**Impacts of Tropical Storms Irene and Lee on the Hudson River**



NASA Satellite Image from September 12, 2011

**September 19, 2012**

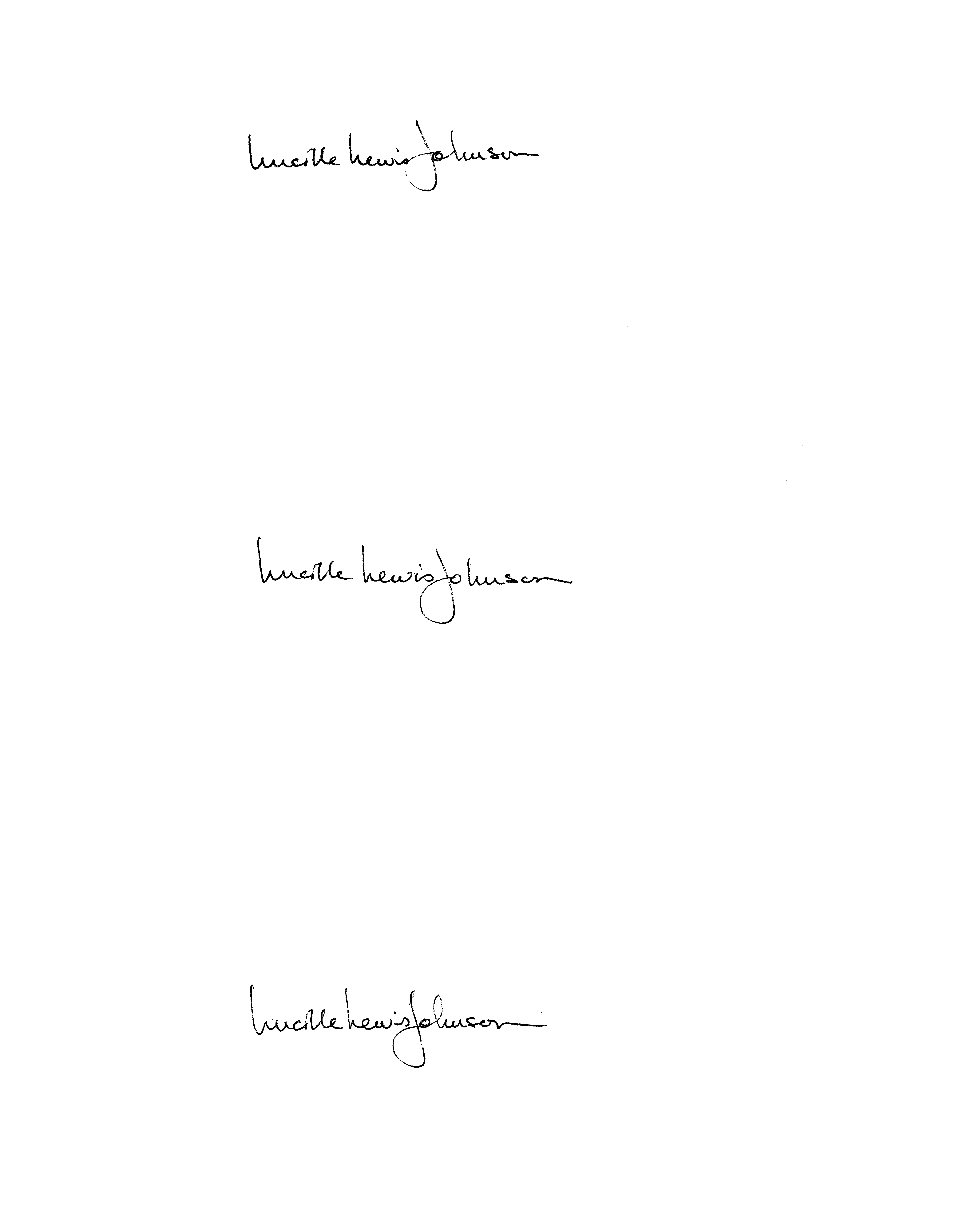
**Cary Institute of Ecosystem Studies, Millbrook, New York**

# Preface

Since 1970, the Hudson River Environmental Society has been organizing and presenting fact-based conferences on issues of importance to the Hudson Valley ecosystem. Our conferences present balanced and responsible reports from the scientists involved in the research. We aim to give policy-makers the best science available from which to draw in making decisions on actions that will impact the Valley. The Hudson River Environmental Society does not advocate for particular positions; rather, we present all sides of controversial issues so that decision-makers have accurate information when deciding their course of action. We also present conferences which outline current knowledge about scientific issues relating to the Hudson Valley environment, such as today’s conference on the impacts of Irene and Lee on the Hudson River, and next spring’s conference on “The State of Hudson River Science,” which we hope to make an annual spring review of what is going on in studying our watershed. We welcome suggestions for future conferences that you would find of interest.

I would like to thank all of our collaborators, our sponsors, our speakers and poster presenters, and all of you for attending today’s conference. We also thank the Cary Institute of Ecosystem Studies for hosting today’s conference. I do hope that you will not only enjoy it but also find value in it.

**Welcome!**

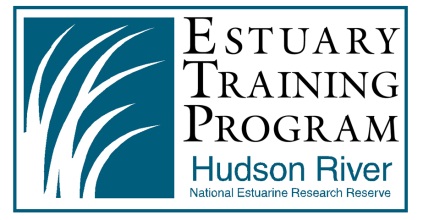
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**Impacts of Tropical Storms Irene and Lee on the Hudson River**

***Cary Institute of Ecosystem Studies, Millbrook, NY***

***September 19, 2012***

# Conference Agenda

**8:00-9:00** - Registration and Light Breakfast

**9:00  – Welcome**: Stuart Findlay, Cary Institute of Ecosystem Studies

**9:15 -****Opening Remarks**: Kathy Moser, NYSDEC Assistant Commissioner for Natural Resources

***Meteorology & Hydrology***

9:30 – The Hudson River and Estuary Physical Response to Irene and Lee –Philip Orton, Stevens Institute of Technology

9:45 – Meteorologic Factors that Resulted in Extreme Rainfall During Tropical Storm Irene and the Remnants of Tropical Storm Lee – Joseph P. Villani, Stephen N. DiRienzo (speaker), Hugh W. Johnson, Vasil T. Koleci, Kevin S. Lipton, George J. Maglaras, Kimberly G. McMahon, Timothy E. Scrom, Thomas A. Wasula, and Britt E. Westergard, NOAA/NWS Weather Forecast Office, Albany, New York

10:00 – Hydrology of Tropical Storms Irene and Lee -Britt E. Westergard (speaker), Joseph P. Villani, Hugh W. Johnson, Vasil T. Koleci, Kevin S. Lipton, George J. Maglaras, Kimberly G. McMahon, Timothy E. Scrom, and Thomas A. Wasula, NOAA/NWS Weather Forecast Office, Albany, New York

