Integrated Water Resources Science and Services
Hudson River Basin Stakeholder Report
June 27, 2013

Executive Summary

On June 27, 2013, the NOAA National Weather Service, in cooperation with the NOAA Cooperative Remote Sensing Science and Technology Center (CREST) at the City College of the City University of New York and the Hudson River Foundation (HRF), convened a one-day water resources stakeholders' meeting in New York City, New York (NY) involving 21 representatives from national, regional, state and local organizations. This meeting was part of a national initiative entitled Integrated Water Resources Science and Services (IWRSS). The IWRSS Federal partner agencies are NOAA National Weather Service, the U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (USACE). At this stakeholders' meeting, participants learned about hydrologic services IWRSS can provide, identified key gaps that IWRSS might fill to inform water resources decisions, and discussed possible demonstration projects to build capacity for enhanced integrated water resources management in the Hudson River Basin.

In advance of the meeting, participants were polled to determine the highest priority resources issues for the basin. Three issues of greatest interest rose to the top: climate change, flooding, and water quality.

During the meeting, participants were divided into two issue-based groups (flooding and water quality, with climate issues incorporated as a topic for both groups) reflecting the above priorities. The groups were charged to identify key decisions, questions, and gaps that IWRSS could help better inform. The most commonly identified gaps involved: (1) models and reliable forecasts; followed by (2) data and monitoring; and (3) sediment transport and sedimentation information needs. The modeling and forecasting needs covered a wide range of time scales and topics, including modeling and forecasting to inform short through extended range planning and design decisions for infrastructure, river transport/shipping, emergency planning, and land use. Data and monitoring needs included common/universal measurements and datum, calibration, data integration, and a one-stop portal for data, as well as improved monitoring of ice jams. Sedimentation-related needs focused on modeling sediment erosion and transport for the range of future event frequencies and magnitudes for infrastructure and dredging decision making and planning; understanding the impact of storm surge on sediment transport and beneficial deposition in wetland areas; information for the prediction of harmful algal blooms; and monitoring of groundwater levels and quality.

The two breakout groups combined to propose pilot projects to demonstrate how some of these information gaps could be filled to address priority issues. Three pilot projects were developed, which are summarized below.

Project #1: Develop a downscaled global climate model in conjunction with a coupled riverine-coastal model to better predict flood frequencies and inform infrastructure planning. The models would provide a wide range of data, including flood frequency, sea-level rise, and storm surge, and serve as a single data portal for this information. In addition, the models would be combined with an improved stream gage network for better calibration and application at the local level.

Project #2: Study the impact of precipitation events on sediment loading and accretion to better predict dredging requirements and prioritize sediment reduction efforts. Perform a study in the New York harbor or Albany harbor to better understand: (a) how sediment loads differ based on the location of precipitation events; and (b) beneficial sediment accretion within wetlands. This study would also integrate existing and new remote sensing and USGS monitoring data to develop more robust sediment budget information.

Project #3: Improve short-term (1-7 day) precipitation and streamflow forecasts to support improved operations of multi-purpose reservoirs and optimize Hudson River navigation. Perform a study in the New York harbor or Albany harbor to better understand the impact of streamflow forecasts on the economics of navigation decisions.

Hudson River Basin

On June 27, 2013, the NOAA National Weather Service, in cooperation with the NOAA Cooperative Remote Sensing Science and Technology Center (CREST) at the City College of the City University of New York (CUNY) and the Hudson River Foundation (HRF), convened a one-day water resources stakeholders' meeting in New York City, New York (NY) involving 21 representatives from national, regional, state and local organizations. IWRSS Federal partner agencies include the U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (USACE). During the stakeholders' meeting, participants engaged in full-group discussions and breakout group brainstorming sessions to achieve the following objectives:

- Learn about hydrologic services that IWRSS can provide for the Hudson River Basin (IWRSS presentation).
- Identify key gaps that IWRSS might fill to inform water resources decision making for priority water resources issues in the Hudson River Basin.
- Discuss possible demonstration projects to build capacity for integrated water resources management in the Hudson Basin and explore the benefits of such projects.

