Piermont Marsh: Fact-finding

Meeting 3: What do we know about community resilience and Piermont Marsh?

January 7, 2015, St. John the Baptist Church, 6:00-8:45pm

This was the third in a series of public fact-finding meetings to inform the development of a long-term management plan for Piermont Marsh by NYS Department of Environmental Conservation and NYS Parks. The goals of these meetings are to address a range of questions and concerns, build a foundation of scientific information to inform the plan, and provide an opportunity to ask clarifying questions of the presenters.

The following summary aims to outline the key information presented by the speakers, capture the question and answer component of the meeting, and compile a record of all of the questions and feedback submitted at this meeting. The list of questions and the feedback will be used to inform future meetings. Speakers included:

- Ronald Busciolano, US Geological Survey
- Sacha Spector, Scenic Hudson
- Y. Peter Sheng, University of Florida Coastal and Oceanographic Engineering Program
- Klaus Jacob, Lamont-Doherty Earth Observatory and School of International Public Affairs, Columbia University

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Summary of Presentations:

Introduction: Betsy Blair, NYS Department of Environmental Conservation/Hudson River National Estuarine Research Reserve

- This is the third fact-finding meeting, focusing on storm protection and the potential role of the marsh. This is part of a process of taking a look at questions that you identified and that we identified; trying to shed light on complex factors involved with managing the marsh. We envision a more collaborative process moving forward.
- Planning for long-term marsh management to keep this marsh viable and performing the useful services that it does for human and natural communities. There is no finite time for this plan, and it will be adapted over time.

Regional Storm Hydrology and Implementation of the USGS SWaTH Network: Ron Busciolano, US Geological Survey

- **Causes of major coastal-flooding events in the southeastern NY region:**
    1. Hurricanes/tropical storms: mostly July to October, usually quick moving (lasting only 1 or 2 tide cycles), greatest winds and tidal flooding near storm center
    2. Nor'easters: most likely November to March, can be slow moving (lasting many tide cycles), greatest winds and tidal flooding generally away from storm center
    3. Hybrid storms: most likely near end of hurricane season/beginning of Nor'easter season, characteristics of both storm types, Sandy was one of these
- **Components of coastal flooding (see diagrams in presentation PDF):**
    - Storm surge: abnormal water-level rise from a storm, above the predicted astronomical tides
        - Combination of wind blowing water, and pressure difference (makes water rise)
    - Storm tide: water level rise due to a combination of storm surge and astronomical tide
    - Wave runup: occurs when a wave breaks and the water is propelled onto the beach
    - Wave setup: occurs when waves continually break onshore and water from wave runup piles up along the coast
- **Major flooding from recent coastal storms:**
    - Storm of Dec. 11-13, 1992: slow moving Nor'easter type storm, produced widespread major coastal flooding over multiple tide cycles, remains storm of record in some areas
        - Graph: blue is predicted astronomical tide; as winds were blowing onshore (from east), green line shows surge + astronomical tide – over a long duration, it was above what the normal tide would be; that's what you normally get in a nor'easter
    - Hurricane Irene (August 2011): weakened to a tropical storm, relatively fast moving, caused localized major coastal flooding over a single tidal cycle; tidal surge was rather high but only over one tide cycle
    - Hurricane Sandy (October 2012): hybrid extra-tropical cyclone; anomalous track and large fetch caused major coastal flooding over multiple tidal cycles; magnitude of local flooding is dictated by phasing with astronomical tide – Sandy matched up with time of high tide; large peak but also over multiple tidal cycles – combination of the two storm types
- **Storm-tide flooding from Hurricane Sandy:** Why was Sandy flooding so bad?
    - Transition to hybrid storm forces wind field out from center; large wind field (fetch) piles water towards coast north of center; anomalous track funnels water into New York/Raritan Bay; as storm makes landfall south of region, winds switch to south to southeast direction, further enhancing surge; max. surge along Atlantic Coast coincides with astronomical high tide

- **Map showing peak storm elevations during Sandy:** red dots = highest storm tide – occurred in this area (water was piled up); affected area less out to the east, more to the west

- **USGS Storm-tide monitoring: Surge, Wave, and Tide Hydrodynamic (SWaTH) Network**
  - Network of long-term gauges and storm-deployed temporary sensors; developed for northeast coast from North Carolina to Maine; about 900 sites proposed
    - Includes deployment (of sensors) for major Nor'easters, in addition to tropical storms
    - Collaborative effort with Federal, State, and local partners; emergency managers; coastal researchers; and modelers
    - Will help get the data needed for modeling work and for resilience work
  - Data will be distributed through online mapper (some sites are real-time), available to anyone
    - Data can be used: to verify sensor data, as indicators of peak storm tide, to reveal effects of waves, calibrate models or to look at evacuation routes
  - Chart (blue/orange lines)
    - Distributed sites (blue): stations spaced geographically to facilitate monitoring on a regional scale or for high-priority sites
    - Transect (orange): transect from wetlands into communities that tend to flood frequently; will show us how storm surge/wave setup dissipate across space
- **SWaTH at Piermont (see map):** USGS will leverage SWaTH network/funds and install brackets for up to 6 storm-deployed tide/wave sensors (both north and south of pier)
  - Wave sensor will be collocated with real-time gauge at end of pier
  - Also a transect of sensors through Piermont marsh – see how wave setup is attenuated as waves move in and vegetation dampens effects of waves through the marsh
  - Sensors would be deployed during severe nor'easters or tropical cyclones expected to produce widespread major coastal flooding
  - Sensors surrounding pier should provide information on tidal and wave characteristics, timing and extent of inundation, and interactions with local landforms
  - Wetland transect should provide information on vegetative wave-setup dissipation to help with marsh resiliency and restoration efforts
- For more information: Ronald Busciolano, RJBuscio@USGS.gov, USGS NY Water Science Center (631-736-0783), http://ny.water.usgs.gov

