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NY's clean water advocate

HOW'S THE WATER? 2014

Water Quality Monitoring, Fecal Contamination and Achieving a Swimmable Hudson River

Acknowledgements

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A swimmer jumps in the Hudson as part of the 8 Bridges swim in June 2014.
Photo courtesy Harris Silver.

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Riverkeeper's citizen sampling program is recognized by the Clinton Global Initiative as a Commitment to Action – a plan for addressing a significant global challenge.

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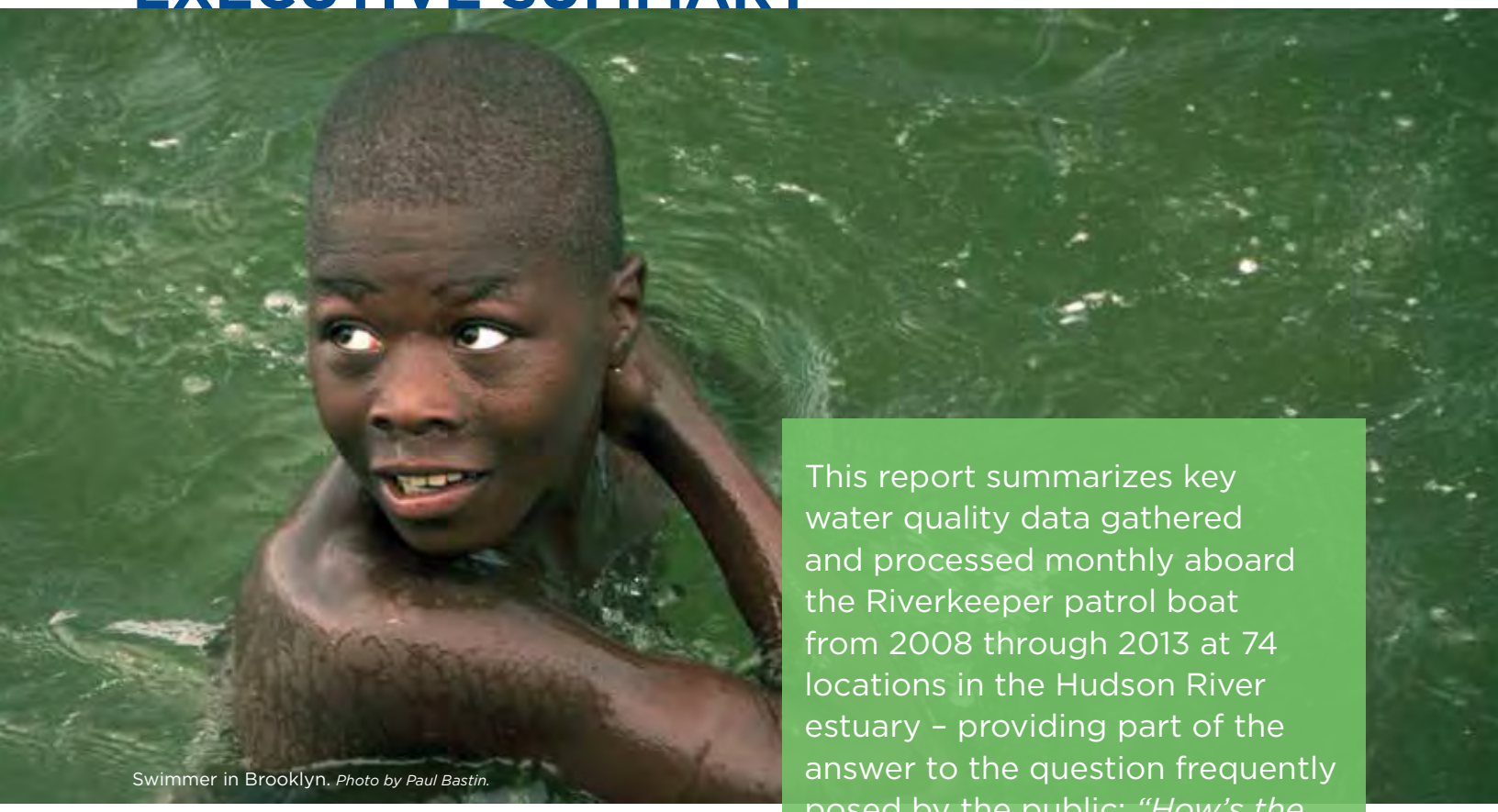
EXECUTIVE SUMMARY



Swimmer in Brooklyn. *Photo by Paul Bastin.*

This report summarizes key water quality data gathered and processed monthly aboard the Riverkeeper patrol boat from 2008 through 2013 at 74 locations in the Hudson River estuary – providing part of the answer to the question frequently posed by the public: *"How's the water? Is it safe to swim?"*

From New York Harbor to the Capital District, the Hudson River estuary serves as a public beach. Thousands participate in organized swim events, and thousands upon thousands more swim, boat, fish and play in the waters of the Hudson and its tributaries. *Yet, in most of the river, the frequency and location of water quality testing is insufficient to protect public health.*

This report summarizes key water quality data gathered and processed monthly aboard the Riverkeeper patrol boat from 2008 through 2013 at 74 locations in the Hudson River estuary – providing part of the answer to the question frequently posed by the public: *"How's the water? Is it safe to swim?"*

The Hudson River study is designed and conducted in partnership with scientists from CUNY Queens College and Columbia University's Lamont Doherty Earth Observatory.

Many areas will fail to meet criteria for safe recreation unless pollution is reduced, according to a reanalysis of our data using the EPA's new 2012 Recreational Water Quality Criteria – the first update in nearly 25 years to the tools states should use to protect people where they swim.

If New York implements EPA criteria as recommended, the public will benefit from better notification when water is contaminated, better regulation of pollution, and improved water quality. The EPA guidelines highlight the need for states to protect the public *not only at official swimming beaches, but throughout all our rivers and estuaries.* Importantly, the EPA recommends the use of three distinct water quality assessment tools to measure both the frequency and degree of fecal contamination.

In many locations on the Hudson, in dry weather, the water meets EPA-recommended safe-swimming guidelines. **But overall, 23% of Riverkeeper's water samples would have resulted in the closure of swimming areas if managed according to EPA guidelines – and more than half of our study sites (61%) failed to meet new EPA criteria for safe recreational water.** The failure rate is significantly higher in our tributaries, at sewage treatment plant outfalls and after rainfall.

Riverkeeper's Water Quality Program has energized a movement to make the Hudson River safe for swimming, and influenced key decisions to invest in public wastewater infrastructure. There has been significant progress on many of our Action Agenda goals in recent months, including:

- *More than $3 billion has been committed to public infrastructure projects to reduce sewage contamination* in New York City, the Capital District and Westchester County.
- In the Sewage Pollution Right to Know law's first year, publicly owned sewage treatment plants reported 1,600 discharge events – accounting for *hundreds of thousands of gallons of sewage dumped into our waterways*. This reporting is helping to identify where sewage infrastructure is most in need of upgrades and to better inform the public when and where contamination occurs.
- To better understand the contamination affecting Hudson River tributaries, *more than 60 citizen scientists working with Riverkeeper sampled 84 locations on seven tributaries in 2013* – 165 miles of water in all. Data from these citizen science projects are presented in this report for the first time.

In the coming year, the public will have the opportunity to contribute in several meaningful ways to this progress. New York State will propose its first update to safe-swimming standards in nearly 30 years, and complete the implementation of the Sewage Pollution Right to Know Law. The public's voice will be key to ensuring that both initiatives protect and inform people to the greatest extent possible.

To keep informed about these issues, please visit riverkeeper.org and sign up to receive updates by e-mail.

SUMMARY OF OUR KEY FINDINGS

1. **Fecal contamination varies from location to location.**
   For instance, 55% of samples at the confluence of the Saw Mill River and the Hudson failed, while just 5% of samples nearby in the mid-channel failed.
   Importance: Localized problems often have local solutions.