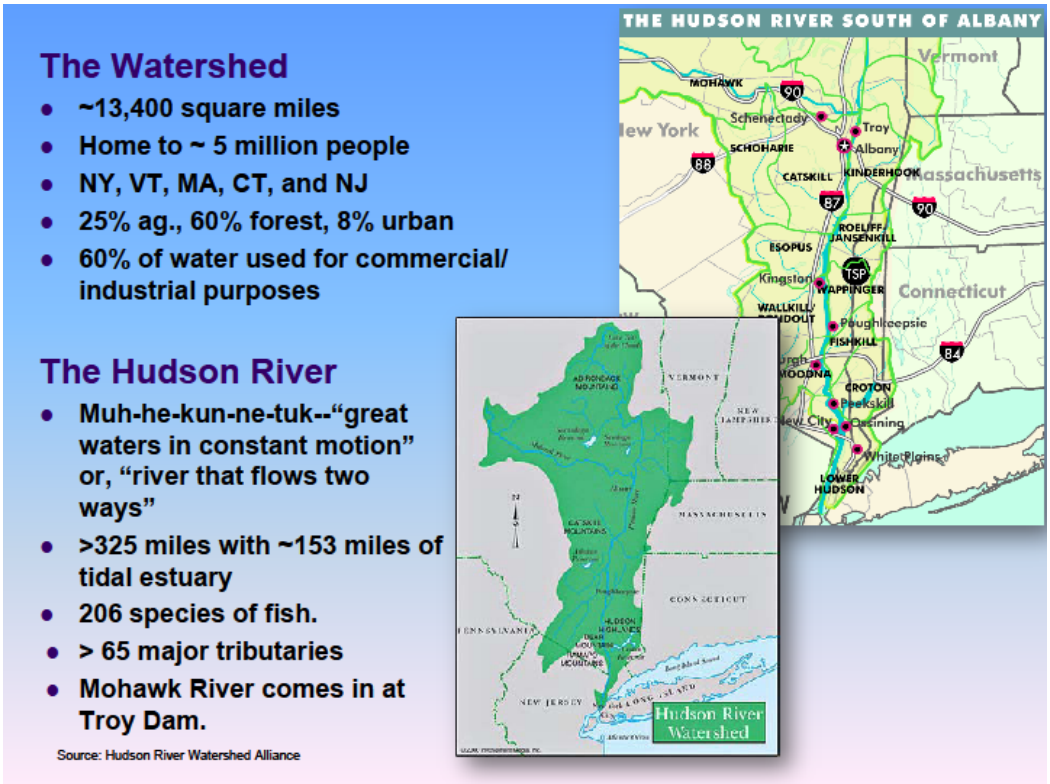

Figure 1: Overview of the Hudson River and Basin

Following is a summary of the discussion and recommendations from the forum.

Priority Water Resources Issues in the Hudson River Basin

The IWRSS team developed a list of priority water resource issues based on a consultation with HRF. The IWRSS team then shared the list of issues with participants prior to the stakeholders' meeting. As part of the registration process, participants were asked to indicate their top three highest priorities (with the option of writing in additional suggestions). Each issue, along with the number of votes it received (indicated in parentheses), appears below.

- Climate change (22)
- Flooding (19)
- Water quality (12)
- Fisheries (9)
- Water supply (8)
- Other (coastal shipping and modeling/forecasting of tides and currents) (2)

Results of the participant poll were summarized and formed the basis for the top three issues of greatest interest to be discussed at the meeting.

Top Three Water Resources Issues:

Water Quality

Water quality issues include: stormwater runoff, sewage discharges, saltwater intrusion, contaminated sediment and concerns about the impacts associated with hydraulic fracking. Upstream migration of the salt front is an issue for communities like Poughkeepsie that draw drinking water from Hudson River. Nutrients and bacteria from wastewater discharges are also an issue, and wastewater system infrastructure upgrades will be necessary in the near future. Contaminated sediment is an issue affecting water quality and aquatic life. Contaminants of concern include PCBs, pharmaceuticals, endocrine disruptors and heavy metals such as mercury.