Questions:

- Will it be installed, and if so, when?
  - Planning to install in the spring; working with resiliency/restoration folks to identify areas; have it ready to deploy sensors during upcoming hurricane season.
- I live on the western side, dock is 4.5 feet above high tide, there was 8 feet over that – was that storm surge or wave surge? There was no wave action.
  - Probably storm tide; it's all combined but I think more of it is storm tide.
- Are you aware of the status of the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model tide station proposal? Is that being actively considered?
  - Not sure about that, I haven't done much work with SLOSH. That's more on NOAA end.

Flood Risk and Resilience: Piermont: Sacha Spector, Scenic Hudson

- Building on Ron's explanation of storm hydrology dynamics, I'll talk about what they mean for Piermont, and what they might be like going into a future with a changing climate
- This is a tidal system, we're part of the ocean, that's why we have all of these coastal hazards (tides, waves, storm surges, erosion, freshwater tributary flooding)
    - Coastal inundation is the hazard we think about the most (leads to events like Sandy)
    - For Piermont, Sandy was the storm of record in terms of storm height and probably for damages as well: 7+ foot storm surge; 140+ structures impacted, $20M+ damages
    - Freshwater tributary flooding affects a different part of town, raises questions about infrastructure integrity over time; key issue Task Force flagged is continued access to the town
- **Flood risk mapping:**
    - We often talk about 1% flood (1% chance of happening in any year) – it resets every year
    - There are new flood maps available for Piermont – can see them at FEMA's website
        - (Map on slide 9): blue area: 1%/100-year flood zone; orange: 500-year flood zone
        - Scenic Hudson: Sea Level Rise Mapper (available on Scenic Hudson website; orange in this map is 1% zone – where you probably need flood insurance and probably were impacted pretty directly by Sandy surge)
    - FEMA bases projections on historical information – changing climate will change flooding, storms of the past won't be exactly like storms of the future
        - Hudson River is over 12" higher than a century ago; 21st century sea level rise (SLR) is much more rapid, seems to be accelerating
            - 1856-2014: 2.84 mm/yr; 1990-2014: 4.64 mm/yr
            - Rolling 5-year average (during 2000-2012): 7.8 mm/yr – too short a time period to calculate SLR rate, but it does indicate that it is accelerating
            - Looking at a rise of multiple feet over the course of this century, compared to 1 foot over the last century
    - SLR interacts with these floods (see flood elevation diagram): higher storm tide – upward and inland → same places will see higher floods, plus new places will flood
    - State has supported lots of science for predicting SLR rate this century (e.g., NYS ClimAID) – many different models to predict rate, then look at frequency that different rates of SLR happen (see table of projections – inches of SLR versus baseline of 2000-2004)
        - Low estimate: 2" or less by 2020s / Middle range: 4-8" by 2020s / High estimate: 10" by 2020s (inches vs. baseline of 2000-2004)
        - Range of 15 inches to 75 inches by 2100
    - This translates to different flood regimes (see bar graph): tide level (blue) + SLR (hatched red/orange) + storm surge (red) – fraction of high water attributable to SLR is increasing
- **Future flood risks for Piermont:** images from the SLR Mapper with increasing amounts of SLR
    - Number of households, people, and land (acres) at risk from flooding – increases with SLR
    - COAST model for Piermont – modeled water levels and vulnerability assessment results, projected expected damage to buildings and improvements from SLR and storms
    - *Can get this info and more on our SLR Mapper and PWRTF page (Scenic Hudson's website)*
- The motivation for this is not to scare you or demotivate you from adapting Piermont, staying here, and being a flourishing community. The point is that Piermont will require a substantial amount of adaptation to stay safe and vibrant and will need all of the resilience it can get. Later presentation will talk about the ways the marsh is part of that picture and the role it may play now and in the future.

Questions:

- What's the horizontal and vertical resolution of your elevation model?
  - 1 meter pixel size, +/- about 9 centimeters (accuracy of the elevation data, derived from LIDAR remote sensing). That's a good thing.
- What's the cause of sea rise?
  - Oceans are warming and expanding
  - Input from land-based ice (glaciers in Greenland, Antarctica) – melting, adding
  - Driven by changes in greenhouse gas concentrations – warming and melting
- Do you believe that the *Phragmites* offer Piermont important protection?
  - I'll leave that to the next 2 speakers; I'll talk later about where *Phrag.* may be in the future
- It's hard to look 100 years from now. For 20 years, looking at the average, what's that mean?
  - 10-15 years, cumulative economic damages may be $20M (~Sandy), cumulative over all the storms. Flooding becomes more frequent – what used to happen once every 10 years starts to happen every 6 years, and water levels get deeper.