2. **Fecal contamination varies over time at all locations.**
   Repeated testing demonstrates high water quality variability at many sites, showing that the risk to recreational users changes dramatically from day to day.
   Importance: Frequent testing, modeling and notification are needed to inform and protect the public.

3. **Sites vary in both the degree and frequency of fecal contamination.**
   Some study sites were frequently contaminated but the degree of contamination did not exceed acceptable levels by much. Then there are sites with infrequent contamination, but a high degree of contamination and therefore a large public health risk if people entered the water on the wrong day.
   Importance: Multiple water quality assessment tools are needed to protect public health.

4. **Rainfall is a common trigger of fecal contamination.**
   The failure rate at our Hudson River sample sites in dry weather was 12%, but rose to 34% after recent rain.
   Importance: We must better manage stormwater, sewer and septic systems, and agricultural practices.

5. **Shorelines and tributaries often have more fecal contamination.**
   The failure rate in tidal tributaries – 34% – and at sewage treatment plant outfalls – 30% – exceeded the mid-channel failure rate. The failure rate in non-tidal portions of tributaries was higher still.
   Importance: To protect the public, test in the full range of places where people use the water.

See Riverkeeper's action agenda for clean water on page 35.

HOW'S THE WATER?
SWIMMING IN THE HUDSON AND ITS TRIBUTARIES

Currents, weather, temperature, underwater hazards, boat traffic, toxics and turbidity are all important considerations in determining whether it is safe to swim. One of the most important factors is fecal contamination that can carry disease-causing pathogens like viruses, bacteria, and parasites.

Nationwide, thousands – and likely many more – fall ill each year with diarrhea, vomiting, and other symptoms after exposure to pathogens in recreational water. The majority of U.S. beach closings and advisories is due to high levels of fecal contamination.[1]

Since our last report, we have begun using "fecal," rather than "sewage" to describe the contamination. This change reflects our understanding of the sources of contamination to our waterways, which include not only overflows and leakage from sewage systems, but also contamination of groundwater and overflows from septic systems, fecal-contaminated sediment, wildlife, and runoff from both livestock and crop farms.

TIPS FOR RECREATIONAL WATER USERS

While Riverkeeper cannot replace a Health Department's role in advising the public, our study suggests several ways individuals can make informed decisions about when and where to enter the water. Keep in mind that the risk of exposure to waterborne pathogens comes not only with swimming but also bathing, surfing, water skiing, kayaking, tubing, skin diving, water play by children and other activities where ingestion of water is likely.

- **Use beaches where testing occurs, and ask that county for the data before swimming.**
- **As a precaution, it is best to avoid the water for a period of 2-3 days after rain.**
- **Make an informed choice about where and when to enter the water by checking historic water quality conditions at riverkeeper.org/water-quality.**
- **Contact your county Health Department to ask for testing and notification where you enter the water**

Although the entire 155-mile long Hudson River Estuary, and its tributaries, are used for swimming and other primary contact recreation, there is currently insufficient testing, modeling and prediction of water quality to properly answer the question, "Is it safe to swim?" While Riverkeeper's sampling is too infrequent to inform the public when and where it's safe to swim on a day-to-day basis, our program serves as a model, showing state and local agencies that water quality testing on a watershed basis is possible, and that the public wants such information.

Water Quality Monitoring by Public Agencies

New York City publishes an annual summary report and since 2012 has updated results regularly online.[2] Riverkeeper applauds this effort and would like to see similar sampling and notification programs conducted by government agencies along the entire length of the Hudson River.

Of the ten counties on the Hudson River Estuary, *only four* test for fecal contamination at their Hudson River shorelines, and that testing is limited in scope and frequency.[3] The EPA recommends weekly sampling at a minimum, and more at beaches with high usage.

- Westchester and Dutchess counties conduct weekly water quality monitoring between Memorial Day and Labor Day at three official swimming areas in Sleepy Hollow, Croton and Beacon.
- Rockland County tests weekly at several shoreline locations.
- Ulster County tests two public Hudson River beaches and four beaches on tributaries (Esopus Creek, Wallkill River and Plattekill Creek) just three times per season, which is insufficient to protect public health.

No Hudson Valley county routinely reports its findings to the public, as Riverkeeper urges.

Despite a dearth of data on water quality, New York State designates most of the Hudson River as appropriate for swimming.[4] Classification of tributaries varies, and includes both stretches designated as appropriate for swimming as well as stretches where swimming is not a designated "best use." After the automatic spending cuts resulting from the 2013 federal budget sequester, New York State eliminated bacterial monitoring from the Rotating Basin Study – the study used to assess and manage the health of our waterways. New York has neither resumed this testing, nor put an alternative assessment plan into place.

Public swim events take place throughout New York City and the Hudson Valley, boaters throughout the estuary enjoy tubing and water-skiing, kayakers cool off in the water, people dive from rocks and wade in from sandy shorelines, and children splash and wade at the water's edge. All of these activities are "primary contact" recreation.

Water quality at 61% of sites sampled by Riverkeeper and our scientific partners on the Hudson failed to meet all EPA-recommended criteria for use as recreational water. Reducing pollution through full implementation of the Clean Water Act and New York's Conservation Law – and implementing more protective standards for recreational water quality – are necessary to achieve water quality that is consistently safe for public recreation.

EXPANDING ACCESS TO FORMAL SWIMMING AREAS

"Millions of people swam in the Hudson River" before water quality declined over the course of decades in the early to mid 20th Century, according to a 2005 DEC study. The study also found that up to 17 new swimming areas could be developed on the Hudson River to expand public access. Water quality was identified as one barrier to realizing this goal.[5]

For more on Waterborne Illnesses and Human Health see the Appendix

A swimmer who took part in the Lower Hudson leg of the 8 Bridges swim in 2014. *Photo by Leah Rae / Riverkeeper.*

OTHER POLLUTANTS IN THE HUDSON RIVER

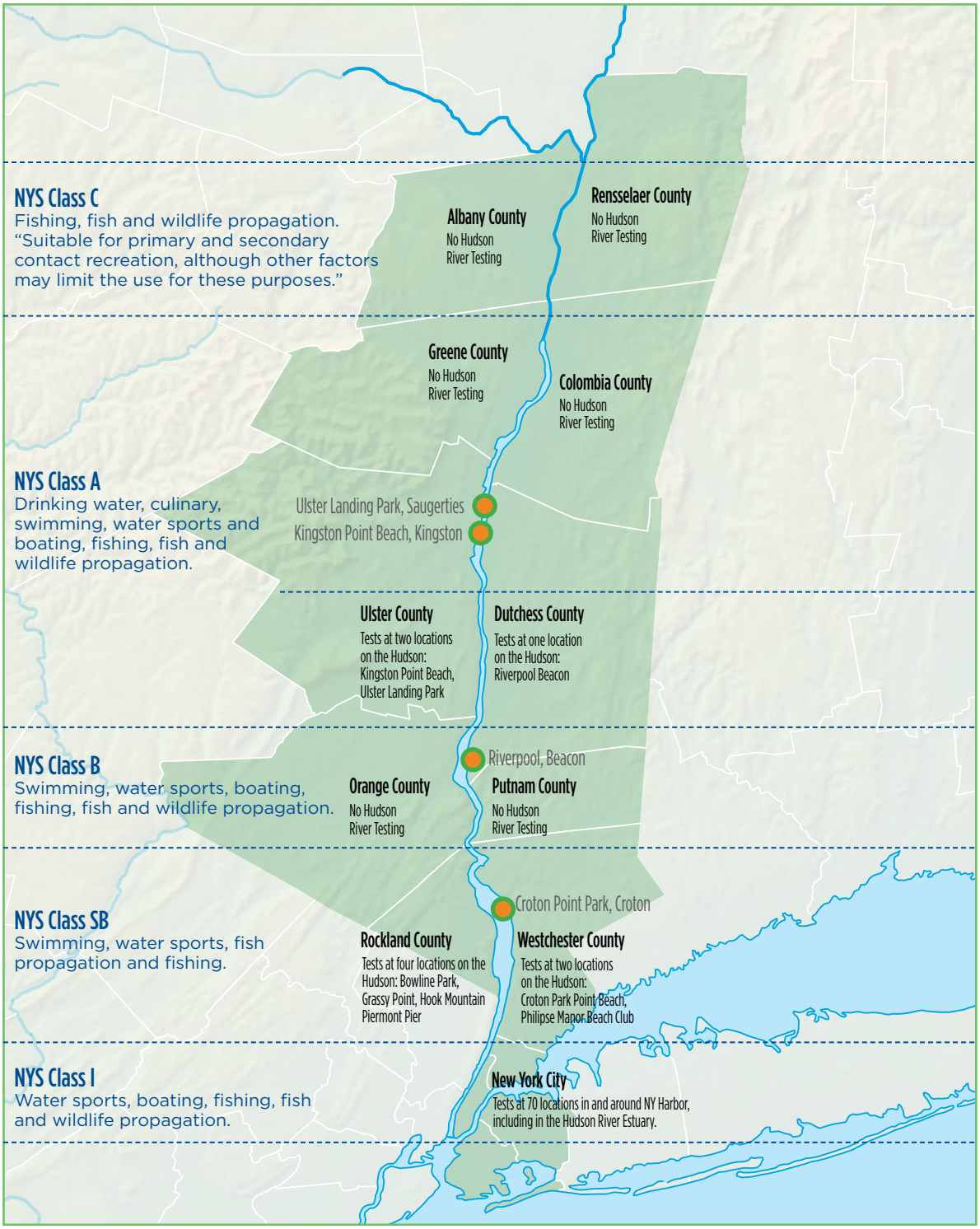
Sewage is just one of the pollutants found in the Hudson River Estuary. As the pollutant most frequently linked to waterborne illnesses it is the focus of Riverkeeper's Water Quality Program.