Flooding

Flooding issues include: ice jams in the upper watershed during spring thaw; damage from extreme precipitation events (including recent hurricanes and tropical storms such as Irene and Sandy); and storm surge in the lower basin. Growing concerns include the combined effects of riverine peak flooding and coastal storm surge, and management of reservoir impoundments to mitigate flooding and prevent catastrophic releases.

Climate Change

Climate change issues include: increased drought, increased frequency and intensity of flooding associated with sea level rise, and stronger storms. Understanding the scope of these issues and adapting to them is gaining increased attention including: building community resilience (including infrastructure); conducting species vulnerability assessments; and developing adaptation guidance for local communities.

Stakeholders' Meeting – Opening Plenary Session

Co-sponsors Dr. Reza Khanbilvardi (NOAA CREST) and Clay Hiles (Executive Director, Hudson River Foundation) delivered welcoming remarks and explained the work of their organizations. Dr. Thomas Graziano (Chief, NWS Hydrologic Services Division) then laid the groundwork for the day by providing an overview of IWRSS. Following his presentation, the facilitator provided an overview of priority issues in the Hudson River Basin.

The group discussed the following questions related to IWRSS and the purpose of this forum:

- How can IWRSS support water resources research?

  One planned objective of NOAA's new National Water Center (under construction on campus of the University of Alabama in Tuscaloosa) is a to establish an IWRSS proving ground or "sandbox" to promote partnered efforts to develop, test, and validate new water resources models and techniques in an operational setting. A key part of this effort is to partner with academia to facilitate and expedite research to operations and operations to research activities.

- To what degree does IWRSS partner with other sectors impacted by water resources issues (e.g., emergency management)?

  IWRSS partner agencies have done extensive in-person stakeholder engagement as well as surveys with a wide range of stakeholders at the local, state, regional, and national levels. Examples include surveys of emergency mangers nation-wide, holding forums at national conferences, and performing service assessments after natural disasters and extreme weather events. A key aspect of IWRSS is to engage a wide range of water resources stakeholders to better inform the design and development of new water resources capabilities. In addition, this forum will be followed by a survey to evaluate the potential benefit of some of the proposed pilot projects. These surveys will include a much larger group of stakeholders.

In preparation for breakout groups, participants discussed each of the top three priority issues and expressed their views and questions about how IWRSS might possibly help address the issues they are currently facing, or may need to address in the future. From this discussion the following topics emerged:

- Climate change:
  - There are distinct trends showing an increase in the frequency of high-precipitation years and an overall increase in amount of precipitation over last 30 years.
  - These trends make it challenging to use long-term averages to create plans for reservoir management and infrastructure design (i.e., "stationarity is dead").
  - The impacts of climate change on reservoir management are big-picture issues that significantly affect local economies (e.g., water supply, power generation, water levels for fishing or white water rafting).
- Flooding

- Docking during flood events is a major challenge to shipping in Albany.
- Early spring runoff causes flooding problems when it builds on already high water levels. For example there was a recent event during which 2-3 inches of rain combined with 3-4 inches of spring runoff.
- Rain events on snow pack in early January is a common cause of flooding in up-state NY.
- Improved quantitative precipitation forecasts and advance-warning prediction services for weather events (48-120 hours) and associated confidence intervals would be ideal for advance tracking and planning for weather systems moving across the country.
- Ice jams are a problem in up-state NY. Developing prediction systems and better tools for addressing release of water upstream of ice jams in real time would be very helpful for emergency managers.
- Locally, in the lower part of the Hudson basin, important issues include stormwater runoff and system overflows.
- An important long-term issue is designing local infrastructure to effectively handle stormwater flooding in the future.
- Planning for extreme events and worst-case scenarios is an increasingly important need. For example, what would be the result of the storm surge of Sandy occurring on the heels of the rains of Irene? What would be the total water level and what people and infrastructure would be impacted, and how?
- Summit-to-sea modeling would be very helpful for determining how to build an integrated riverine and coastal (storm-surge) protection system.