How and how effectively can vegetation dissipate storm surge, wave, and flooding? Modeling for Protection-, Risk-, and Marsh-Management Decisions: Y. Peter Sheng, University of Florida Coastal and Oceanographic Engineering Program

- Coastal communities are struggling to reduce coastal flooding due to storm surge and sea level rise
- 1992 Hurricane Andrew – Miami, 2005 Hurricane Katrina – New Orleans, 2012 Superstorm Sandy – NY
  - These are the 3 areas with highest risk for coastal flooding, lots of things in common, lots of things that are different; we have modeled all these storms
- **Inundation is caused by storm surge plus:** 1) Dynamic coupling of tides and waves with surge; 2) Precipitation and river flow (adding to coastal flooding and affecting currents/salinity); 3) Sea level rise
  - Climate change is causing more intense and frequent (some debate) hurricanes and accelerated SLR
  - *Need to take all of these things into account, use models to predict, probably need to combine different models together*
- Maps: 1% Annual Probability Inundation Map in Miami by 2080-2100
  - Left: dynamic climate + coastal models – this is what would happen in the late 21st century, based on average IPCC climate predictions, high resolution, used ensemble of hurricanes
    - Compare this map with FEMA map (which doesn't take into account climate change) – 100-year flood water level increases 1 meter or more due to climate change
  - "Bathtub" approach to modeling (just adding SLR on top of maximum surge, not using dynamic modeling) produces much higher flooding than you would really get; need to account for dissipation across landscape
- After Sandy in NYC: tremendous interest in role of coastal wetlands in reducing storm surge/inundation – lots of ideas (trees in water, oyster reefs). But, how well do coastal wetlands actually reduce storm surge?
- **The questions are: What role did Piermont Marsh play in reducing flooding? What are the relative roles of various species?**
- Can ecosystem service (healthy marshes and mangroves) be used to dissipate storm surge and coastal flooding? **Yes. It depends on many things (based on observations, modeling):**
  - **Vegetation type, height, density, and distribution**
  - **Local bathymetry and topography**
  - **Local climate and weather – wind and pressure deficit**
  - **Local hydrodynamic condition – waves and currents**

- Local salinity and temperature and water quality
- Sediment supply (is sediment accretion keeping up with SLR?)
- Available space for vegetation migration (will seawalls/other structures block migration?)

- **Vegetation-resolving hydrodynamic modeling:** improves modeling and quantifies influence of vegetation on storm surge; investigates the vegetation's performance during real storms
  - **How does vegetation affect surge and wave?**
    - Slows down flow by introducing friction (stems and leaves), dissipating wave energy and height, reducing flow; drag and friction depend on flow speed and on area of vegetation; vegetation creates turbulence but also dissipates turbulence
    - Example publications (see slide 9 for full citation): Sheng, Lapetina, and Ma (2012); Lapetina and Sheng (2014); Lapetina and Sheng (submitted)
  - **Recent incorporation of vegetation processes into a 3D model (CH3D-SSMS)**
    - Compared model with lab experiments, tested in field, now using to do predictions
  - **How well does coastal vegetation reduce storm surge?**
    - Likely varies due to canopy height, canopy width, canopy density (stems per area)
    - Run model of storm with vegetation present, absent, and with varying characteristics
      - Compare total amount of inundation, measure how effectively vegetation can dissipate the energy (**vegetation dissipation potential**, VDP) – want VDP close to 1 (completely stopped); least effective is 0
        - VDP increases when increase width, density, and height
    - **Storm characteristics (forward speed and intensity) affect dissipation**
      - For a more intense storm, VDP is actually *more* effective
  - Field test: effect of vegetation during Hurricane Ike (2008, TX)
    - Graph: green = USGS gauge, red = vegetation-free model, black = model with vegetation
      - Results: add vegetation, significantly decrease water level (see table)
  - Field test: effects of wetlands in Miami (mangroves and cattails) – during Hurricane Andrew (1992)
    - Maps: vegetation free vs. with vegetation (and varied vegetation parameters)
      - With vegetation, see much less flooding than without vegetation
      - Increasing density and height further reduces flooding
- Last example – I dreamed up something like Piermont and got results this afternoon
  - Results: vegetation dissipates wave height
  - Charts: water level/surge/surge+waves, with vegetation (green) vs. without vegetation (red)
    - (Note: does not include tide)
    - Vegetation reduces storm surge, wave height, and flooding
- We can model that with detailed information about storms, local bathymetry/topography, and vegetation distribution (density, height, type, vertical profile, leaf area index) – some of this information is available
  - Very much depends on local conditions
- **How can we use vegetation-resolving modeling to predict effectiveness of PM in protecting people from future flooding risk?**
  - Conduct a forensic study of Hurricane Sandy to assess the role of Piermont Marsh
  - Conduct modeling in conjunction with USGS SWaTH field program in Piermont Marsh
  - Calculate flooding risk under current climate and future climate, using ensembles of storms
  - Need detailed vegetation data for model; need water level & current data to validate model

Questions:

- Can you give us any estimate of how effective *Phragmites* might be in terms of curbing flooding, compared to other types of vegetation?
    - The way we recognize vegetation in the model is by density, height, horizontal area, and vertical distribution of leaf area index (LAI). What I presented is not an ecological model but a model that recognizes the physical properties of vegetation. Hence the model is not species-specific. Currently I don't have the answer for the question, but the model could be used to answer the question in the future provided additional information is made available. From my perspective, if you can make any vegetation tall and dense, it doesn't matter what it is. It should work to curb flooding. I don't make a difference the type of vegetation.
- If you say you could conduct a forensic study, and you could calculate the flooding risk, if you had these detailed information, how do you get it, and why haven't you done it yet (or anybody)?
    - As I understand, some of this needed data exist – I just found out today that some of the vegetation distribution data exist, and I'm encouraged to hear that USGS will collect SWaTH data.
- Which factor plays a greater role?
    - That question requires further investigation. The relative roles of various factors depend on the specific vegetation region and specific storm. It depends on local topography/bathymetry.
- Can your model deal with those complexities?
    - Yes. I have modeled every major estuary in Florida, the Chesapeake Bay, and Hurricane Sandy.
- Does what's going on at the mouth of the river (e.g., filling low areas of Staten Island) impact this?
    - I can't say for sure, but it certainly could. Alterations at the mouth of the river could affect the water level and flood as well as the sediment supply and vegetation at the Piermont. If they build a tidal/storm barrier, that can have an impact, but they can all be looked at (with modeling).