***10:15 – 10:45: Coffee Break***

***Sediment Transport***

10:45 – Hudson River Watershed Sediment Transport following Tropical Storms Irene and Lee- Gary R. Wall (speaker) and Timothy F. Hoffman, U.S. Geological Survey

11:00 - Salinity and Sediment in the Hudson River Estuary after Tropical Storms Irene and Lee- David K. Ralston (speaker), W. Rockwell Geyer, Woods Hole Oceanographic Inst. and John C. Warner, US Geological Survey

***Impacts to Other Systems***

11:15 – Impacts of Tropical Storm Irene on the Connecticut River– Jon Woodruff, University of Massachusetts Amherst

11:30 – 2011 Storm impacts on Nutrients and Sediments in the Susquehanna River Basin – Kevin McGonigal, Susquehanna River Basin Commission

***11:45 –1:00 Lunch (provided)***

## 1:00 – 1:45 Keynote: Impacts of tropical cyclones on North Carolina coastal carbon and nitrogen dynamics: Implications for biogeochemical cycling and water quality in a stormier and warmer world–Hans W. Paerl (speaker), Joseph R. Crosswell, Nathan S. Hall, Benjamin L. Peierls and Karen L. Rossignol, University of North Carolina at Chapel Hill, Institute of Marine Sciences and Department of Environmental Sciences and Engineering

***Impacts to the Biology of the Hudson River Estuary***

1:45 – Storms caused river to take a ‘breath’ –Stuart Findlay, Cary Institute of Ecosystem Studies, HRECOS

2:00 – Effects of tropical storms Irene and Lee on fish in the Hudson River Estuary: a preliminary analysis – David Strayer, Cary Institute of Ecosystem Studies

***Impacts to the Hudson River Tributary Habitats***

2:15 – Some implications of recent extreme weather events for environmental management and policy in the Catskills Region –Mark Vian, NYC Environmental Protection’s Stream Management Program

2:30 - Documenting Impacts of Storm Response Construction Activities upon Stream Ecosystems Following Tropical Storms Irene & Lee –Joshua Thiel, NYS DEC Bureau of Habitat

2:45 - Impacts to the Macro-invertebrate Community –Alexander J. Smith (speaker), NYS DEC Stream Biomonitoring Unit and Mohawk River Basin Program and Barry P. Baldigo, Mike McHale, US Geological Survey

**3:00 – 3:15 Closing Remarks and Completion of Evaluations**

***Break to move to Poster Session and Reception***

3:30 – 5:30 Poster Session and Reception

“Save the date for the following upcoming event!”

**2013 Hudson River Science Symposium**

***“The State of Hudson River Science”***

**State University of New York at New Paltz**

**Student Union Building**

**Wednesday April 24, 2013**

**9:00AM - 5:30PM**

*Check* [***www.hres.org***](http://www.hres.org) *for updates!*

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# Keynote Address

## Impacts of tropical cyclones on North Carolina coastal carbon and nitrogen dynamics:

## Implications for biogeochemical cycling and water quality in a stormier and warmer world

## Hans W. Paerl, Joseph R. Crosswell, Nathan S. Hall, Benjamin L. Peierls and Karen L. Rossignol

## University of North Carolina at Chapel Hill, Institute of Marine Sciences and Department of Environmental Sciences and Engineering

Coastal North Carolina has been impacted by eight major hurricanes and six tropical storms in the past fifteen years, and this frequency is forecasted to continue in the foreseeable future. Each of the past storms exhibited unique hydrologic and nutrient loading scenarios for the US’s second largest estuarine system, the Pamlico Sound System (PSS) and its major tributaries (*e.g.*, Neuse River Estuary (NRE)). During this period, the PSS has also been impacted by record-breaking droughts. Different rainfall amounts resulting from storms and droughts have led to highly variable freshwater discharge and hence variable nutrient, organic matter, and sediment enrichment. Large, high rainfall storms (e.g., Hurricanes Fran, 1996 and Floyd 1999, Tropical Storm Ernesto 2006; Tropical Depression Nicole 2010), greatly increased freshwater discharge and nutrient (nitrogen and phosphorus) loading to the PSS. Annual nitrogen loads in years with these storms were near double those of non-storm years. Phytoplankton-dominated primary production and phytoplankton community composition were strongly affected by nutrient enrichment and altered water freshwater flushing rates (residence times) associated with storms. Hurricane-impacted years, and in the case of very large storms (*e.g.*, Floyd) the following year, tended to exhibit increased numbers of algal blooms, including harmful ones (e.g., the toxic dinoflagellate *Karlodinium*) and extensive bottom water hypoxia. Other large but drier storms (Isabel 2003, Irene 2011) caused major physical perturbations (i.e. intense vertical mixing and sediment resuspension), but new nutrient inputs were minor, as were productivity and algal bloom responses. Summer droughts, especially after a wet winter or spring, favored dominance by slower-growing, thermophilic cyanobacteria. It is expected that global warming will enhance cyanobacterial bloom potentials, especially in storm-impacted, nutrient enriched systems.

Long residence times and high rates of primary production make North Carolina’s estuaries large repositories of allochthonous and autochthonous-generated carbon (C) that are highly sensitive to perturbations from major storms. Intense wind-driven mixing can rapidly aerate the entire water column and mobilize C that has accumulated in sediments over much longer time-scales (months-years). In two days, Hurricane Irene (2011) released more CO2 from the NRE-PSS than the cumulative CO2 uptake over the prior year, during which the NRE-PSS had been a monthly sink of atmospheric CO2. High-rainfall storms can further elevate CO2 emissions in nearshore waters by increasing riverine delivery of labile allochthonous organic matter and high pCO2 freshwater. Irene brought moderate rainfall to the NRE watershed and most of the associated C loading occurred within the 2.5 weeks that followed landfall. By contrast, C loading was ~10 times greater after Hurricane Fran (1996), and the three back-to-back hurricanes in 1999 (Dennis, Floyd, Irene), and water quality was affected for months rather than weeks. Major storms dramatically affect the coastal C cycle and can result in CO2 emissions that exceed those from much larger terrestrial or open-ocean systems. If the observed trends in storm intensity and frequency continue, storm-driven release of CO2 to the atmosphere may represent a positive feedback to the climate system via reduction in long-term C storage in estuaries.

Freshwater discharge, wind forcing and warming are important drivers that must be integrated with nutrient loading in assessing biogeochemical and ecological and impacts of these storms. In the short term, these climatic forcings are not manageable but must be incorporated in water quality management strategies for these and other estuarine and coastal ecosystems world-wide faced with a warmer climate, with increased frequencies and intensities of tropical cyclones, flooding, and droughts.

