation 9 ft. NAVD'88. This could only be done by extensive field measurements or utilization of the post Sandy LIDAR.

The question: *"Did the breaches at IBSP significantly contribute to the water levels in Barnegat Bay?"*, is a subjective one because "significantly" is a relative term.

In any case, this analysis discloses that the IBSP breaches contributed "significantly" more than the Stockton report purports.

Stevens Institute of Technology:

The Stevens report attempts to make the same assessment as the Stockton report. The Stevens report uses a different methodology. It relies on their touted hydrodynamic modeling simulation software. This storm simulation software was calibrated by comparing it against various real-time telemetry tide guage data with varying degrees of success.

The Stevens report indicates a difference of 1.33 ft. (Stevens page 15) in the water levels between actual measured heights at the Waretown tide guage and their simulated model based on theory. Also, Stevens peak ocean surge level is almost a foot lower than the Stockton report and this analysis. Both the Stockton report and this analysis place the ocean surge level at elev. 9.0 ft. NAVD'88. I don't know how the Stockton report arrived at that figure but, this analysis arrived at the same figure in the following manner:

There are three tide gauges that are primarily used along the coast. Atlantic City, Sandy Hook and Battery Park in Manhattan. Peak water levels during Sandy were as follws:

- Atlantic City……. 6.28 ft. NAVD'88
- Sandy Hook……...10.42 ft. NAVD'88
- Battery Park in Manhattan…….11.28 ft. NAVD'88

Although the Stevens report utilized the Atlantic City tide guage, this analysis disregarded the Atlantic City tide guage for two reasons. First, the guage is a mile and a half from the actual ocean, being located at Farley's marina inside Absecon Inlet. Secondly, it is located south of the center of the storm during landfall with winds from a different direction than IBSP. It is apparent that the Battery Park figure is higher because of the New York bight funneling effect where water is stacked up in a smaller more confined area. Because of that, this analysis assumes that the farther south of Sandy Hook the lower the storm surge would be. Since IBSP is twice as far from Sandy Hook than Battery Park,the ocean storm surge level at IBSP can be prorated thus:

11.28 (Battery Park) minus 10.42 (Sandy Hook) = 0.86 times 2 (twice the distance) = 1.72.
10.42 (Sandy Hook) minus 1.72 = 8.7 ft. NAVD'88 (9 FT. Stockton report & this analysis).
Stevens report indicates an ocean peak surge of 8.25 ft. NAVD'88 based on their simulated modeling.

The Stevens report indicates that there was a 4 hour differential between the peak water levels in ocean and the peak water levels in the bay at IBSP. This is indicated by their following graph:

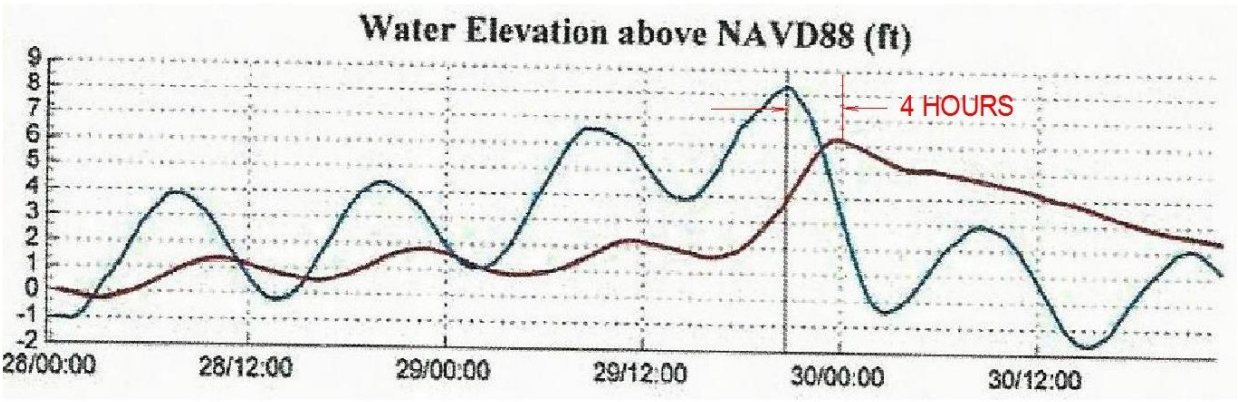

Figure 5: Graph shown on page 17 of Stevens report

This analysis notes that the above graph is not based on real time measured tide data. It is based solely on their simulated computer modeling. It shows once the water levels reach its peak it rapidly declines. Actual real-time tide guage measurements disclose that was not the case. ***Figure 6*** shows a sustained water level for the peaks lasting over 2 hours. In such a case there wouldn't be 4 hours between peaks as shown on the Stevens report. They would almost overlap.