Storms, Floods, Waves and Debris: Observations and Inferences for Protection-, Risk-, and Marsh-Management Decisions: Klaus Jacob, Lamont-Doherty Earth Observatory and School of International Public Affairs, Columbia University

- This presentation has 3 parts:
    1. Relationships between marsh and storms/floods
    2. How these relationships could change if some of the marsh was going to be modified
    3. My personal comments and recommendations based on parts 1 and 2 for pending development of a marsh management plan
- **1. Marsh effects during storms:**
    - **1. Marsh does not diminish the still-water flood elevation** (slow rise and fall of the water)
        - This is different from Peter's modeling results – we have to ask ourselves why
        - This applies to extreme surges (i.e., Sandy)
            - Hypothesis: Sparkill Creek provides passageway bypassing the marsh
        - This also applies to ordinary high-tide flooding, not just extreme storm cases
    - **2. Marsh reduces wave action substantially**
        - In Bogertown, neither Irene nor Sandy had any perceptible waves that were observed – waves don't matter much south of the pier behind the marsh; in contrast, north of the pier, wave heights were estimated at least 2-3 ft. during Sandy
        - Example: modeling wind waves and morphodynamics near the Corte Madera salt marsh – inside San Francisco Bay, not at the ocean – pretty comparable to Tappan Zee; but has *Spartina,* not *Phragmites*

- "In the shallow areas of Corte Madera wetland, waves dissipate their energy mainly by bed friction and vegetation. The presence of vegetation has a significant impact on wave heights on the salt marsh."
- Vegetation reduces waves and sea level heights; more effective for higher wind speeds

- **3. Marsh catches debris and reduces risk of debris impact to houses**
  - Is the function of Piermont Marsh effective? The answer seems to be yes. Arrows point to debris fields.
  - How wide does the marsh have to be under various storm conditions (post-Sandy pattern in this case) and how come this happens to be deposited at some places and flattens the *Phragmites*, rather than other areas? That requires more local input. I have a hunch of where it might come from, but that's only a hunch. Sparkill and rivulets – topography is slightly higher next to the rivulets because during flooding sediments get deposited there faster. I believe that when waves come over the marsh and sense the upslopes, they break and debris gets deposited there.
- **4. High and dense *Phragmites* works better than lesser plants** (Sheng et al. figure)
- **5. This is especially true for very high storm surges. Why?**
  - Because *Phragmites* is so high, it exceeds height of flood crests (even for Sandy) and therefore it's extremely effective even for the highest storms
  - The entire water column and wind boundary layer experiences friction – slows down wind, which is important for creating waves in the first place
- **6. Marsh (even with *Phrag.*) needs to be sufficiently wide to catch debris, attenuate waves**
  - It took quite a distance for the debris to be deposited during Sandy
  - With SLR, does the marsh elevation more or less stay as it is, or does it vertically keep up with SLR? If it doesn't keep up, that debris lines could move.
  - Not sure if we can answer the question of how wide the marsh needs to be. Peter, I'm not sure if your modeling work can 'catch the catchment' issues.
- **7. Where marsh was not wide enough, there were impacts from Sandy (e.g., damage to condo retaining wall)**
- **8. Debris and breaking waves seem to flatten *Phragmites* in distinct patterns; heavy snow can too**
  - *Phragmites* gets tipped over by weight of heavy snow – if you combine that with heavy winds, understandable how it will be flattened, temporarily weakening wave attenuation and debris catchment functions in some locations

- **2. Potential flood effects and risks from *Phragmites* removal:**
  - **1. Marsh loses much of its capacity for wave attenuation and debris protection, probably for a decade or more** (not clear to me how long it takes to establish a mature marsh)
  - **2. The risk for marsh erosion is increased**
    - Photo: Iona Marsh (Dr. Spitzer) – Iona has a protective wave barrier (rail road causeway), prevents storms getting into the marsh itself. I don't think we can use that as a simple analog here to learn what would happen in the Piermont Marsh.
  - **3. If herbicides were used, high tides could flood them into gardens, low-lying houses, ball field, children's playgrounds** – could be potential for contamination
    - This is an unresolved issue in terms of quantification, but I think there is potential
    - I raise this simply as an issue, but I don't think people have answers yet
  - **4. If herbicides were used, risks to amphibians and fish are likely, and because of transport during floods, risks to flood-exposed residents cannot be ruled out** (see slide 14 for sources)
    - I'm not saying they will, but I'll raise it at least as an issue that should be addressed