Other pollutants found in the Hudson include PCBs, radioactive contaminants such as tritium and strontium-90, nutrients such as nitrogen and phosphorus, heavy metals and a variety of toxins. Some of the toxins in the Hudson come from our wastewater treatment plants, which also process water from industrial facilities and factories in river communities. Other toxins come from our bodies and homes, via wastewater. These are the byproducts of the medicines, beauty care products, and household cleaners, disinfectants, insecticides and other products we use, many of which are not efficiently removed with current wastewater treatment technology and therefore end up in the river.

Our water quality study, and this report, address only fecal pollution. Riverkeeper does, however, advocate for the removal of hazardous pollutants affecting the Hudson River.

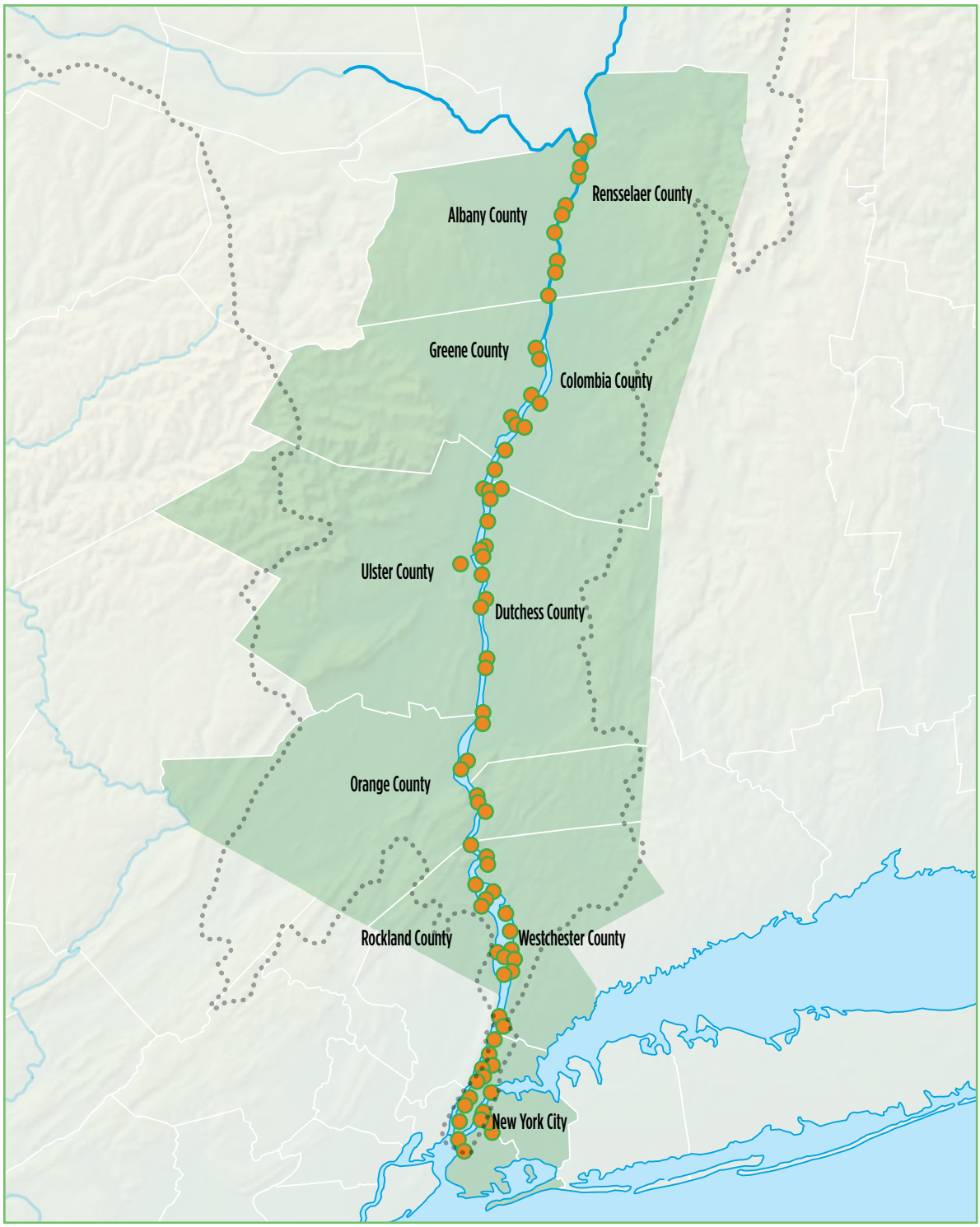
COUNTY MONITORING AND STATE WATER CLASSIFICATIONS

Testing refers to monitoring for fecal contamination only



Official Public Swimming Beach

RIVERKEEPER'S 74 WATER QUALITY MONITORING SITES



Riverkeeper's fixed sampling sites

Hudson River watershed boundary

RIVERKEEPER'S WATER QUALITY STUDIES

Hudson River Estuary Study

Riverkeeper, in collaboration with our science partners at CUNY Queens College and Columbia University's Lamont Doherty Earth Observatory, started a pilot Water Quality Program on the Hudson River in 2006. The program reached its current size and established consistent methods in 2008. This report summarizes data gathered from 2008-2013. The program tests for fecal contamination, temperature, salinity, turbidity, chlorophyll and oxygen concentrations in the Hudson River and shares this information with the public.

We sample at 74 fixed Hudson River locations, once a month, from May through October. It is important to note that the public uses the majority of our sites for recreation. In addition to our fixed sites we also conduct exploratory sampling at a variety of locations to investigate specific events and problem areas.

The Riverkeeper patrol boat, the *R. Ian Fletcher*, is equipped with a mobile lab that allows us to process and incubate water samples onboard. It takes 4-5 days to travel the 155 miles of estuary and collect and process the samples each month. The Hudson River Estuary, as referred to in this report, includes the Hudson River north to the Troy dam, the tidal portion of tributaries as far north as the Capital District, and waters around New York City including the East and Harlem Rivers, Newtown Creek and Gowanus Canal.