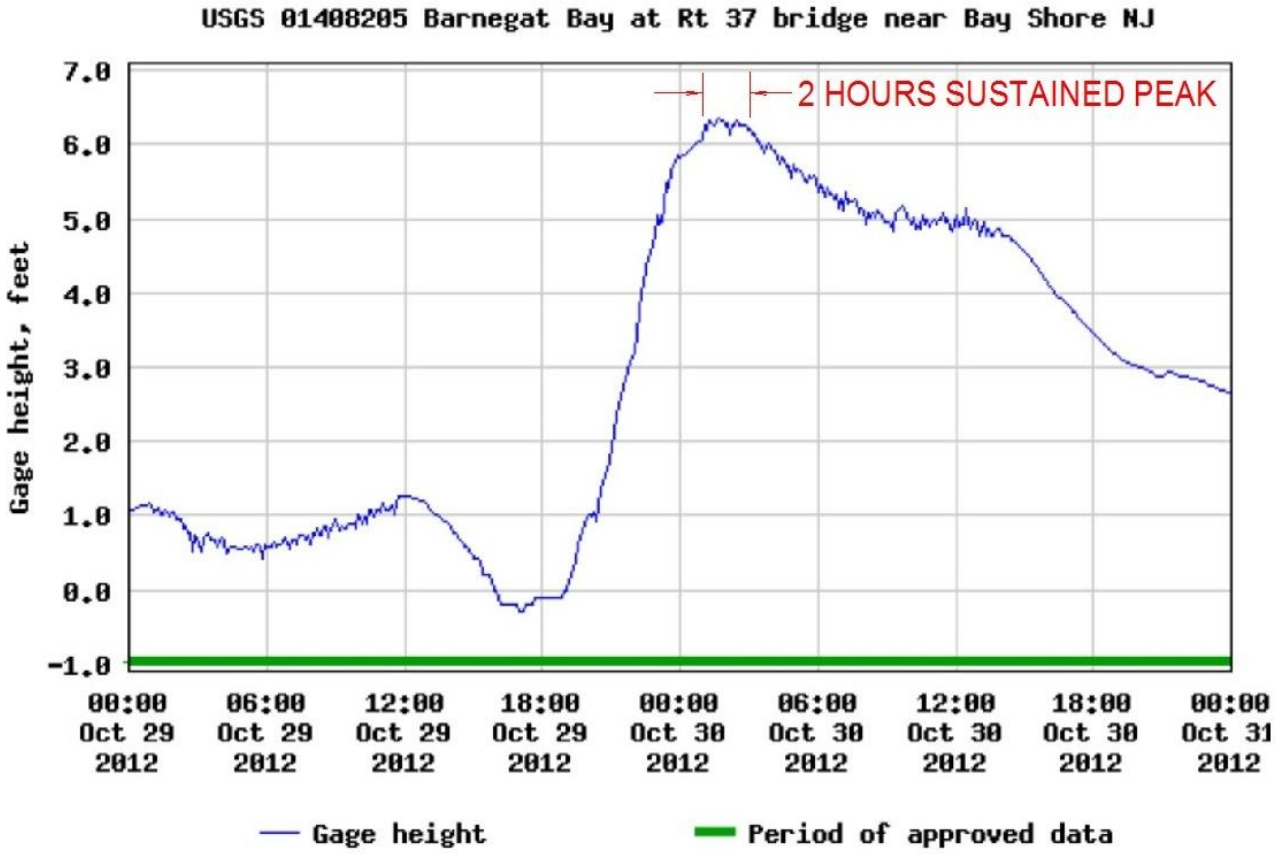

Figure 6: Actual Tide Guage readings at the Mathis Bridge during Superstorm Sandy

Figure 6 above shows a sustained water level during the storm peak not a rapid decline as the theoretical modeling indicates in the Stevens report.

It is very difficult for this analysis to truly validate Stevens theoretical storm surge modeling software. An overall accredidation can be discounted by the declaration on page 2 of the Stevens report. It states:

"At no time does the SBIMS hindcast of Hurricane Sandy show any evidence of overwash or breaching in the Park".

It also states on page 17: "Looking carefully at Island Beach Inset, there is no evidence of overwash or breaching occurring across the barrier spit".

I suggest that the authors of the Stevens report look at the photograph at mile marker 5.05 on page 7 of this analysis and the various other photographic evidence on pages 4 thru 10 of this analysis to re-evaluate their theoretical computer modeling program.

Again as stated before, the question: *"Did the breaches at IBSP significantly contribute to the water levels in Barnegat Bay?"*, is a subjective one because "significantly" is a relative term.

This analysis discloses that the IBSP breaches contributed "significantly" more than either the Stockton report or the Stevens report purports as outlined herein.

USGS Report:

This analysis also took note of the report entitled " Hurricane Sandy: Observations and Analysis of Coastal Change" prepared by U.S. Department of Interior, U.S. Geological Survey. That report states that the USGS performed pre-storm and post-storm LIDAR flyovers of IBSP. The LIDAR data discloses the dune and park elevation contours before the storm and after the storm. This information can be very useful in restoring the dunes to is pre-storm condition.

That report can be accessed by: http://pubs.usgs.gov/of/2014/1088/

On page 34 of the report it states:

"*The dunes along New Jersey's Island Beach State Park (DFL = 47-60 km) were also severely impacted with an average elevation loss of 1.4 m and a mean loss of sand volume from the beach of 69.0 cubic meters per meter (m3/m) along the barrier-island dune system. Waves atop elevated water levels eroded the face of the dunes, resulting in dune scarping and breaching of the dune line in places allowing waves to carry sand inland and deposit sand on roads and in parking lots".*

In other words IBSP lost an average of 4.6 feet of dunes for the full 9 miles of IBSP.

In conclusion, it is suggested that steel sheeting be installed at the 13 breaching points along the dune line. This should be done to reinforce any proposed artificial dunes over the steel sheeting. The rationale is that artificially constructed dunes don't hold up as well as natural dunes as indicated by L. Stanton Hales, Jr., Ph.D. of The Barnegat Bay Partnership. The State of New Jersey is installing 4 miles of steel sheeting along the dune line in the Borough of Mantoloking and Brick Township in the northern part of the barrier island.

Respectfully Submitted,

_____

William E. McGrath, Chairman
Berkeley Township Water Commission