    - **5. Sea level rise accelerates and amplifies all of the above**
        - That's not necessarily anything that the marsh has any influence on, but that's where the other Piermont Waterfront Resilience Task Force work will have to come in.
- **3. Inferences for management plan:** my personal thoughts, you may want to take them with a grain of salt
    - **1. Removal of *Phragmites*,** if at all contemplated, should be limited to a small "diversity garden" near the central part of the marsh. I suggest the area surrounded by the oxbow.
    - **2. Reason: preserve maximum wave attenuation, debris catchment, sedimentation, and nutrient cleanup, and avoid erosion.** Lesser plants provide poorer protection especially during severe storms. Liability re: home damage and values.
    - **3. Use freed up resources to consider oyster reefs** (or similar) on eastern side of the marsh and/or off north Piermont/marinas as breakwaters
    - **4. No herbicides in marsh (with flooding risks) for public health and liability issues alone**
    - **5.** Since we are not fully understanding the science between all of those things, then we should **use the cautionary principle** (which is not how the EPA regulates herbicides or many other things)

Questions: (Ran out of time – opportunity for questions during the question and answer period later on)

Piermont Waterfront Resilience Task Force (PWRTF): Sacha Spector, Scenic Hudson

- I recognize many of you from the PWRTF project or the public meetings
- PWRTF report is available online (Scenic Hudson website, Village website)
- **Partners:** NYSDEC Hudson River estuary Program, New England Interstate Water Pollution Control Commission, Lincoln Institute of Land Policy, Scenic Hudson, Consensus Building Institute
- **Goals:** 1. Initiate a community-driven process to better understand risks tied to SLR and tidal river flooding; 2. Identify and prioritize strategies for making Piermont more resilient; 3. Generate a locally-specific, broadly understood and supported Resilience Roadmap
- Focused on solutions: what can be done now and in the immediate future; what the community can do to be more resilient in today's storms and changing storms in the future
- Community-driven process: task force members; additional members of the public; federal, state, and county agencies and NGOs
- **Planning process:** 1) Identify and assess risks to community assets; 2) Prioritize vulnerabilities; 3) Develop adaptation vision and select strategies; 4) Identify implementation tools; 5) Develop adaptation roadmap
- **Outcome:** table of 24 recommendations, grouped by immediate/near-term/medium-term (next 5 years), and 5 different sectors; 6 recommendations prioritized by the Task Force
    - **Recommendation 10:** Incorporate the findings/recommendations of the PWRTF into the new Local Waterfront Revitalization Program (LWRP) – that process has begun already
        - LWRP is a plan administered by NYS Department of State, Coastal Resources Division
        - **Points within the recommendation:** Revise local code to –
            - Promote the use of green shoreline infrastructure (nature-based solutions)
            - Promote the long-term persistence of the marsh as a natural storm buffer
            - Encourage the use of natural buffers and green shoreline infrastructure to reduce flood risk and erosion and conserve natural resource functions
- **Visualized adaptation strategies: nature-based solutions** (see slides for images)
    - Elevated seawall, fronted by a sequence of high to middle to low marsh (not just creating a gray concrete wall) – marsh could provide ecological function and reduce wave height

        - Bay Institute in San Francisco – horizontal levee integrating gray infrastructure behind an engineered marsh system – able to reduce the height of the levee required by fronting it with natural features; task force found this intriguing and promising for Piermont
    - Piermont Marshway solution – outside-the-box scenario; Bogertown and the Patch – residents would be relocated over time; remove seawall; open up commercial core and allow the marsh to migrate through as sea level rises to maintain storm buffer function and allow flood waters to move through; cross-section: create new commercial zone on other side of the marshway
- The task force clearly recognized the marsh as a component of the long-term resilience of the community; working with the marsh could be in the community's future, rather than holding the line against the marsh
- Encourage you to download the PWRTF report: http://www.scenichudson.org/ourwork/riverfrontcommunities/waterfrontresiliencetaskforces/piermont

Questions:

- It sounds like, at least the DEC's original plan of getting rid of all of the *Phragmites* in the Marsh is contrary to the Task Force's findings, and it sounds like you're saying the marsh is essential to resilience planning.
    - I don't think that any of the analysis that we did during the Task Force project really elucidated quantitatively the role of the marsh as a storm barrier. There's been much more information tonight than anything we really dug into during that process. But I do think the Task Force recognized the marsh as part of the defenses.
- Would it be possible to divert some of the money for eradicating *Phrag.* to these resilience options?
    - I can't answer that; I don't have control over the money. I do think that creativity is encouraged, and I think that Scenic Hudson and Riverkeeper, who advocated for mitigation projects from the Tappan Zee Bridge, are interested in a range of environmental benefits coming from those funds.
- Can you quantify the resiliency of your plan? How much more resilient is it going to be?
    - We ran economic analysis. It's hard to protect a community that's very linear and doesn't have a huge amount of assets that wind up being protected. Easier to focus on a dense, circular object from an economic standpoint. Financing is a real issue. Marshway option was a net negative, but very simplistic economic analysis, doesn't take into account other benefits.

Predicting the Future of Piermont Marsh in an Era of Accelerating Sea Level Rise: Sacha Spector, Scenic Hudson

- Tidal wetlands exist at a very specific place – in the tidal zone; elevation, relative to tidal inundation, influences the development of marshes. Zones: tidal flats (mud flats, may be vegetated); low marsh (between mean sea level and high water); high marsh (above high water, gets inundated sometimes); transitional zone (big storms sometimes inundate). Each zone has different kinds of vegetation.
- **As marshes here evolved over time, they've kept pace with sea level rise (SLR)** – marshes build through sediment accretion (trap sediment, let it settle) and peat formation (add sediment through organic matter)
    - **Question: Into the future, will Piermont Marsh continue to keep up with SLR? Will it be able to move inland where possible?**
- **Scenic Hudson has been modeling that process: Sea Level Affecting Marshes Model (SLAMM)**
    - Key parameters: elevation, accretion, SLR, salinity