Tributary Studies and Citizen Science

As an extension of the Hudson River study, Riverkeeper works with local citizen groups and individuals to sample at an additional 84 sites in the non-tidal portions of tributaries. These studies began on some tributaries in 2010, and consistent monthly sampling on seven tributaries took place in 2012 and 2013.

Our Science Partners

This project is conducted in collaboration with scientists from CUNY Queens College and Columbia University's Lamont-Doherty Earth Observatory. Our Co-Principal Investigators, Gregory O'Mullan, Ph.D. and Andrew Juhl, Ph.D., contribute their expertise in environmental microbiology and oceanography to the project. They developed our testing protocol and oversee our field sampling, environmental sensor measurements and microbiological data analyses.[6]

Measuring Fecal Contamination

Riverkeeper tests for fecal-indicating bacteria of the genus *Enterococcus* (Entero). The Hudson River contains salt, fresh and brackish (mixed) water. Entero is the only group of microbes recommended by the EPA for use as fecal indicators in both salt and fresh water. It takes 24 hours to process each water sample and quantify its level of Entero. Throughout this report "Entero count" refers to the number of colonies or cells of *Enterococcus* per 100 ml of water.

Sharing Data with the Public

Complementing this report, our website (www.riverkeeper.org/water-quality) is our primary means of disseminating data to the public. The database and interactive map of the Hudson River and several tributaries are updated monthly during the recreational season, and we encourage the public to explore this resource frequently. We send monthly e-mails summarizing recent testing data (sign up at www.tinyurl.com/rvk-eml) and publish other updates at riverkeeper.org. We also make presentations at conferences and community events, and to agencies involved in water quality management.

Use of these data for any presentation, publication, website or educational product should be attributed as follows: "Data collected by O'Mullan GD, Juhl AR, and Lipscomb J, available at riverkeeper.org. Funding provided in part by the Hudson River Estuary Program, New York State Department of Environmental Conservation, with support from the New York State Environmental Protection Fund, in cooperation with the New England Interstate Water Pollution Control Commission; the Wallace Research Foundation; the HSBC Water Programme; the Kowitz Family Foundation; the Dextra Baldwin McGonagle Foundation, Inc.; The Eppley Foundation for Research, and the Brinson Foundation."

WATER QUALITY GUIDELINES AND HOW RIVERKEEPER USES THEM

Croton Point Beach, Westchester County. *Photo by Leah Rae / Riverkeeper*

States set their own standards to protect swimmers in recreational waters, and we urge New York State to adopt EPA recommendations in setting new state standards.

New Federal Water Quality Criteria

Riverkeeper bases our assessment of water quality on the latest EPA Recreational Water Quality Criteria.[7]

The EPA criteria for primary contact recreation were revised in 2012 for the first time since 1986. Primary contact recreation includes activities such as swimming, bathing, surfing, water skiing, tubing, skin diving, water play by children and other activities where ingestion of water is likely.[8] States set their own standards to protect swimmers in recreational waters, and we urge New York State to adopt EPA recommendations in setting new state standards.

The new EPA guidelines include several important clarifications that are relevant to protecting the public and accurately assessing water quality:

1. All waters used for recreation – not just official swimming beaches – should be managed to achieve water quality sufficient for primary contact recreation.[9] Hundreds of miles of shoreline on the Hudson and its tributaries are used for primary contact recreation, not just official beaches.
2. Waters used for recreation, like the Hudson and its tributaries, must be managed to be protective of public health, regardless of "intensity of use."
3. Entero, the fecal-indicating bacterium used by Riverkeeper, is the preferred indicator in waters like the Hudson that have fresh, brackish and salt water, and there are now uniform guidelines for assessing water quality, rather than different freshwater and saltwater guidelines.
4. EPA criteria are relevant for protecting public health, whether fecal contamination is from human or animal sources.

The new EPA guidelines recommend the use of three distinct water quality assessment tools, each of which is reflected in the data presented in this report. If New York utilizes these three tools in combination, as intended by the EPA, the public would benefit from better assessment and regulation of water quality. As our report describes, the Hudson River displays a variable degree and frequency of contamination, and therefore the combined use of all three tools will be most protective of health and effective for management, as some of the standards best measure frequency of contamination and others best measure the degree of contamination.

WATER QUALITY GUIDELINES AND HOW RIVERKEEPER USES THEM

Managing Swimming Areas

The new EPA guidelines includes a new recommendation to set a Beach Action Value (BAV) to determine when an area used for primary contact recreation should be closed to protect public health, based on the bacteria count in a single sample of water. The beach can re-open when a subsequent sample falls below the BAV. The EPA recommends setting the BAV at an Entero count of 60.

In Riverkeeper's data charts, the red and green bar charts illustrate the percentage of samples that passed or failed the EPA's recommended BAV.

Regulating Water Quality

Accurate assessment of water quality is a critical step in implementation of the Clean Water Act, and achieving its goals of making waters safe for swimming and fishing. The EPA's new guidelines provide New York with the best science-based tools to assess water quality where the public uses the water. If waters designated for primary contact recreation fail to meet state standards set based on these EPA criteria, the water should be listed as "impaired" under the Clean Water Act 303(d) regulations, and regulators should reduce contamination levels until water meets standards necessary to protect public health. This is achieved by altering discharge permits for polluters and managing non-point pollution sources in order to restore and maintain water quality sufficient for safe recreation. Furthermore, if assessment shows that waters that are not currently designated for primary contact regulation are, or have been, used by the public, and could meet primary contact standards with additional pollution controls, EPA regulations require that the waterway's designation be upgraded, and the water quality should be restored and maintained to fully support the public's use.

The EPA recommends high frequency testing, and the use of two measures of long term water quality together to assess both the frequency and degree of fecal contamination – the Statistical Threshold Value (STV) and the Geometric mean (GM). Fecal contamination in a water body must stay below both the STV and GM criteria for the water quality to be considered acceptable for recreation. The EPA recommends setting the STV at an Entero count of 110, and water quality is acceptable for primary contact recreation if no more than 10% of samples in a 30-day interval exceed this amount. The GM is a weighted average of Entero counts that dampens the effect of very high or low values. The EPA recommends setting the GM at 30, and water quality is deemed acceptable for primary contact if the GM for a 30-day interval remains below this level.

In Riverkeeper's data charts, the percentage of samples that exceeded the STV, and the GM for each location over the course of our study are printed in red or green to indicate whether each exceeded the EPA's recommended criteria. Riverkeeper does not sample frequently enough at each site to evaluate the monthly STV or GM, and therefore we use our full data set to calculate the STV and GM values presented in this report.

The criteria are set at levels meant to prevent more than 32 illnesses per 1,000 people engaged in primary contact recreation. The EPA alternately allows the use of criteria meant to prevent 36 illnesses, but Riverkeeper uses and recommends that New York State adopt the more protective criteria, as it represents, in the EPA's words, an "incremental improvement in water quality."[10]

New York State Water Quality Criteria

New York is updating nearly 30-year-old water quality standards that currently use fecal and total coliform bacteria and consider only the GM to assess and manage its waterways for fecal contamination.[11] The EPA no longer recommends the use of coliform bacteria as indicators, nor use of the GM in isolation. Riverkeeper has been representing the public interest on a stakeholder group that is advising the DEC during this process. We have urged DEC to adopt the 2012 EPA criteria using the more protective illness rate of 32 illnesses per 1,000 recreational users, and to use the BAV, the STV and the GM, as intended by the EPA guidance. We also have recommended that DEC adopt the fecal-indicator *Enterococcus* as recommended by EPA, and that water quality sampling include not just official swimming beaches but a set of sites that accurately reflects the public's use of the water for primary contact recreation.