***Speaker Bio:***

*Hans W. Paerl, Institute of Marine Sciences, University of North Carolina, Morehead City, NC*

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Hans W. Paerl is Kenan Professor of Marine and Environmental Sciences at the University of North Carolina’s Institute of Marine Sciences, located in Morehead City, NC . His research includes; microbially-mediated nutrient cycling and primary production dynamics of aquatic ecosystems, environmental controls and management of harmful algal blooms, and assessing the effects of man-made and climatic (storms, floods) nutrient enrichment and hydrologic alterations on water quality and sustainability of inland, estuarine, and coastal waters. His studies have identified the importance and ecological impacts of atmospheric nitrogen deposition as a new nitrogen source supporting estuarine and coastal eutrophication. He is involved in the development and application of microbial and biogeochemical indicators of aquatic ecosystem condition and change in response to human and climatic perturbations. He directs the Neuse River Estuary Modeling & Monitoring Program, ModMon (w[ww.unc.edu/](http://www.unc.edu/ims/neuse/modmon)ims/neuse/modmon) and ferry-based water quality monitoring program, FerryMon (w[ww.ferry](http://www.ferrymon.org/)mon.org), which employs environmental sensors and microbial indicators to assess near real-time ecological condition of the Albemarle-Pamlico Sound System, the USAs second largest estuary. In 2003 he was awarded the G. Evelyn Hutchinson Award by the American Society of Limnology and Oceanography for his work in these fields and its application to interdisciplinary research, teaching and management of aquatic ecosystems. In 2011 he received the Odum Lifetime Achievement Award from the Estuarine and Coastal Research Federation for his work on the cause and consequences of eutrophication and harmful algal blooms in estuarine and coastal waters.

# Meteorological Factors that Resulted in Extreme Rainfall During Tropical Storm Irene and the Remnants of Tropical Storm Lee

## Joseph P. Villani, Stephen N. DiRienzo, Hugh W. Johnson, Vasil T. Koleci, Kevin S. Lipton, George J. Maglaras, Kimberly G. McMahon, Timothy E. Scrom, Thomas A. Wasula, and Britt E. Westergard.

NOAA/NWS Weather Forecast Office, Albany, New York

During the early morning of 28 August 2011, Tropical Storm Irene produced extremely heavy rainfall across eastern New York and western New England, which resulted in record flooding along several rivers in the Hudson River Basin. The heavy rainfall and record flooding were especially prevalent across the eastern Catskill River watersheds, including the Schoharie Creek, which fed downstream into the Mohawk River. A maximum area of 30 cm to 45 cm (approximately 12-18 in.) of rainfall fell across the elevated terrain of Greene County, which was followed by extreme runoff into the Schoharie basin. This area received much more rain than the rest of the Albany Forecast Area from the land-falling tropical storm.

Large scale weather patterns allowed tropical moisture from the remnants of Tropical Storm Lee and from the Atlantic Ocean to stream northward across the area from September 6th through September 9th, 2011. This stalled pattern allowed continuous rain, heavy at times, to persist for 48 hours. Although rainfall totals in the Hudson River Basin from the remnants of Tropical Storm Lee were not as high as from Tropical Storm Irene, an additional 8 to 23 cm (3 to 9 inches) of rain fell in the Hudson River Basin and wet soil conditions enhanced runoff. The largest area of heavy rain in the Hudson River Basin fell in the upper Mohawk River Watershed. This produced additional river flooding, affecting many communities along the Mohawk River and the infrastructure of the New York State Canal System.

This presentation will outline the meteorological factors that led to the heavy rain and flooding across the Hudson River Basin from Tropical Storm Irene and the remnants of Tropical Storm Lee.

***Speaker Bio:***

*Steve DiRienzo, Warning Coordination Meteorologist, National Weather Service, Albany, NY*

Steve DiRienzo is the Warning Coordination Meteorologist at the National Weather Service Forecast Office in Albany, New York. He is responsible weather related decision support services to emergency managers and first responders, for evaluating forecast office products and services, and ensuring that people in the Albany county warning area are aware of local weather hazards by conducting preparedness planning and education. Prior to becoming Warning Coordination Meteorologist, He served in the National Weather Service as Senior Service Hydrologist at the Albany, NY weather forecast office. Before joining the National Weather Service, he served as a Meteorologist in the U.S. Air Force.

# Storms Caused River To Take A ‘Breath’

## Stuart Findlay

Cary Institute of Ecosystem Studies, Millbrook, New York

The passage of two major Tropical Storms through the Hudson Valley caused large, rapid and often obvious changes in the Hudson River and its tributaries. There were large loadings of sediment and particulate organic carbon delivered from both the upper Hudson/Mohawk watersheds as well as some of the mid-Hudson tributaries. Often, a depletion of dissolved oxygen follows storm events as this organic matter is decomposed or nutrient loads generate blooms of phytoplankton. In the case of the Hudson, this potential oxygen drawdown was partially counter-acted by inputs of cooler, high DO waters from tributaries. While it appears that the large load of organic matter did stimulate oxygen consumption, the fact that oxygen levels had been augmented by new inputs helped offset any negative effects. Calculated respiration was approximately 4X higher than normal values and bacterial growth rates were elevated for over a month post-Irene.

Both phyto- and zooplankton were washed out of the mid-Hudson by the large increase in flow and the high turbidity levels persisted long enough to prevent any recovery during autumn 2011. These storms may have had longer-lasting effects. Presence of submerged aquatic vegetation appears to be greatly reduced in summer of 2012. Loss of these plants may have significant effects on the dissolved oxygen dynamics in the Hudson.

The Hudson River Environmental Conditions Observing System was critical to our ability to detect and interpret the rapid changes that occurred during and after these storms. HRECOS data provide a valuable context for the manual data collection required for most measurements of ecological processes.

***Speaker Bio:***

*Stuart Findlay, Cary Institute of Ecosystem Studies, Millbrook, NY*

Stuart Findlay is an Aquatic Ecologist at the Cary Institute of Ecosystem Studies.  He has studied the Hudson for over 25 years, focusing on microbial processes, wetlands and littoral habitats.  He has worked closely with management agencies and efforts at broadening education.

# Salinity and Sediment in the Hudson River Estuary after Tropical Storms Irene and Lee

## David K. Ralston, W. Rockwell Geyer, Woods Hole Oceanographic Inst.

## John C. Warner, US Geological Survey

The extraordinary freshwater flow in the Hudson watershed from Hurricanes Irene and Lee caused a rapid expulsion of the saline water from the estuary, pushing the salt-water front to lower Manhattan, based on observations and model results. The large freshwater inflow was accompanied by very high sediment loading—almost 3 million tons based on preliminary estimates by Wall at USGS. We simulated the flow and sediment transport during and after the hurricanes with the USGS-ROMS numerical model, in order to determine whether these high flows would result in significant export of sediment from the river and estuary to New York Bay and the ocean. The model was tested against an extensive set of salinity observations, indicating a one-day lag in the model response to the floods relative to the data, but otherwise accurate representation of the observed changes in estuarine conditions during the event. The simulated sediment transport showed surprisingly little sediment export—most of the sediment delivered by the storms was trapped in the tidal river north of West Point according to the model. Unfortunately this result could not be tested against data due to the absence of turbidity data or water samples in the estuary during the event. These results underscore the importance of improving our understanding of the mechanisms of sediment trapping and remobilization in the tidal river and of expanding the array of long-term monitoring stations for suspended sediment.