        - Accretion rates high marsh (where *Phragmites* grows) – used 3 scenarios: current (3 mm per year), medium (6 mm per year), high (11 mm per year – start needing more sediment than what is available). Also give high marsh an initial bonus of 4 mm per year – taller vegetation (*Phrag.*, *Typha* (cattail)) traps more sediment than low marsh
        - Also used 3 SLR scenarios: low, middle, high
        - Salinity – we don't have good information on how the salinity wedge (complex set of dynamics between freshwater coming down the river and saltwater coming in from the ocean) is affected by sea level rise. It will probably exceed the salinity tolerance of several plants that are currently in the marsh, including *Phragmites.* So by leaving salinity out of the modeling, it's a conservative projection, in terms of the future presence of *Phragmites* in the marsh.
    - Maps: green is high marsh – where *Phragmites* lives now; darker green is low marsh; brown is tidal flats/mud flats (see slides 9-14). Showing 3 scenarios: 1) high accretion, slow SLR; 2) medium accretion, medium SLR; 3) low accretion, fast SLR.
        - 2007 to 2020 – not seeing a dramatic change
        - 2040 – start to see breakdown in the fast SLR scenario – see a lot more low marsh, probably where *Phragmites* and other tall plants won't live
        - 2060 – in the worst case scenario, it's entirely low marsh – probably *Spartina* covering the entire area; middle scenario – start to see expansion of low marsh
        - 2080 – in the medium scenario, most of the high marsh is gone; in the high SLR scenario, it's all tidal flats (could be vegetated)
        - 2100 – in the high scenario, marsh is entirely open water; in the medium scenario, marsh is entirely low marsh (inundated at high tide)
    - **What does this mean?** The pace of SLR appears far more important than the rate of accretion in determining marsh fate. Transitional marsh and high marsh (*Phragmites* habitat) decline over the 21st century at Piermont marsh in the 2 plausible scenarios, unless SLR slows down (less plausible). Increasing salinity may accelerate the process.
- Based on this model:
    - **Given current SLR rates, high marsh habitat is likely to be greatly reduced or disappear (*Phragmites* is likely to track this shift).** Not a guarantee that *Phragmites* disappears rapidly, but in most of our model runs, it seems like that habitat disappears.
    - **To maintain high marsh may require significant management inputs (i.e., physical structures or assisted accretion).** Can't keep water out (that's where sediment is coming from), but need to trap water long enough for sediment to settle, or could add sediment to the marsh (this is happening in Florida (dredge material from channel deepening, spray on marsh in winter).

Questions:

- This model does not include climate change and increase in storms. Storms might bring more sediment in.
    - Sacha: It's possible. There's variation in the amount of accretion that happens in any given year; partly driven by storms – big accretion events; could be happening more frequently; but as SLR inundates the marsh, there's a hump-shaped function for accretion – it stops helping.
- There's a big divide in Hudson River concerns between NYC and what's going on upstream. I know there must be impacts from what's going on upstream, because it's tidal. Is anyone looking at this holistically? What I'm hearing here today is mostly very localized views of things.
    - Sacha: You've heard a lot of focus on this particular marsh. We've all been doing our best to run our models for this particular spot. I think a holistic approach is absolutely needed. Storm

barriers don't change SLR, all of these dynamics would still take place. Storm protection projects could starve us for the big sediment years that we would need to keep up with SLR.

- Did the Task Force or the DEC ever think of a boardwalk out into the marsh? Part of the way to get people to care about a marsh is to get them out in it.
    - Sacha: One of the Task Force recommendations is to improve and increase public access to the river; access to the marsh is mentioned in the text. Access is something that defines this community, there's not a ton of it, but its relationship to the river is fundamental to this place.
- If *Phragmites* is eventually going to disappear anyhow with natural forces, then why are we spending money to get rid of them maybe a little bit faster?
    - Sacha: My question is what might happen. This model doesn't guarantee that this is what will happen, but most of our models lead to the conclusion that high marsh habitats disappear here (where *Phrag*. lives). You can do with that what you will. You could argue that we'd be spending money on something that will happen anyway, or that trying to keep this stuff here is also futile.
- Question for Betsy: Are we going to tear down part of the marsh?
    - Betsy: A lot of you may think that we have something in mind and we're going to do it regardless. I can tell you that I don't know what the right thing to do is here, so I am proceeding in good faith from the goals that we have and the goals we heard from people who participated in the process early on. We're trying to understand what's an incredibly complex decision with complex factors. If it was easy, we could all probably agree on a course of action. My question to the speakers was – for storm protection, how much marsh and what kind of marsh is enough? We're trying to get at that, but we need to understand the fundamentals. This is the foundation.
    - Comment: Do no harm.
    - Betsy: No one's intending to do any harm.

Questions and Answers:

Alternated questions from hand-raising and written questions submitted on cards, which were chosen and asked by Mayor Sanders.

Question: Betsy, would there be funds for a seawall? Majority of people in Piermont are very concerned about ramifications of any eradication (storm protection and herbicides). I don't favor herbicides, there are other treatments, but I do favor biodiversity – having a diverse marsh is important. Having a means to protect people and their investments is very important, and I think a seawall would help. If we can propose a mitigation plan and introduce some of the species, but have the seawall there – would the money be available from DEC for constructing a seawall?

- Betsy: Reminder that the funding is from the Thruway Authority. DEC approves the plan. Whether other funding would be available is a question for the community. That's not a question that I can answer. A hard structure would not meet the terms of the Thruway Authority mitigation funds. Need to decide whether you could pursue that as a community through a different means, and whether it would be cost effective in the long run.