OUR WATER QUALITY FINDINGS

Riverkeeper has processed over 3,500 water quality samples from the Hudson River Estuary since 2008. Based on that number of samples, and the expert analyses of our science partners at CUNY Queens and Columbia University's Lamont Doherty Earth Observatory, we are able to identify patterns of fecal contamination in the Hudson River Estuary. Although we have found evidence of fecal contamination at every one of our 74 testing locations, the levels of contamination vary enormously over time and by location. *Overall 23% of our samples failed to meet the EPA's recommended guideline for safe swimming* (exceeded the EPA's recommended BAV). Riverkeeper encourages the public to check our online database and interactive map at www.riverkeeper.org/water-quality frequently during the recreational season to make informed choices about where and when to use the river.

1

FINDING #1:
Contamination Varies from Location to Location

Importance: Localized problems often have local solutions.

At eight Riverkeeper study sites, more than 50% of samples failed the BAV, whereas at 20 sites fewer than 10% of samples failed. Some of these contrasting sites are quite near one another. For instance, the Yonkers waterfront at the Saw Mill River had a 55% failure rate, while the failure rate was just 5% at a nearby site in the river channel.

Many of the study sites with the highest failure rates – in the Capital District, throughout New York City and in Tarrytown – should benefit from recent commitments to improve public infrastructure. Future samples over the course of years will demonstrate to what degree these investments benefit water quality.

FINDING #1: (continued)

This finding is relevant to people using the water: it matters where you get in the water. It also relevant to several items in our action agenda:

- frequent and widespread testing is necessary;
- citizens have an important role to play in solving some local problems;
- the acute need to invest in wastewater infrastructure will, in many cases, have a local benefit; and,
- enforcement of existing laws is an important tool.

10 HUDSON SITES WITH LOWEST FAILURE RATE

Croton Point Beach	3%
Stony Point Mid-channel	3%
Tappan Zee Bridge Mid-channel	3%
Poughkeepsie Drinking Water Intake	3%
Yonkers Mid-channel	5%
Yonkers STP Outfall	5%
Little Stony Point	5%
Haverstraw Bay Mid-channel	5%
Irvington Beach	6%
Poughkeepsie Launch Ramp	8%

10 HUDSON SITES WITH HIGHEST FAILURE RATE

Mohawk River at Waterford	66%
Hudson River above Troy Lock	62%
Newburgh Launch Ramp	58%
Gowanus Canal	57%
Yonkers Waterfront at Saw Mill River	55%
Dunn Memorial Bridge, Albany	55%
Rondout Creek – Kingston STP Outfall	53%
Newtown Creek – Metro. Ave. Bridge	53%
Island Creek/Normans Kill	49%
Tarrytown Marina	48%

10 TRIBUTARY SITES WITH LOWEST FAILURE RATE

Esopus – Saugerties Village Beach	15%
Esopus – Marbletown, Tongore Park	15%
Catskill – Cauterskill, Rt. 23 Bridge	20%
Esopus – Kingston, Washington Ave.	23%
Catskill – Jefferson Hgts., W. Main St.	27%
Rondout – below Rondout Reservoir	33%
Esopus – Hurley, Wyncoop Rd.	38%
Esopus – Mt. Marion, USGS gauge	38%
Esopus – Lincoln Park, Orlando Park	38%
Catskill – South Cairo Bridge	45%

10 TRIBUTARY SITES WITH HIGHEST FAILURE RATE

Sparkill – Sparkill, Route 340	100%
Sparkill – Tappan, Moturis	100%
Sparkill – Orangeburg, Rt. 303/340	100%
Wallkill – Middletown, Cemetery Rd	100%
Wallkill – Goshen, Rio Grande trib.	100%
Sparkill – Blauvelt, Blauvelt Arm trib.	100%
Sparkill – Blauvelt, Spruce St.	100%
Wallkill – New Paltz, Saw Mill Brook	100%
Wallkill – Shawangunk, Galeville Br.	100%
Wallkill – Montgomery, I-84 Crossing	100%

Hudson River rankings reflect data collected from 2008-2013 in collaboration with CUNY Queens and Columbia University's Lamont Doherty Earth Observatory. Tributary data reflect data collected in the non-tidal portion of seven tributaries sampled by citizen scientists monthly in 2012 and 2013. Visit www.riverkeeper.org/water-quality to find data for and descriptions of each testing location

2 FINDING #2: Contamination Varies Over Time at All Locations

Importance: Frequent testing, modeling and notification are needed to protect and inform the public.

Many study sites have high variability of fecal contamination due to wet weather. Locations near combined sewer overflow outfalls can show extreme fluctuations in water quality due to the volume and intensity of those discharges. Infiltration and inflow, failing septic systems and farm runoff can also contribute to fecal contamination triggered by rainfall.

However, at other locations variable water quality is *not* connected solely with wet weather. For example, at the Newburgh Launch Ramp, our data shows that the public comes into contact with water that can have high levels of fecal contamination whether the weather is wet or dry.

This finding is relevant to several items in our Action Agenda:

- New York State should establish a protective BAV consistent with EPA recommendations to protect the public at times when water fails to meet safe-swimming standards;
- high-frequency sampling and use of the STV and GM is necessary to understand the causes of the variability in frequency and degree of contamination, and to identify solutions; and,
- both predictive modeling and public notification are key tools for protecting public health.

3 FINDING #3: Sites Vary In Both Degree and Frequency of Contamination

Importance: Multiple water quality assessment tools are needed to protect public health.

When assessing water quality at any location it is important to consider both:

1. The degree of the contamination: The higher the Entero count, the greater the chance of getting sick.
2. The frequency of contamination: The more frequent the contamination the more opportunities there are for exposure.

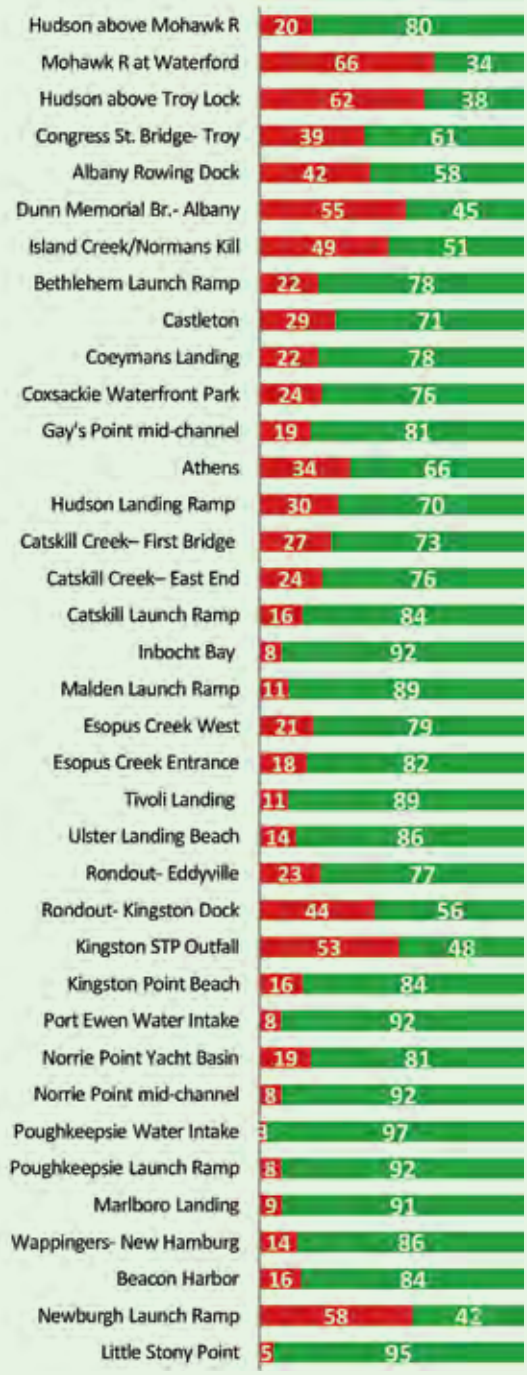
Some study sites were *frequently* contaminated but the *degree of contamination* did not exceed acceptable levels by much. Then there are sites with *infrequent contamination*, *but a high degree* of contamination and therefore a large public health risk if people entered the water on the wrong day.