· Water quality

- Current impacts from fracking are largely outside of the Hudson River Basin.
- Contaminated sediments are limiting dredging activity and impacting shipping routes.

Because climate change issues have a significant impact on both water quality and flooding, the group decided to break up into only two breakout sessions–water quality and flooding, with climate issues integrated into both discussions.

Stakeholders' Meeting – Breakout Sessions

Following is a summary of the breakout group discussions. For the first breakout session, each group was asked to take on the following task:

Identify up to three key decisions or outstanding questions (event-driven, high impact, or important routine high value decisions/questions) that "keep you up at night". For each

decision/question, identify key information gaps that need to be filled to inform these decisions (keeping in mind the capabilities of IWRSS).

For the second breakout session, the two breakout groups combined to develop the general scope of a potential project for each priority area to be considered as a possible IWRSS pilot project. For each project, the group was asked to provide a short narrative describing the project, identify key benefits of the project to help make the business case for implementing it, and determine what partner organizations and agencies would need to be involved to undertake the project.

Participants in each group are listed below.

- Water Quality: Jim Lodge, Peter Coyle, Rob Breault, Marouane Temimi, Kate Abshire, Arleen ODonnell, and Anne Kitchell.

- Flooding: George McKillop, Reza Khanbilvardi, Ward Freeman, David Vallee, Ellen Mecray, Scott Cuppett, Scott Ireland, Tarendra Lakhankar, Nir Krakauer, Tom Graziano, Jonathan Norris, Justin St. John, Ali Zahraei, Mary Mullusky, and Sam Allin.

Flooding

Key Decisions/Questions and Gaps that IWRSS Could Fill

Question #1: What are the potential impacts of climate change and flooding on sizing of infrastructure (e.g., culverts, roads, bridges, locks, dams, waste water infrastructure)?

- What will a 100-year (0.1% chance) flood look like 20-30 years from now?
- Infrastructure needs to be correctly sized in order to accommodate increased flooding levels that may result from climate change.
- Probable maximum precipitation (PMP) has a direct financial impact on decisions involving construction, safety, and modernization of dams, water supply systems, and waste water infrastructure (e.g., right-to-know requirements for combined sewer overflows (CSOs)).

Gaps:

1. Long-term infrastructure impacts:
    - Need downscaled climate models showing impacts of a changing climate on precipitation and river levels
    - Need updated intensity-duration-frequency (IDF) curves and flood frequencies (e.g., 1-year, 5-year, and 10-year storms)
    - Need to predict dynamic IDF curves 50 years in the future
    - Need to project PMP and probable maximum floods (PMF) incorporating data from recent extreme storms
2. Short-term infrastructure impacts:
    - Need to extend the range and account for uncertainty associated with precipitation forecasts used in operational hydrologic models, and provide streamflow forecasts which quantify the overall forecast uncertainty (i.e., atmospheric, hydrologic, anthropogenic, etc.) to better inform decisions and manage risk
    - Need to better predict CSO events based on precipitation forecasts
    - Need more accurate, higher temporal and spatial resolution quantitative precipitation forecast (QPFs) on the regional, national and global scales, which account for precipitation phase (i.e., rain, snow)
    - Need improved observations and forecasts of river icing to inform decisions which reduce downstream impacts

Question #2: How can we provide better and more accurate forecasts for making decisions (e.g., porting or moving ships, amount of cargo, and dredging) that affect ship navigation?

Gaps:

1. Need improved data on cross-sectional currents and water surface level

2. Need better and more accurate longer-range streamflow forecasts (out through 7 days)

3. Need to better forecast the impacts of wind on river levels

Question #3: How can we improve county-level and local-level decisions on pre-positioning resources, planning evacuations, and properly sizing infrastructure?