Written: Peter, in your presentation you mentioned a study of Piermont Marsh at the end – what would the parameters be? Would it take a year or years for the study to be done? Could funding be used for that?

- Peter: It's hard for me to say without knowing the scope of work. I think we could possibly do something on the order of 18 months, depending on the level of detail needed and the level of information you have.

Comment: I want to commend Betsy and Ed and the project people. I hope that our whole community, especially people who think there's a plan in place or a hidden agenda, has taken note that you have not shied away from presenting information that is complex, even contradictory, and how impartial and thorough these presentations have been. A lot of us want to have our views confirmed in what we hear, but you have not shied away from the complex issues and contradictory evidence.

Question: Ron, you mentioned earlier that you were going to use the funds to place 6 sensors into the Piermont area – are those funds approved and where are they coming from?

- Ron: These are funds appropriated by the USGS through the Department of the Interior for our Sandy SWaTH network. A certain amount of funds go to each regional water center. There is some funding available for local communities that need extra monitoring. The work at Piermont is all funded already as far as putting the brackets in and having stuff ready. What isn't funded is future SWaTH sensor deployments – that's usually funded by FEMA. If local communities wanted to put sensors out there more frequently, that isn't funded. This is just for major storm events.

Question: Betsy, at one of the first meetings I was at, there was a conversation about how the funding was allocated for a certain use and would run out. Is it possible to apply for an extension of that money so that we're not forced to use it or lose it, while we continue to do studies (such as Sheng's modeling)?

- Betsy: That could be explored. The Thruway Authority would like to wrap up their mitigation work within that timeframe (7 years since permit was issued). My goal is to try to work within the boundaries of the permit timing to do as much good as possible within that time, and to try to lay out a good plan with this process (developing a management plan for the marsh) to maintain momentum.

Written: So is the vegetation that we desire to reintroduce into the marsh less dense and shorter than *Phragmites*? There is time before regrowth, but still risks for flooding. How will Piermont be protected?

- Ed: This is a learning process for all of us. I'm learning from tonight's presentations as we go. We're trying to learn about all of these issues. The earlier composition of the marsh included relic areas of *Spartina* and significant areas of cattail (*Typha*). These have diminished significantly in the last 20 years. A marsh with a cattail-dominated condition has different characteristics than *Phragmites*. Peter's model might be able to tease out how the structure of cattail affects storm surge/waves, relative to *Phragmites*. Klaus's example from the west coast was a *Spartina* marsh – it does serve some function, it's a relative difference. As far as recovery of the marsh – Iona is a different location with different dynamics, but what we saw is that you have a return of annual plants, slow return of cattail – completely unassisted, relying just on movement of seeds and native seed banks. Other projects have used hand planting to accelerate the process. We don't have this (a management plan for Piermont) worked out in terms of the scale and location – we're holding back until we go through these meetings. It's essential not to get ahead of ourselves, and we really want to see this process out.

Question: I really enjoyed these meetings, feel I've learned a great deal. I have a question for Betsy, and I hope it doesn't sound confrontational. My understanding is that these meetings wouldn't have been held if many members of Piermont hadn't objected to use of herbicides. Would DEC have gone ahead with plan to use herbicides if members of Piermont hadn't objected? I am interested to know what the DEC was thinking before all of these unknowns were raised.

- Betsy: A constellation of state agencies are involved in these management actions. In this case it will be the Thruway Authority, but DEC needs to approve their plan and carry it out. I can tell you that we would not have authorized spray of 200 acres. At the time when this was recommended as a possible mitigation project, our thinking was much different. Our pattern up to that point was to do small-scale approaches. At the time, we were thinking about the future of marshes, about resilience of natural and human communities. We didn't have a deeply researched plan, we had a concept – that we might want to start the process (of *Phrag.* control) and see what happened. We were monitoring changes in other marshes where *Phrag.* had been controlled, where we thought that was the appropriate course of management. This is all really adaptive; we're in a new world and trying to understand it. That's as honest as I can be in terms of where we were and where we are. I expect my thinking to continue to evolve. It's been enormously helped by these people who have largely volunteered their time to come help out.

Written: Sacha, since sedimentation seems to be key for addressing sea level rise, should we be asking for sediment from the Tappan Zee Bridge dredging?

- Sacha: That's the kind of source that's been used in other examples. There are issues around contamination levels in that material, but I also want to go back to the results of the modeling we did, which didn't necessarily suggest that it would be easy to add enough sediment to keep up.
- Klaus: I want to add another option, may raise more questions than solutions, but could be considered technically. Much of the locally produced sediments come from the Sparkill, and right now they're going out into the channel. It's conceivable to do an engineering intervention to get the sediment on the marsh.
- Sacha: Stuart Findlay pointed out in an earlier meeting that about 90% of the sediment that's accreted in marshes comes from the Hudson River. Even though you have a muddy Sparkill, but the daily flood (from the Hudson) twice a day with all that sediment is where most of it comes from.

Question: Betsy, you said that the money must be used for "habitat mitigation" – what falls under that rubric and who decides?