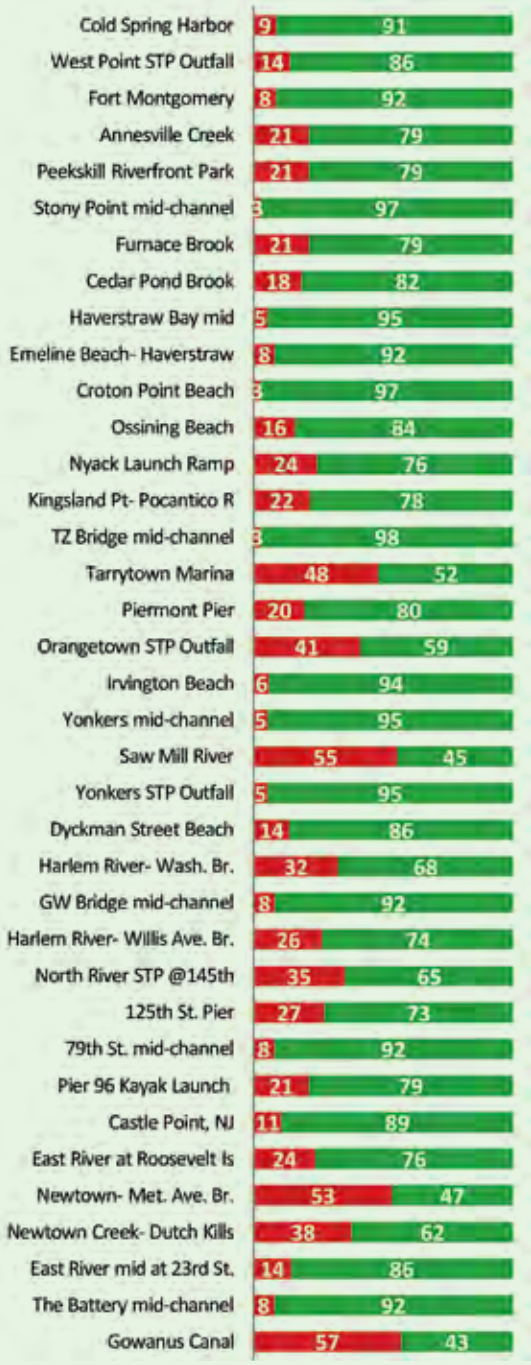
This finding is relevant to our call for New York State to use each of the three EPA-recommended tools for assessing water quality: the BAV, STV and GM. Used together, these will inform the public when exposure to the water presents an unacceptable risk, and to control pollution sources so waterways achieve water quality sufficient for safe swimming.

See the Regional Maps on pages 24-29 for a listing of Maximum and Minimum Entero counts by location

RIVERKEEPER'S HUDSON RIVER MONITORING RESULTS, 2008-2013

Red bars show the percentage of samples that would have resulted in closure of a swimming area managed according to EPA guidelines.





STP = Sewage Treatment Plant

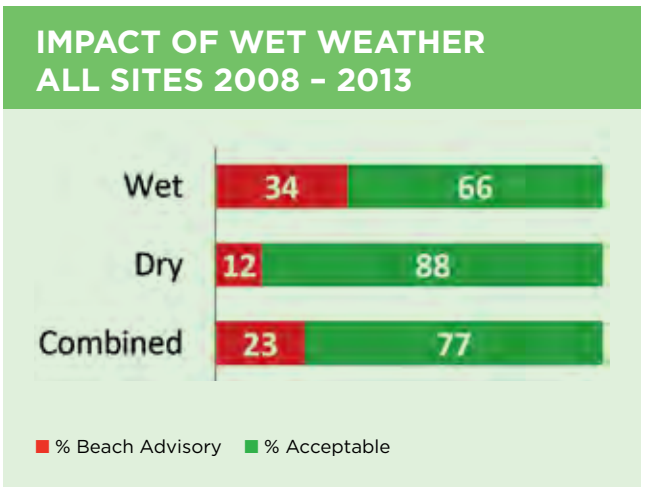
■ % Beach Advisory ■ % Acceptable

4

FINDING #4:
Rainfall is a Common Trigger of Contamination

Importance: We must better manage stormwater, sewer and septic systems, and agricultural practices.

During and shortly after rainfall the frequency of fecal contamination increases in all the regions and at all the types of sites where we sample, but not at every location. Overall the percent of Hudson River Estuary samples that failed EPA's BAV guidelines increased from 12% in dry weather to 34% in wet weather.



Wet weather is classified as more than ¼ inch of cumulative rainfall in the three days prior to sampling

Several sources can contribute to rain-related fecal contamination. One contributor is rain-triggered overflows from our sewage infrastructure. These overflows fall into two categories – combined sewer overflows (CSOs), which happen by design, and sanitary sewer overflows (SSOs), which are the result of faulty or overloaded sewer systems. Together these rain-triggered overflows dump *tens of billions* of gallons of combined sewage and stormwater into the Hudson River each year. Rainfall can also cause fecal fecal-contaminated groundwater to enter the river and its tributaries, or cause contamination from agricultural sources, such as the runoff of manure spread on farm fields.

This finding is relevant to several items on our Action Agenda:

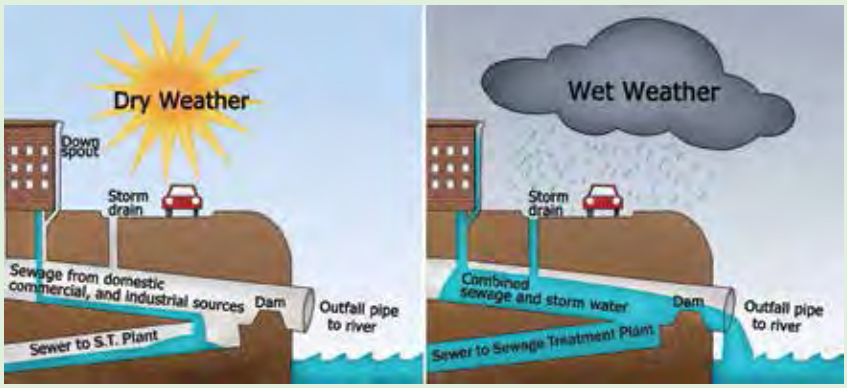
- reinvesting in wastewater infrastructure is critical to control contamination from CSOs and SSOs;
- informing the public about all types of known sewage discharges, including CSOs, is important to protecting public health; and,
- developing new technologies is necessary, for instance using technology to maximize the treatment of sewage during rain events and notify the public of an overflow.

MUNICIPAL WASTEWATER SYSTEMS AND OVERFLOW

COMBINED SEWER SYSTEM: ONE PIPE FOR SEWAGE AND STORMWATER

WHAT ARE COMBINED SEWER OVERFLOWS (CSOS)?

CSOs are remnants of the country's early infrastructure. In the past, communities built sewer systems to collect both stormwater runoff and sanitary sewage in the same pipe. During dry weather, these "combined sewer systems" transport wastewater directly to the sewage treatment plant. In periods of rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant.



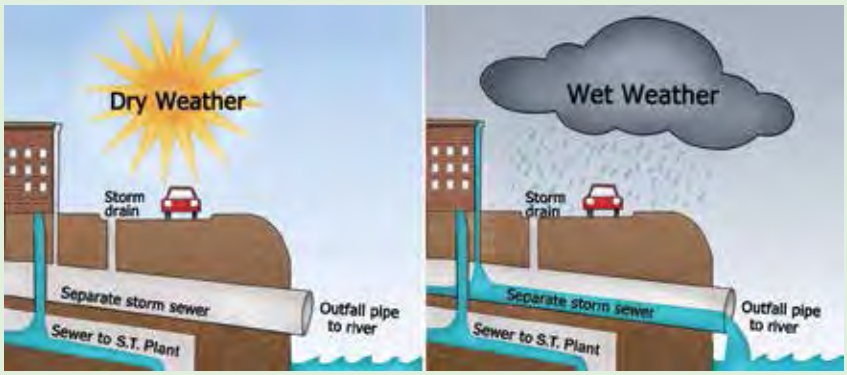
For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, lakes, or estuaries. Combined sewer overflows (CSOs) contain not only stormwater but also untreated human and industrial waste, toxic materials, and debris. This is a major water pollution concern for cities with combined sewer systems. CSOs are among the major sources responsible for beach closings, shellfishing restrictions, and other water body impairments.