***Speaker Bio:***

David K. Ralston, Woods Hole Oceanographic Inst.

David Ralston is an Associate Scientist at Woods Hole Oceanographic Institution.  His research interests are in coastal and estuarine physical oceanography, including estuarine circulation, stratified turbulence, sediment transport, and physical-biological interactions.  He has used a combination of field observations and numerical models to study flow physics and sediment transport in broad range of estuaries, including the Hudson, Connecticut, and Merrimack River estuaries, San Francisco Bay, and Puget Sound.

# Impacts of Tropical Storms Irene and Lee on the Hudson River

## Kevin McGonigal

Susquehanna River Basin Commission, Harrisburg, PA

In 1985, the Susquehanna River Basin Commission along with the United States Geological Survey, the Pennsylvania Department of Environmental Protection, and United States Environmental Protection Agency began an intensive study of nutrient and sediment transport in the Susquehanna River Basin. The long-term focus of the project was to quantify the amount of nutrients and suspended sediment transported in the basin and determine changes in flow-adjusted concentration trends at twelve sites. Several modifications were made to the network including reducing the original twelve sites to six long-term sites then adding 13 sites in 2004, four sites in 2005, and four sites in 2012. The current network consists of 27 sites throughout the Susquehanna River Basin varying in watershed size and land use. Water quality samples are collected during baseflow and storm flow conditions and analyzed for various nitrogen and phosphorous species, total organic carbon, and suspended sediment. Data are used to calculate annual, seasonal, and monthly nutrient and suspended sediment loads and annual flow adjusted trends.

Flows during 2011 included multiple extreme events occurring over the entire calendar year in the Susquehanna River Basin. This included a very wet winter and spring followed by sustained flow levels above the historic median values for August through November, and drastic flooding due to Hurricane Irene and Tropical Storm Lee. Extensive monitoring was conducted during both events to capture the amounts of nutrients and SS transported through these historical events which produced the highest recorded flows for the entire 28 years of data collection. High flows during September were 584% of the monthly long term mean resulting in total nitrogen, total phosphorous, and suspended sediment loads of 645%, 1,862%, and 3,295% of the long term means respectively.

***Speaker Bio:***

*Kevin McGonigal, Susquehanna River Basin Commission, Harrisburg, PA*

Kevin McGonigal has worked as the manager of the Susquehanna River Basin Commissions Sediment and Nutrient Assessment Program for the past 10 years.  The program consists of a 27 station network that is part of the Chesapeake Bay Program’s non-tidal water quality monitoring network.

# The Hudson River and Estuary Physical Response to Irene and Lee

## Philip Orton

Stevens Institute of Technology, Hoboken, NJ

A general overview will be presented on the back-to-back impacts of Tropical Storms Irene and Lee, including information on the storms, the river and estuary responses, and a “Hudson-eye view” animation of the flood elevations and water properties. The New York Harbor Observing and Prediction System (<http://stevens.edu/NYHOPS>) and Hudson River Environmental Conditions Observing System (<http://hrecos.org> ) will be utilized with available governmental data to describe the freshwater inputs, water velocities, elevations, and salinity changes caused by the storms. Irene washed nearly all salt from the Hudson River estuary southward of Manhattan, and there was only a brief return to brackish conditions before Lee nearly did it again. Also, the merging of flood waters from coastal storm surge and inland rain will be quantified and demonstrated. Understanding this merging flood will help us better understand how future sea level rise and potential increases in storm intensities and rain rates might influence flooding along the Hudson.

***Speaker Bio:***

*Philip Orton, Stevens Institute of Technology Maritime Security Laboratory, Hoboken, NJ*

Philip Orton is a postdoctoral research associate at the Stevens Institute of Technology in Hoboken, New Jersey.  He holds a PhD in physical oceanography from Columbia University and a Masters Degree in marine science from the University of South Carolina. His newest research examines the threat of flooding from storm surges, rainfall and sea level rise around the tri-state area with a particular focus on New York City and the Hudson Valley.  In nearly 20 years doing science research, he has studied air-sea interaction, turbulent mixing, sediment transport, carbon dioxide and ocean acidification, and relationships between fish, climate and ocean physics.

# Assessing the effects of Hurricane Irene on benthic macroinvertebrate communities

# in the Upper Esopus Creek in New York State

## Alexander J. Smith, NYS Department of Environmental Conservation

Barry P. Baldigo, Mike McHale, US Geological Survey

The Upper Esopus Creek, located in the Catskill Mountains of New York State is well known as a premier trout fishing stream. In an ongoing study of the stream that began in 2009, NYSDEC, and USGS have been intensively sampling benthic macroinvertebrates, periphyton, fish, discharge and water chemistry from 20 sites in the Upper Esopus Creek Watershed. The occurrence of Hurricane Irene on August 28 and 29, 2011, provided an opportunity to study the effects of extreme high flow events. Rainfall from Hurricane Irene averaged 12 inches in the region, causing one of the most severe flood events in recent regional history. Current estimates place the flooding in the 100-500 year occurrence interval. Post Hurricane Irene sampling was conducted at 5 sites in September and November of 2011 and will continue in 2012. Early results of benthic macroinvertebrate community analysis suggest significant loss in species composition from all sites post-hurricane. Community metrics such as species richness, mayfly-stonefly-caddisfly richness, decreased on average by 60 percent, compared with before the hurricane. Up to 20 species were lost from post- Hurricane Irene communities. Losses were not restricted to swimming organisms such as the mayflies *Acentrella turbida* and *Baetis* species; losses also included attached taxa such as *Polypedilum flavum* (filtering midge), and *Dolophilodes* sp. (filtering caddisfly). Community assessment metrics indicate sites scored as much as two impact categories worse than pre-Hurricane Irene. Non-metric multidimensional scaling shows distinct clustering of pre- and post-hurricane communities based on the similarity of species data between sites. The dramatic loss of biodiversity coupled with significant geomorphological changes in the watershed indicates ecosystem recovery in the Upper Esopus Creek will take years. Continued sampling will monitor the recovery of this system and document long-term changes in community structure due to loss of diversity.

***Speaker Bio:***

*Alexander J. Smith, NYS Department of Environmental Conservation, Troy, NY*

Alexander J. Smith is a Research Scientist with the New York State Department of Environmental Conservation, Division of Water, and Stream Biomonitoring Unit Program Manager. Alexander has undergraduate and graduate degrees from the State University of New York (SUNY) College of Environmental Science and Forestry (ESF) and SUNY Albany. Presently he is a PhD student under the direction of Dr. Neil Ringler and Karin Limburg, at SUNY ESF. Alexander is also a North American Benthological Society Certified Taxonomist. His research projects focus on applying stream ecological theory to statewide datasets in an effort to advance water quality assessment and water quality regulation in NYS.