- Betsy: It's not sewage treatment plant updates. In this case, it includes green infrastructure projects in the watershed. It's really a function of what the Thruway Authority thinks is a good idea and wants to propose to DEC, and also what makes sense to DEC and Parks staff. That's partly informed by a large group of people thinking about what would benefits habitats, and it's informed by what you all think would benefit habitats. I don't have a 'pick three from list A,' I have to be convinced in order to recommend approval. It's not my final call, but the idea is that there would be some sort of benefit for habitat.
- **Question: Whose habitat are we talking about?**
    - Betsy: We're talking about natural habitat of the ecosystem. Other types of restoration projects are being done (including oyster restoration and a side-channel restoration that will benefit shallow-water fishes and birds). For the supplemental funds (from the permit), other ideas have come up (such as restoring submerged aquatic vegetation). Something like a seawall is not a habitat enhancement. That may have value but it's for a different purpose, and it's not a positive for habitat.

Question: Sacha, I was really struck by how you said the marsh would evolve and it would end up in *Spartina* grass. Why are we planning with this marsh since it's going to change, and it's probably going to change in the direction you want to drive it?

- Sacha: There's not a right answer to that question. As a conservation biologist, I would call the period before you start to get that habitat back a bottleneck – species would undergo a period of a few decades where the seed bank would start to disappear. It's an ecological bottleneck. You might decide that you want to maintain some remnant of that habitat/those other species now to act as a springboard for that habitat down the road. That might be a justification for management. I don't think the data say it's not worth doing now, or that it's not worth keeping *Phragmites*.
- **Comment:** We might end up trying to revive the *Phragmites*.

Feedback Forms (10 total):

How much has this meeting increased your knowledge and understanding of the topics discussed today?

- A great deal: 4
- A lot: 3
- Some: 2
- A little: 1
- Not at all: 0

This meeting was a good use of my time:

- Strongly agree: 3
- Agree: 4
- Unsure: 2
- Disagree: 1
- Strongly disagree: 0

What was the most valuable information you heard here today?

- The need to prepare for the inevitable rise in the tides and storm surges.
- Klaus Jacob's presentation.
- Info provided by Klaus Jacob – concise, clear, and to the point! Unlike many predecessors at this and other meetings.
- Long-term sea level rise predictions; NY is equal to FLA and LA in flood risk!!
- Factors in predicting conditions given future scenarios (sea level rise, storm protection, salinity, marsh response).
- Sacha's model info/results that predicts highland marsh etc.
- Little of any?
- Function of marsh plants for slowing down water (friction) and wind. Resiliency Plan Task Force work, and SLAMM projections.
- Future (possible) of marsh, sea rise, of Paradise Ave.
- Sacha's information.

What worked well and what didn't?

- Too many numbers and statistics to justify eradication of *Phragmites*.
- What worked well: speakers, pacing and calm tone of discussion; what didn't: microphones.
- Better this session – less of an intro into the entire process. Let's start and get going. Klaus was the only speaker to not be given time to ask question…Ed asked everyone to hold questions for later. Just saying…
- Microphone didn't.
- Great presentations! A lot of info to take in.
- Excellent information from speakers.
- Discussing Miami.

How could the format of the meeting be improved for future fact-finding meetings?

- Just layout future plan.
- More time for questions – I learned a lot from them too.
- Good format. Thanks for keeping time and format structure.
- It's good – perhaps start just a half hour later.

Have you attended a previous fact-finding meeting?

- Yes: 7
- No: 3

Do you think you might attend the next fact-finding meeting?

- Yes: 8
- Maybe: 2
- No: 0

Other comments:

- Is this window dressing for your plans to eradicate *Phragmites* thru use of herbicides?
- DEC should work harder and apply itself to the task of spending the financial resources allocated for mitigating ecological ? of Tappan Zee reconstruction to the benefit of Piermont as unique ecosystem. Not take a simplistic route and ruin the precious place that nature gave us. Shame on you!!

Cards Submitted

- Compare the height, density, and mass of *Phragmites* to *Spartina*.
- If we get rid of some *Phragmites*, there will be some time before any regrowth - yet we will still have risks for flooding (1% of another Sandy-type). How will Piermont be protected during regrowth?
- For Betsy: Is the vegetation you desire to reintroduce to the marsh less dense and shorter than the existing *Phragmites*?
- While listening to the presentations and viewing the models and predictions, nowhere do I hear how *Phragmites* could be harmful in relation to flooding, tide surge and sea level rising.
- Is the marsh big enough to slow wave action?
- Paradise Avenue floods more since the *Phrags* have taken over. Would a restored marsh act like a sponge? Instead of pushing water along the creek.
- To anyone: Assuming sea level rises to first eliminate *Phrag* then possibly all marsh, would a preservation/at least part of the native marsh now, facilitate a healthier marsh at the later time?
- How has or has not the Sparkill Creek dam removal been considered related to sediment accretion and the marsh and to reduce storm flooding?
- Sediment seems key to address sea level, should we be asking for sediment from the new Tappan Zee?
- For Peter Sheng: He mentions doing a "study" of Piermont M. at the end of his presentation. Would would be the parameters of such a proposal - would it take a year, years? And if recommended would DEC consider using the funding to help conduct a study?
- To the DEC: Would you be willing to do Peter Sheng's modeling with various plant species before deciding on action?
- To the DEC: Have you contacted FEMA (which insures all of houses from flood damage) about your plans to remove the *Phragmites*? If not, why? If yes, what did you discuss?
- For Dr. Sheng: Can you point out where on your surge protection chart our 3 kilometer buffer would appear?
- Klaus noted that the *Phragmites* are commonly flattened by wind, waves, and debris. How much does flattening or ? down of *Phragmites* diminish their wave and surge attenuation?
- What falls under the rubric of "habitat mitigation"? Who decides what falls under that rubric?