Gaps:

1. Need gages, modeling, and inundation maps (depicting both the areal extent and depth of flooding) to properly inform local decisions related to flooding, including future events that could occur under different climate-change scenarios

2. Need common datum and universal measurements: Too much information with different datum often result in reduced usefulness of the data and miscommunication about potential impacts

3. Need a "one-stop shop" for integrated access to water data from Federal agencies, NGOs, and others (Note: This gap is applicable to all of the flooding questions.)

Question #4: How do we make land-use decisions under different climate-change scenarios? How do we evaluate negative water health trends, including the trend of "migration toward mediocrity," where the low-quality waters are improved but high-quality waters continue to degrade?

Gaps:

1. Need better forecasting for low flow and to produce forecasts of water quality

2. Need to evaluate the impacts of nutrient loads and related land-use/land-cover changes

Water Quality

Key Decisions/Questions and Gaps that IWRSS Could Fill

Question 1: In the future, how will an increase in precipitation frequency and intensity influence how often and in what locations we will need to dredge (dredge forecasting)? How much material will be dredged and, depending on the level of sediment contamination, what are the options for disposal?

Gaps:

1. Need integration of weather data and future atmospheric predictions (storm duration, intensity, droughts) to model sediment transport. Modeling sediment transport requires an understanding of watershed conditions, hydrology, channel erosion rates, sediment loading, etc. for each of the major tributaries.

2. Need to calibrate the sediment transport model, which requires better sediment science (long term monitoring, scenario testing for different management schemes, research). Existing modeling efforts include the Contamination Assessment and Reduction Project (CARP) for contaminant forecasts used by USACE, and USGS for long-term monitoring to help calibrate sedimentation rates. Need to extend funding for monitoring for calibration efforts.

3. How do particle sizes change in relation to flooding and what impact do droughts have on sediment transport?

4. How do changes in coastal morphology/bathymetry (in addition to stream geomorphology) affect sediment transport?

5. Need to better understand how much sediment is pushed up river or down river into the estuary from extreme storm surge events (e.g., Sandy) or when combined with extreme precipitation events (e.g., Irene/Lee).

Question #2: How will rising sea levels and increased stormwater infiltration influence water table height and groundwater quality (e.g., increased salinity, contamination)?

Gaps:

1. Need monitoring to better understand the impact of best management practices (BMPs) on groundwater and flooding. USGS is no longer conducting groundwater monitoring in New York City.

2. Need groundwater monitoring in the Five Boroughs for groundwater quality and quantity.

Question #3: What spectrum of events (e.g., frequent small storms (<1 inch of precipitation), large events, superstorms, or combination of events) should be considered when planning future infrastructure (e.g., treatment plants; nuclear power plants; roadway, culvert, and bridge design; shoreline stabilization) and waterfront development? How can facility planners use this information to prevent water quality degradation?

Gaps:

1. Need to combine flood inundation mapping with infrastructure mapping to assess socioeconomic impacts and identify which facilities will be flooded or overwhelmed to determine which structures should be elevated, enclosed, replaced, or relocated.

2. Need flood inundation mapping specifically around flood-vulnerable facilities, in coastal zones, and in areas not close to gages (>1 mile, extended areal coverage from limited gages)

3. Need to know facilities and land uses where there is both a high pollution generation potential and high level of vulnerability to flooding (this could be cross-referenced with EPA industrial discharge permits)

4. Need more likely scenarios of extreme events or combinations of extreme events (e.g. coastal surge plus flooding from precipitation)

5. Need to know the changing frequency of smaller events (e.g., if stormwater BMPs are designed to manage the 1-yr design storm, what does that storm look like in 20 years) as well as the predicted 2080 100-yr storm event, which is important for designing storm infrastructure

Question #4: Can we better predict harmful algal blooms?

Gaps:

1. Tools to predict harmful algal blooms and inform decisions which mitigate their environmental impact.

Potential Pilot Project, Benefits, and Partners

Pilot Project #1

Pilot Project: Develop a downscaled global climate model to better predict flood frequencies and inform infrastructure planning.