# “Effects of tropical storms Irene and Lee on fish distributions in the Hudson River estuary:

# A preliminary analysis”

## David L. Strayer

Cary Institute of Ecosystem Studies, Millbrook, NY

I analyzed data from the electric utilities’ beach seine survey to look for evidence that tropical storms Irene and Lee affected the abundance, distribution, and species composition of fishes in the Hudson River estuary. Results from a preliminary analysis of eight abundant species (alewife, blueback herring, American shad, tessellated darter, banded killifish, spottail shiner, and striped bass, white perch) show that these storms reduced the number of fishes in the beach seine samples and displaced fish populations downriver. I found no evidence that the storms washed fishes from the tributaries into the estuary. These storms had measurable but not catastrophic effects on the Hudson River fish community.

***Speaker Bio:***

*David Strayer, Cary Institute of Ecosystem Studies, Millbrook, NY*

Dr. Strayer is a freshwater ecologist at the Cary Institute of Ecosystem Studies. He works chiefly on the ecology of non-native species, freshwater conservation, and the Hudson River. Although most of his research has focused on invertebrates, he has worked with fisheries biologists on previous analyses of Hudson River fish populations.

# Documenting Impacts of Storm Response Construction Activities upon Stream Ecosystems Following TS Irene & Lee

## Joshua Thiel NYS Department of Environmental Conservation, Albany, NY

In late August and early September 2011, Tropical Storms Irene & Lee passed over NY causing record flooding over wide areas of the state. Roads, bridges and homes were heavily damaged, and numerous streams were filled with debris. In the recovery from these conditions, various entities were given permits to conduct in-stream construction. Many operators however took very liberal actions while performing this work, often times exceeding permit conditions and site specific recommendations. Reports of these abuses became increasingly common. After learning of these instances, DEC enacted a survey to document the scope and scale of these occurrences. Staff were sent to 19 counties and visited 2,000 plus work sites to document and assess stream conditions. Of these, 412 were found to exhibit some form of improper work activity. These sites were documented with a site assessment form, georeferenced pictures and coordinate data. Sites where abuses occurred were most often characterized by over-dredging and channelization, as well as the creation of ‘side-cast’ berms and the destruction of riparian habitat. Beyond acute impacts to biota and habitat, it is expected that these conditions will contribute to raising water temperatures, increased erosion and sedimentation and an increase in morphological stream instability.

***Speaker Bio:***

*Joshua Thiel, NYS Department of Environmental Conservation, Albany, NY*

Josh Thiel (“teal”) is a biologist with the NYSDEC where he manages the Aquatic Habitat Protection Program. He maintains programmatic responsibility for ‘Protection Of Waters’ regulations and permitting. As such, his work focuses on protecting the habitat of New York streams and pursuing initiatives to support this.

# Consequences of Recent Extreme Weather Events for Environmental Management and Policy in the Catskills Region

## Mark Vian

NYC Environmental Protection, Kingston, NY

The Catskills Region of New York State represents a large landscape within NYS with relatively less-disturbed ecological functions. This landscape is nonetheless heavily managed to sustain highly-valued environmental services to our economy and culture: a clean drinking water supply for NYC, coldwater fisheries, “wilderness” recreational opportunities, agricultural production, *etc.*; while at the same time serving as home to many residents and communities. Extreme weather events like the recent flooding associated with last year’s Tropical Storms Irene and Lee (as well as numerous lesser flood events of the last decade) present enormous challenges to the many agencies responsible for the practical work involved in these management activities. Central among these challenges are the changes to the physical condition of stream channels, floodplains and hill slopes directly resulting from the storms, and then the changes resulting from immediate post-flood channel reshaping by heavy equipment operators. In the process of responding to these very large flows and the physical changes resulting from them, we recognize that our theoretical understanding of many inter-related landscape processes is likewise challenged, and that the policies that have grown up out of that theory need to be revisited.

***Speaker Bio:***

*Mark Vian, Stream Management Program, NYC Environmental Protection, Kingston, NY*

Mark Vian has been active in river management in the Catskills for the past seventeen years, developing community-based stream management plans, helping plan and conduct research on fluvial geomorphology in Catskills streams, coordinating educational workshops and trainings on a variety of river management topics, and managing multi-objective stream restoration projects. He works for the Stream Management Program of the NYCDEP, but presents today on behalf of the Catskill Creek Watershed Awareness Project.

# Hudson River Watershed Sediment Transport following Tropical Storms Irene and Lee

## Gary R. Wall and Timothy F. Hoffman

U.S. Geological Survey, Troy, NY

Runoff from Tropical Storms Irene and Lee discharged more than 2.8 million tons of suspended sediment into the tidal Hudson River north of Poughkeepsie, NY; 1.8 million tons of that entered the Hudson River at the head-of-tide at Green Island, NY. The Green Island total was affected by record-high daily suspended-sediment discharges on August 29, 2011, recorded at the Mohawk River at Cohoes (694,000 tons) and Hudson River at Waterford (140,000 tons) USGS sediment monitoring stations. The Schoharie Creek, the largest tributary to the Mohawk River, experienced a flood with an annual exceedance probability (AEP) of less than 0.2% (>500-year flood), and contributed the majority of flow associated with sediment discharged by the Mohawk River. The Hoosic River experienced a flood with an AEP between 1 and 0.2 percent and likely contributed much of the sediment observed at the Waterford monitoring station.

Provisional estimates of suspended-sediment discharge from monitoring stations established in 2011 near the mouths of six mid-Hudson River tributaries (Normanskill, Catskill, Kinderhook, Roeliff Jansen, Rondout, and Esopus Rivers) totaled approximately 1 million tons with the majority of that total (610,000 tons) contributed by Catskill Creek. The sediment discharge from Catskill Creek on August 28, 2011, was approximately 370,000 tons, a load comparable to a typical year of sediment discharge from the Mohawk, a river with a drainage area 8.5 times larger than the Catskill watershed.

Data from the HRECOS monitoring network, Cary Institute, the City of Poughkeepsie, and USGS indicate suspended-sediment concentrations remained elevated in the tidal Hudson River near Poughkeepsie for about 8 weeks after the storms until the end of October 2011. Estimates on the amount of sediment discharged by the tidal river past Poughkeepsie in the weeks following the events indicate the majority of sediment delivered to the Hudson River north of Poughkeepsie remained north of Poughkeepsie.

***Speaker Bio:***

*Gary Wall, US Geological Survey, Troy, NY*

Gary Wall is a hydrologist with the U.S. Geological Survey New York Water Science Center in Troy, NY.  Over the past 13 years, Gary has worked with the New York State Department of Environmental Conservation to address the state’s concerns over sediment loading and sediment related contamination in the Hudson River Watershed.