– U.S. Environmental Protection Agency

SANITARY SEWAGE SYSTEM: SEPARATE PIPES FOR SEWAGE AND STORMWATER

WHAT ARE COMBINED SEWER OVERFLOWS (CSOS)?

Properly designed, operated, and maintained sanitary sewer systems are meant to collect and transport all of the sewage that flows into them to a publicly owned treatment works (STP). However, occasional unintentional discharges of raw sewage from municipal sanitary sewers occur in almost every system. These types of discharges are called sanitary sewer overflows (SSOs). SSOs have a variety of causes, including but not limited to blockages, line breaks, sewer defects that allow storm water and groundwater to overload the system, lapses in sewer system operation and maintenance, power failures, inadequate sewer design and vandalism.



– U.S. Environmental Protection Agency

FINDING #4: (continued)

Reducing Wet Weather Sewage Overflows

In communities where impervious surfaces (i.e. roads, rooftops and parking lots) are plentiful, like New York City, as little as ¼ inch of rain can trigger a sewage overflow. When stormwater and snowmelt run off the hard surfaces in our built environment they scour an assortment of contaminants with them into our waterways such as oil, road salts, litter and animal waste.

Significant investments to reduce CSO discharges are planned in New York City, the Capital District and Kingston over the coming years.

There are two approaches to reducing wet weather overflows – grey infrastructure and green infrastructure projects.

COMBINED SEWER OVERFLOW OUTFALLS DISCHARGING TO THE HUDSON ESTUARY AND TRIBUTARIES
Listed by community and number of outfalls

New York City*	426
Capital District**	92
New Jersey	26
Yonkers	13
Newburgh	11
City of Hudson	8
Catskill	6
Poughkeepsie	4
Kingston	4
Waterford	2
West Point	1

* Includes CSO outfalls to waters other than Hudson River Estuary, such as Jamaica Bay.
** The Capital District includes Albany, Cohoes, Green Island, Rensselaer, Troy and Watervliet.

Sources include Long Term Control Plans, NYS DEC, U.S. EPA, NY/NJ Baykeeper and municipal sewer departments. Some sources are conflicting.

Grey infrastructure refers to traditional built solutions like separating combined sewer systems by laying new pipes, or building holding tanks to temporarily divert overflows from waterways. Green infrastructure refers to the use of natural landscapes, and/or engineered systems that mimic natural landscapes, to collect and divert stormwater, reduce flooding and improve water quality.

Green infrastructure projects, such as greenways, wetlands, and rain gardens, reduce the amount of water that enters our storm drains and sewer systems, reducing the volume and frequency of sewage overflows. It can be a cost-effective approach to improving water quality that has added benefits including recharging groundwater, reducing the urban heat effect and improving air quality.

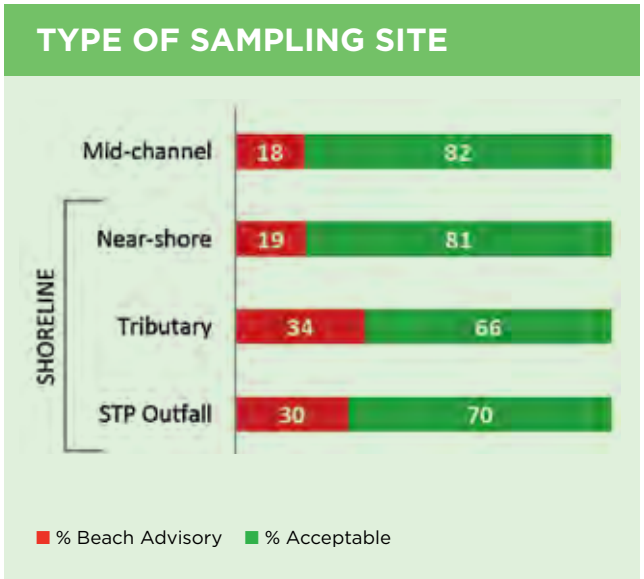
5

FINDING #5:
Shorelines and Tributaries Often Have More Contamination

Importance: To protect the public, test in the full range of places where people use the water.

To better understand the location and source of fecal contamination we grouped our 74 sampling sites into two categories: mid-channel and shoreline sites. The shoreline sites are further sub-divided into near-shore, tributary, and sewage treatment plant (STP) outfall sites. The "near-shore" sites include beaches, boat launch ramps and other public access sites that are *not* at an STP outfall or tributary. It's important to note that people use all types of sites for recreation.

Water quality at the sites on the shoreline is not as good as mid-channel water quality. The shoreline is typically where fecal contamination enters the river, while the channel tends to be the deepest and fastest moving part of our tidal river, so dilution, mixing and self-flushing may have a greater impact.



This finding is relevant to several items in our Action Agenda, including:

- widespread testing is needed, and all monitoring programs should include sampling along the shoreline;
- reinvesting in wastewater infrastructure will be key to achieving higher water quality; and,
- citizen scientists can play an important role in defining water quality in tributaries.

Tributary Water Quality

Our Hudson River study contains 16 standard tributary sites; samples are taken in the Hudson River at the confluence with a tributary, or in the tidal portion of the tributary itself. At these tributary sites, 34% of samples exceeded the EPA-recommended BAV from 2008-2013. Some tributaries are chronic sources of fecal contamination – no matter what the weather. When it rains, even more contaminated water enters the Hudson from tributaries. Our study found a more than threefold increase in the frequency of failed samples at our tributary sites after wet weather.[12]

FINDING #5: (continued)

To understand what is causing contamination in our streams, brooks and creeks, we have undertaken multi-year studies in cooperation with citizen scientists in several tributary watersheds. Initial findings show that the answers vary by waterway and watershed. Fecal contamination could be entering tributaries from a number of sources, including wet-weather overflows from sewage systems, contaminated groundwater from failing septic systems, fecal-contaminated sediment, and chronic leaks from sewer pipes or illegal sewage hook-ups. Contamination may also come from wildlife or agriculture in some areas.

See Hudson River Tributary Citizen Science Data on page 34.

Sewage Treatment Plant Effluent

STP outfalls discharge treated wastewater (effluent), and pollutant concentrations in the treated water must not exceed limits set by DEC permits. At times, partially treated wastewater from the plant enters the water, and our STP sites fail more frequently than the rest of the river. But this doesn't tell the full story because results vary widely at different STP outfalls, and sewage can be discharged to water before it reaches treatment plants.

Some of the outfalls, like the combined Orangetown and South Rockland County STP at Piermont Pier, have high variability in test results, ranging from acceptable single-digit Entero counts to a high exceeding the upper limit of our testing system. (A $104,000 upgrade to a failing pump station in Orangetown was approved in 2012.) Other STP outfalls, like the Westchester County plant in Yonkers, have consistently low Entero counts. That is encouraging; however, the infrastructure that feeds the treatment plants (the "collection system") can fail to get the sewage to the plant, especially during wet weather. The first annual Sewage Pollution Right to Know report showed that manholes release frequent, low-volume discharges, while pump station failures, though less common, release much larger volumes of sewage. CSOs, sewer infrastructure failures, and collection system leaks and failures, are sources of contamination to the Hudson and its tributaries – because sewage is discharged without reaching the plant for treatment.