Develop a downscaled global climate model and a coupled riverine-coastal model in the Hudson River Basin/New York State to show the impact of climate change on vulnerable infrastructure in New York City. Combined, the models would provide a wide range of data, including flood frequency, sea-level rise, and storm surge, and would serve as a single data portal for this type of information. Combine the modeling system with an improved gage network for better calibrating the model at the local level.

This project would fill the following gaps:

- Need forward-looking information with a global model
- Need input to DOT and others for infrastructure vulnerability studies
- Need a single data portal for flooding, sea-level rise, and storm surge information
- Need criteria that private firms can use for planning and design
- Need inundation forecasts for updating emergency management and evacuation maps
- Need to demonstrate multi-agency collaboration, particularly for post-Sandy infrastructure planning (e.g.,$20 million USACE study)
- Need a model that actually runs fast

Key Benefits of this Project:

1. Provide better warning systems for flood emergencies to increase evacuation times and emergency response preparations. (Note: Four-hour warning leads to 10 percent reduction in costs of flood damage, according to Day (1970).) Bloomberg Report (June 2013) on Sandy Study estimated $19 billion in damages.
2. Mitigate vulnerabilities by informing infrastructure planning and design specifications (e.g., DOT, ASHTO design criteria for culvert sizing).
3. Save money by better prioritizing infrastructure projects and increasing infrastructure longevity though flood resilience.
4. Minimize CSOs in recreational areas (fine avoidance) and provide better guidance for public safety (e.g., creation of a warning system for CSO occurrences).
5. Reduce flood damage costs.

6. Reduce costs of treatment to improve quality of water supply and for public health.
7. Reduce costs and damages to recreational boaters.
8. Develop more efficient infrastructure designs (saved man-hours) with better standards.
9. Improve our ability to successfully maintain growth and urbanization of coastal communities.

Key Partners:

- HRECOS, Stevens Institute, and possibly the Beacon Institute (data collection)
- New York Department of Transportation (NYDOT)
- New York State Department of Environmental Conservation (NYDEC)
- NOAA-CREST
- NY Open Data Initiative (NY departments put information online)
- NY climate clearinghouse
- SUNY-Stonybrook
- Northeast Coastal Ocean Forecast System (NECOFS)

Pilot Project #2

Pilot Project: Better understand the impact of precipitation events on sediment loading and accretion to better manage sediment reduction projects.

Perform a study in the New York harbor (thousands ships per year) or Albany harbor (350 ships per year) to better understand: (a) how sediment loads differ based on the location of precipitation events within the basin and (b) opportunities for beneficial sediment accretion, particularly within wetlands. This study would integrate existing and new USGS monitoring and remote sensing data to develop improved sediment budget information. This project would fill the dredging gap.

Key Benefits of this Project:

1. Improved ability to plan for capital costs of future dredging and disposal. Estimate disposal costs of $100/cubic yard. Approximately 70-80% of the sediment dredged from Hudson is contaminated.
2. Increased revenue to shipping sector.
3. Prioritized investment in sediment reduction projects.

Key Project Partners:

- Sediment transport working group (USGS and academia)
- New York State Department of Environmental Conservation (NYSDEC)
- Port Authority
- Soil and Water Conservation Districts
- Hudson River Pilots
- Consortium of ship owners in Albany, NY
- Canal Corporation

Pilot Project #3

Pilot Project: Improve short-term (1-7 day) streamflow forecasts

Improve short-term (1-7 day) streamflow forecasts to support improved operations of multi-purpose reservoirs and optimize Hudson River navigation. Perform a study in the New York harbor or Albany harbor to better understand the impact of streamflow forecasts on the economics of navigation decisions.

Key Benefits of this Project:

1) Save approximately $2 million each year in shipping costs (more accurate 4-5 day water level forecasts could help move moves thousands more tons of cargo, which would have savings/benefits for shippers and customers).
2) Increased revenue to shipping sector.
3) Reduce flood damage costs.
4) Increase efficiency in hydropower production and reduce downstream risk (flooding vs. downstream uses vs. operations).

Key Project Partners:

- Port Authority
- Hudson River Pilots
- Consortium of ship owners in Albany, NY
- Canal Corporation