# The Hydrology of Tropical Storms Irene and Lee

## Britt E. Westergard, Joseph P. Villani, Hugh W. Johnson, Vasil T. Koleci, Kevin S. Lipton,

## George J. Maglaras, Kimberly G. McMahon, Timothy E. Scrom, and Thomas A. Wasula.

NOAA/NWS Weather Forecast Office, Albany, New York

Tropical Storm Irene produced extremely heavy rainfall across eastern New York (NY) and western New England from 27-28 August 2011. A maximum area of storm total precipitation of 12 to 18 inches (30 to 46 cm) fell across the elevated terrain of the Catskills in Greene County. A New York State 24-hour rainfall record was set at a National Weather Service (NWS) rain gage in Tannersville, NY. Record flooding occurred at thirteen forecast points in the NWS-Albany Hydrologic Service Area. Heavy rainfall and record flooding were especially prevalent across the eastern Catskill river basins, which contributed to significant rises down the Mohawk River and into the Hudson River, including major flooding on the Hudson River at Troy and Albany. The path of Tropical Storm Irene also caused record flooding on the Hudson River at Poughkeepsie due to storm surge.

Nine days after Tropical Storm Irene, the remnants of Tropical Storm Lee produced storm total rainfall amounts of 3 to 6 inches (7 to 15 cm), with isolated areas of 7 to 8 inches (17 to 21 cm) across eastern NY and western New England. The Mohawk-Hudson watershed did not receive the 8 to 12 inches (20 to 30 cm) of rainfall that caused major to record flooding throughout the Susquehanna watershed. However, the rainfall it did experience combined with antecedent saturated soils following Tropical Storm Irene produced major flooding in the western Mohawk-Hudson watershed and minor to moderate flooding elsewhere in the watershed.

This presentation will review both the hydrologic effects and impacts of these two events and the operational challenges of forecasting widespread rapid rises to record flooding.

***Speaker Bio:***

*Britt Westergard, NOAA/NWS Weather Forecast Office, Albany, NY*

Britt Westergard is the Senior Service Hydrologist at the National Weather Service (NWS) Forecast Office in Albany, NY where she manages the office hydrology program. Hydrologic services provided by the Albany Forecast Office include Flash Flood and River Flood Watches, Warnings and Advisories for the Hudson – Mohawk and Housatonic River basins as well as the headwaters of the Connecticut River. Her contributions to the National Weather Service mission to protect life and property during Tropical Storms Irene and Lee earned her the NWS Eastern Region Employee of the Month award in October 2011. Britt has over a decade of experience as a hydrologist with the federal government and has held positions as a hydrologic forecaster at the NWS Arkansas-Red Basin River Forecast Center in Tulsa, OK, a Service Hydrologist at the Jackson, KY NWS Forecast Office and an intern at the Troy, NY U.S. Geological Survey (USGS) Water Science Center. She holds a Bachelor of Science in Geological Sciences from the State University of New York at Binghamton.

# Impacts of Tropical Storm Irene on the Connecticut River

## Jon Woodruff, University of Massachusetts, Amherst, MA

In 2011 Hurricane Irene inundated the uplands of the Connecticut River watershed with as much as 250 mm of rain in less than 12 hrs. Flooding was extreme within the Deerfield tributary (1440 km2), reaching 3100 m3/s, the flood of record for the river. Landslide and gully erosion along the Deerfield valley walls, as well as scour and incision within the main channel mobilized clays and silts within glaciolacustrine and till deposits. Once suspended, fines were routed directly to the Connecticut River mouth, resulting in record-breaking sediment loads 5-times greater than predicted from the pre-existing rating curve. Over the 3 days of peak flooding approximately 1.2 Mtonnes of sediment were transported through the low-lying reach of the Connecticut River. As much as 40% of this total load was derived directly from the Deerfield River, resulting in a sediment yield of 350 tonnes/km2 for the tributary (one-to-two orders of magnitude greater than annual yield estimates for glaciated tributaries in the region). When compared to sedimentation from the preceding spring freshet, resultant deposition from Irene in off-river ponds and coves is anomalously low in organics, is finer grained, and exhibits higher K/Zr ratios. This unique sedimentary imprint is consistent with the enhanced fluvial supply of glacial fines from upland tributaries during the event, which served to dilute particulate organics during transport, and cap contaminated industrial depocenters downstream with a relatively clean, inorganic, clay/silt layer. Results point to the important role of tropical cyclones in removing glacial sediments from the uplands for major North American rivers along the western Atlantic slope, as well as their unique depositional signature within lower-lying reaches.

***Speaker Bio:***

*Jon Woodruff, University of Massachusetts, Amherst, MA*

Jon Woodruff is an Assistant Professor in the Department of Geosciences at the University of Massachusetts where he has been a faculty member since 2009. Jon completed his Ph.D.  and M.S. in the Joint Program between Woods Hole Oceanographic Institution and Massachusetts Institute of Technology, and his undergraduate studies at Tufts University. His research interests lie in the area of sediment transport in coastal, estuarine and tidal river environments, with a focus on event-driven deposition.

**Impacts of Tropical Storms Irene and Lee on the Hudson River**

## *Poster Abstracts*

**The Impact of Tropical Storms Irene and Lee on Submerged Aquatic Vegetation**

# and Water Quality in the Tivoli Bays

## *Sarah Fernald1,2, Christopher Mitchell2, Christine Healy3, and Lisa Renee Williams4*

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Tropical Storm Irene made landfall in the Hudson River Estuary on August 28, 2011, with additional precipitation from Tropical Storm Lee extending to September 10, 2011. The impact of these storms on estuarine vegetation can be seen in data from the Hudson River National Estuarine Research Reserve (HRNERR) study assessing the impact of climate change stressors, specifically sea level change and increased storm surges, on vegetated habitats within Tivoli Bays, a freshwater tidal system. Within submerged aquatic vegetation (SAV) beds, rising water levels and higher turbidity are expected to favor invasive *Trapa natans* over native *Vallisneria americana*. There are differences in plant productivity, organic matter dynamics, and biogeochemical processes among these vegetation classes, so changes in cover may affect overall ecosystem function. Hudson River SAV maps were used to assess bed coverage throughout the estuary. Transects were established to assess annual dynamics in the Cruger Island South SAV bed. Transect data were collected prior to the storms in 2011, and again in 2012. An adjacent water quality station collected percent dissolved oxygen (DO%) values. A few trends were noted: 1) The observed SAV absence following the storms was more extensive that the SAV loss mapped in 2007; 2) Native *Vallisneria americana* was dominant before the storms, with more bare cover in the bed interior; 3) Following the storms, invasive *Myriophyllum spicatum* was sparse with more bare cover on the bed edge; 4) The July average DO% was ~6.5% lower during post-storm SAV absence than during 2011 pre-storm conditions or during 2007 SAV loss conditions.

**Water Level Monitoring in the Tivoli Bays**

## *Sarah Fernald1,2, Christopher Mitchell2, Christine Healy3, and Lisa Renee Williams4*

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The focus of this study is to assess the impact of climate change stressors, specifically sea level change and increased storm surges, on emergent tidal marsh within the Hudson River National Estuarine Research Reserve (HRNERR) site at the Tivoli Bays, a freshwater tidal system. In the Hudson River Estuary, the anticipated increase in water level of about 50 cm by the end of this century is close to the existing elevation difference between the vegetated lower intertidal community and the *Typha angustifolia* high marsh community. With sea level rise, a conversion of *Typha angustifolia* high marsh to vegetated lower intertidal community is anticipated. There are differences in plant productivity, organic matter dynamics, and biogeochemical processes among these vegetation classes, so changes in cover may affect overall wetland function. To monitor long term changes in water level and marsh inundation, groundwater wells containing tide gauges were installed at the beginning, middle, and end points of vegetation transects along an elevation gradient from open water to high marsh within the Inner Tivoli North (ITN) segment, a site of potential marsh migration. RTK GPS was used to survey the marsh surface elevation to sub-decimeter accuracy, allowing tide gauge data to be converted to water elevation. ITN baseline inundation data was collected from 6/3/11 to 6/17/11, and the storm surge from Tropical Storm Irene was captured 8/26/11 to 9/9/11. A comparison between these two data sets showed that water levels during the storm were 1 meter greater that baseline levels.

# The Impacts of Irene and Lee as seen through the eyes of the Hudson River Environmental Conditions Observing System (HRECOS)

## *Stuart E. G. Findlay1, Alene Onion2, Gary Wall3, Sarah Fernald4, Alan Blumberg5, and Wade McGillis6*

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The Hudson River Environmental Conditions Observing System (HRECOS) monitors weather and water conditions on the Hudson and Mohawk Rivers. Every fifteen minutes, HRECOS stations at various sites–including a mobile station on the sloop Clearwater – record information (data) and relay it to a website for anyone to see and use ([www.hrecos.org](http://www.hrecos.org)). Tropical storms Irene and Lee caused major changes in the Hudson River. Just like many human residents of our river valley, the river ecosystems are still feeling the effects of these storms. Most HRECOS stations continued to record data even during the worst of the storm conditions. These data surprised our collaborating scientists. For example, oxygen levels in the Hudson rose quickly after the rain began. One possible explanation is that the creeks and streams draining to the Hudson River had higher-than-normal oxygen levels. HRECOS is operated by a consortium of government and research partners. Funding is provided by the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, Hudson River Foundation, and the Hudson River Estuary Program of the N.Y.S. Department of Environmental Conservation.

# Decision Making involving Hudson River Shorelines

## *Emilie Hauser1,2, Ona Ferguson3, Shawn Dalton4, and Betsy Blair2*

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Two social science studies found that key challenges to the implementation of ecologically friendly shoreline structures include the following: design decisions are made early in the development process and are driven by upland land use; ecological impacts of shoreline structures, climate change, and sea level rise are not considered in the design process; there are conflicting goals between the stakeholders; and the installation of innovative designs requires advocates. While it is difficult to find regional land planning solutions because of local home rule, railroads present an opportunity since they control a large portion of the shoreline. To help overcome such challenges, decision makers need information on the design, construction, cost, ecological benefits, and engineering effectiveness of ecologically friendly shoreline structures. They also need a better understanding of projections and impacts of climate change and sea level rise. Key stakeholders such as consulting engineers, developers, regulators, and railroad managers need means and incentives to share expertise. The studies used key informant interviews and case studies of development projects to lean how decisions are made and information shared concerning shoreline design. This work is part of the Hudson River Sustainable Shorelines Project, funded by the NERRS Science Collaborative.

# Images of Evidence of High Water along the Hudson River after Irene

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Volunteers were asked to document evidence of high water after tropical storm Irene by photographing lines of woody debris, wrack and litter or mud lines on vertical walls and record the location with GPS or Google maps. Volunteers were contacted through direct email and email networks right before and after the storm. This was a last minute effort to capture photos immediately. Because wrack and debris can be moved by wind and current, the debris lines are not an exact mark of high water. They do provide a vivid image of where the water was, without requiring direct observations at the peak of the flood. We received about one hundred photos, including ones taken during the storm. Volunteers were happy to provide images from their areas. The photos are on a publicly accessible site:

<https://picasaweb.google.com/109559470569812944573/IreneFloodingHudsonRiverWatershed>

There is no tracking mechanism to know whether the images are used, but we refer requests of such images to the website. These images are a qualitative, visual documentation resource for outreach about the effects of flooding and storm surge combined with projected sea level rise. Exemplary photos and locations will be highlighted in the poster.

**Impact of Tropical Storm Irene-Associated Precipitation Event**

# on the Hudson River and Estuary Ecosystem

## *Mohammad "Shahidul" Islam1,2, James S. Bonner2, Chris Fuller2, Temitope Ojo2, and William Kirkey2*

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Tropical storm Irene passed through New York State on August 27 and 28, 2011, severely affecting the Hudson River ecosystem. The assorted automated sensors systems comprising the River and Estuary Observatory Network (REON) captured various impacts of this extreme episodic event at several locations within the Hudson River watershed. Water current increased substantially at all sites (*e.g.*, from 30 cm/s to 2.5 m/s at Albany, NY), with water levels peaking near their historical highs. The high current briefly overwhelmed the tidal influence at a monitoring site in the Hudson River estuary and pushed the salt front downstream. Continuous monitoring data at the PCB superfund site at Fort Edward, NY also showed significant and coincident increases in sediment flux (22 metric ton/hr to 2400 metric ton/hr) and stream flow (85 m3/s to 480 m3/s) following Irene. In addition, in-situ particle size measurements suggest that significant amounts of small particles (<70 µm diameter) were transported during the flood event. Smaller particles have a higher capacity for contaminant mobilization in the water column, compared to larger particles, due to their higher surface area/ particle volume ratio and their longer retention time in the water column. Moreover, the contribution of these extreme storm effects to the overall loading is comparable to that of long-term sediment transport under ordinary conditions. This suggests that effects of episodic events should be considered as part of ecosystem management during activities such as navigational channel dredging, remediation projects, and long-term water usage and discharge control.

**Floodplain Water Storage and Release Following Hurricanes Irene and Lee**

## *Laura Livingston1and Kirsten Menking2*

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Hurricanes Irene and Lee caused the highest discharge in the Casperkill stream in Poughkeepsie since a continuous monitoring program began in 2007. The Casperkill frequently floods, affecting homeowners in the lower sections of its watershed. During Irene and Lee the stream exceeded bank full discharge by approximately 6-fold. Our continuous monitoring program uses YSI sondes and a HOBO water pressure sensor to record pH, specific conductance, temperature, turbidity, dissolved oxygen, and water pressure every twenty minutes at a site along Boardman Road in the town of Poughkeepsie. During the non-winter seasons, specific conductance, which is a proxy for chloride concentration, displays an inverse relationship with discharge as runoff dilutes groundwater-derived baseflow in the stream. This relationship was maintained during Irene and Lee, with specific conductance values rapidly returning to their pre-storm levels within 4 days. While hydrographs for other rainfall events generally show an exponential decline following peak discharge, the hydrographs for Irene and Lee contain a “shoulder” where the discharge decline slows, interrupting the normal exponential decline. The “shoulder” is more prominent in the hydrograph associated with hurricane Irene than for Lee. This “shoulder” is probably related to the storage of water on the floodplain followed by its release through seepage.

# Hydrological Impacts of Hurricane Irene and Tropical Storm Lee in Historical Context: Is the Frequency of Extreme Hydrological Events Changing in Southern New York State?

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In August and September of 2011 Hurricane Irene and Tropical Storm Lee precipitated large amounts of rain, which resulted in unusual flooding and significant material damage across various parts of the eastern US, including our study area which includes the Catskill Mountains and Hudson River Valley in southern New York State. In this study we analyze precipitation and stream gage records in order to determine (1) how large these events were in comparison to earlier extreme events; and (2) whether this region has experienced a change in the frequency of extreme events in recent years. Statistical analyses are applied to streamflow records from ten USGS gauges and to precipitation records from twelve meteorological stations across the region. We find that taken together, Irene and Lee were unprecedented events in this region due to a combination of: the magnitude of precipitation in each event, the proximity in space and time of these two events, and antecedent and subsequent precipitation. For most areas in our study region return periods for Irene and Lee estimated using warm period statistics are larger compared to conventional annual maximum based statistics; this is consistent with the public perception that these events were much larger when considered in seasonal context. Furthermore, there has been a marked increase in the frequency of extreme hydrologic events during the last one to two decades. This increasing trend is more evident during the late summer and early fall, the season of the most extreme precipitation events.

# Impacts to Infrastructure in the Hudson River Estuary Watershed

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In late summer 2011, Irene and Lee barreled through the Hudson Valley. The storms changed the landscape, particularly the streams of the Hudson Valley and the infrastructure they intersect with. The New York State Department of Environmental Conservation Hudson River Estuary Program has collected information about the impact on infrastructure, and the related economic cost of the storms within ten Hudson River Estuary counties. Information on roads, culverts and bridges, dams, public water supplies, power outages, chemical spills, and others hint at the full economic cost of large storm events like Irene and Lee. In the coming year, we hope to use this information to get a more complete picture of the damage that large storm events can inflict on our natural and built environments. Understanding how different watersheds were affected by Irene and Lee will help communities make better decisions about what parcels are suitable for development, versus what areas will help protect our communities from flooding if left undeveloped. Irene and Lee were catastrophic events, but future generations will benefit if we can become more resilient now to major storm events.

**Water Quality Impacts of Hurricane Irene on Ecosystems at the Confluence of**

# Tributaries to the Hudson River Estuary

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The confluences of major tributaries to the Hudson River Estuary are locations of high biological importance. Pre-storm, post-storm and prior year data of physical and chemical parameters at the confluence of seven tributaries with the Hudson River Estuary, including the upper Hudson River and the Mohawk River, were analyzed to determine what influence Hurricane Irene and Tropical Storm Lee had at these locations. Both physical and chemical parameters were significantly altered by the storms. Physical parameters (suspended solids, water clarity) showed the greatest change with significant differences in the suspended solids and clarity. This effect was particularly strong at the confluence of the Mohawk River. Total Phosphorus, pH and Conductivity were all significantly altered immediately following the storms. However, there was no significant change to Total Nitrogen. Of the areas investigated, only the upper Hudson River showed no significant change following the storms for the parameters analyzed. The physical parameters associated with the Mohawk River were significantly different pre- and post-storm, but the chemical parameters remained unchanged. The tributaries within the Estuary showed significant change to both the physical and chemical parameters. The implications of these water quality impacts on the biota of these embayments are currently under investigation.

**Hudson River Environmental Conditions Observing System:**

**A Collaborative Effort in Real-time Monitoring**

## *Alene Onion1, Sarah Fernald2, and Gary Wall3*

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In 2008, the Hudson River Environmental Conditions Observing System (HRECOS) was established to provide high frequency geographically distributed real-time data between Albany and New York – New Jersey Harbor. It builds upon existing monitoring and observing activities on the Hudson River estuary, including the Hudson River National Estuarine Research Reserve System-wide Monitoring Program (SWMP), the U.S. Geological Survey, the NYS DEC Rotating Integrated Basin Studies, and modeling and monitoring efforts undertaken by Stevens Institute of Technology in the New York – New Jersey Harbor. HRECOS is operated by a consortium of partners from the government and research community who collaborate to provide data in real-time to a public website ([www.hrecos.org](http://www.hrecos.org)). The goals of HRECOS are to provide baseline monitoring data necessary for applied research and modeling, to improve the capacity of research entities to understand the ecosystem and manage estuarine resources, to provide policy makers with timely data products to guide decision making, and to support the use of real-time data in educational settings. Recently HRECOS expanded to include a pump house monitoring station at the Marist College campus in Poughkeepsie to collect water from the main channel. In addition, a monitoring station was established last fall (2011) to expand the network into the Mohawk watershed.

**Documenting Impacts of Storm Response Construction Activities upon Stream Ecosystems Following Tropical Storms Irene & Lee**

## *Joshua Thiel*

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In late August and early September 2011, Tropical Storms Irene & Lee passed over NY causing record flooding over wide areas of the state. Roads, bridges and homes were heavily damaged, and numerous streams were filled with debris. In the recovery from these conditions, various entities were given permits to conduct in-stream construction. Many operators however took very liberal actions while performing this work, often times exceeding permit conditions and site specific recommendations. Reports of these abuses became increasingly common. After learning of these instances, DEC enacted a survey to document the scope and scale of these occurrences. Staff were sent to 19 counties and visited 2,000 plus work sites to document and assess stream conditions. Of these, 412 were found to exhibit some form of improper work activity. These sites were documented with a site assessment form, georeferenced pictures and coordinate data. Sites where abuses occurred were most often characterized by over dredging and channelization, as well as the creation of side-cast berms and the destruction of riparian habitat. Beyond acute impacts to biota and habitat, it is expected that these conditions will contribute to raising water temperatures, increased erosion and sedimentation and an increase in morphological stream instability.

# Dissolved Organic Matter Export from a Forested Watershed during Tropical Storm Irene

## *Byungman Yoon*

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We incorporate high resolution time-series data to calculate the total amount of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) transported during Hurricane Irene in Esopus Creek in New York (August 2011). During this 200-yr event the Esopus Creek experienced a 330-fold discharge increase and a 4-fold increase in concentration, resulting in the export of roughly 43% and 31% of its average annual DOC and DON fluxes in just 5 days, respectively. The source of this large dissolved organic matter (DOM) flux also shifted during its course and showed an increased contribution of aromatic organic matter. We conclude that more frequent large events due to climate change will increase the export of terrigenous dissolved organic matter, and potentially impact the water quality and biogeochemistry of lakes and coastal systems. In addition, we show that the use of conventional models for extreme events lead to erroneous flux calculations, if not supported by high resolution data collected during the events.