Swimmers, stand-up paddleboarders and kayakers at Kingston Point Beach in June 2014.
Photo by Dan Shapley / Riverkeeper.

REGIONAL VIEWS AND SITE DATA

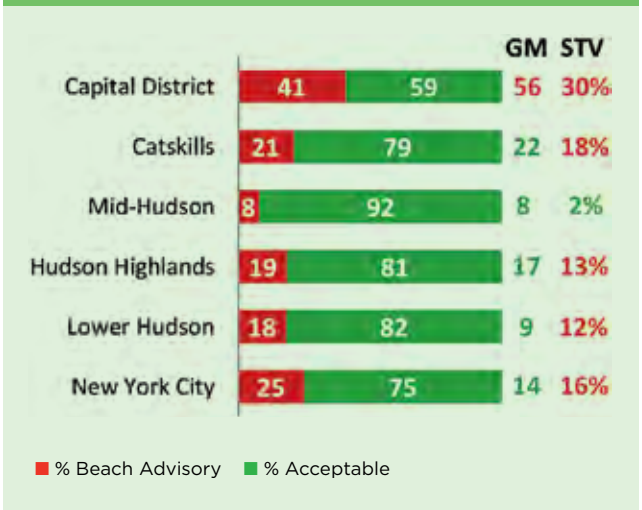
A member of the Rochester Environmental Conservation Commission samples the Rondout Creek in October 2013.
Photo by Dan Shapley / Riverkeeper

Six Regional Views

In this report, we have divided our Hudson River sampling sites into six geographic regions – Capital District, Catskills, Mid Hudson, Hudson Highlands, Lower Hudson and New York City. Now regions are consistent to the divisions that state regulators use. *(See map, page 8.)*

The number and type of testing locations in any region may influence the overall picture of water quality significantly, and suggests that more testing is needed to appropriately protect public health and manage the water for public use. For instance, the Mid Hudson region, with few test sites overall, and a relatively large proportion of mid-channel testing sites, appears to have better water quality than the Catskills Region, which has a larger number of sample sites, and a larger proportion of tributary sites. Comparisons between regions should be made cautiously, with this in mind.

REGIONAL WATER QUALITY

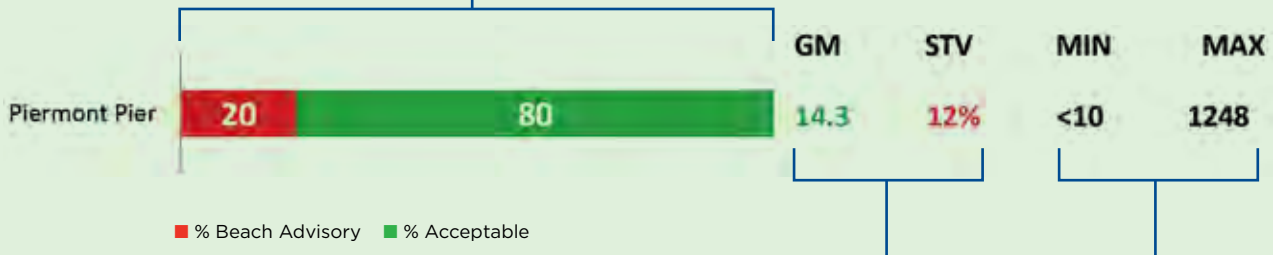


HOW TO READ RIVERKEEPER'S DATA CHARTS

MANAGING SWIMMING AREAS

Should the beach be open or closed?

The red bar shows the percentage of samples that would have resulted in a closure if the area were managed according to EPA recommendations for a swimming area. The "Beach Advisory" level corresponds to a single-sample Entero count greater than 60, the EPA's recommended "Beach Action Value" (BAV) for protecting public health.



REGULATING WATER QUALITY

Does water meet Clean Water Act standards for safe recreation?

The Statistical Threshold Value (STV) and Geometric Mean (GM) scores listed to the right of the bar chart are measures of water quality over time. If water designated for primary contact recreation (swimming, tubing, child water play, etc.) fails to meet *either* of these criteria, regulators should take action to improve water quality.

- The GM is a weighted average of Entero counts. A GM over 30 exceeds EPA recommended criteria, and is listed in red type.
- The STV column shows the percentage of samples with Entero counts exceeding 110. An STV failure rate greater than 10% exceeds EPA recommended criteria, and is listed in red type.

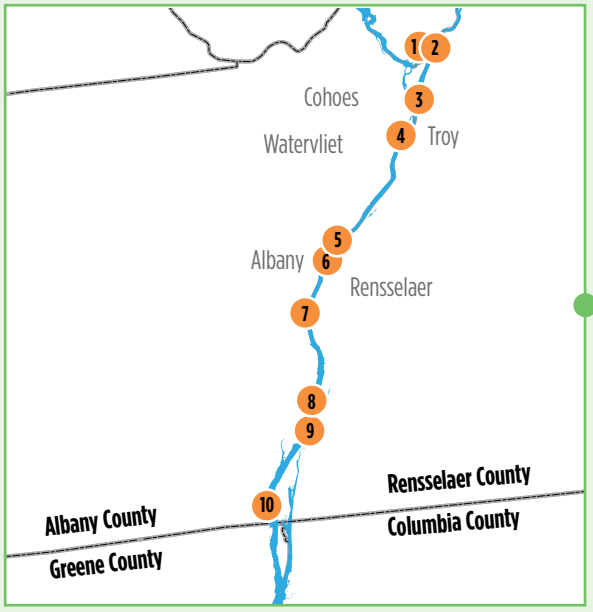
ADDITIONAL INFORMATION

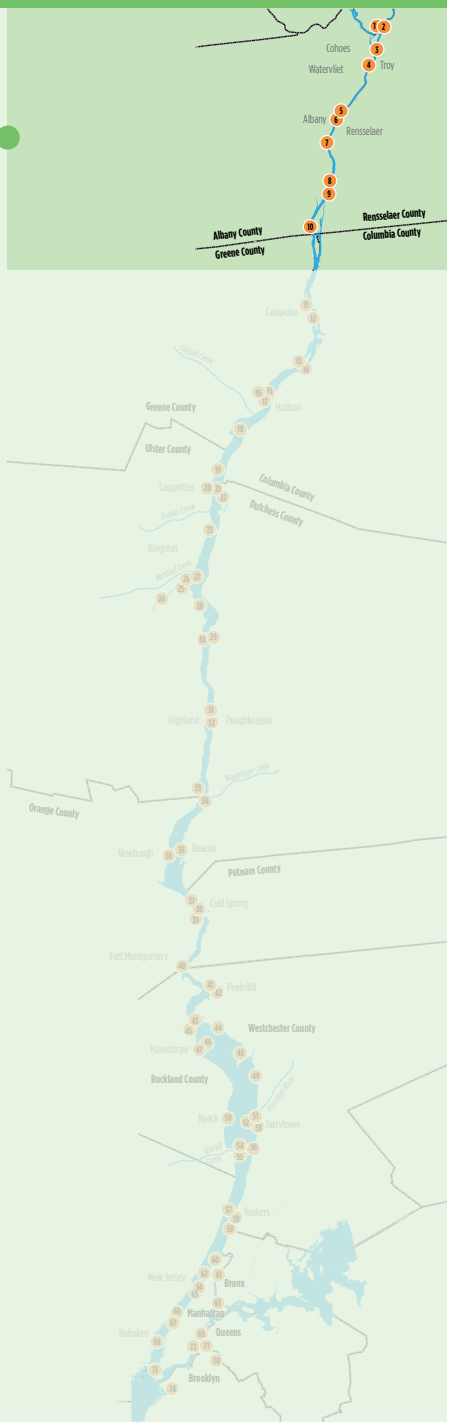
The minimum (Min) and maximum (Max) counts refer to the lowest and highest Entero counts observed at each site, and help to illustrate both the severity of contamination and the ability of the waterway to recover from pollution events. A greater-than or less-than symbol indicates a sample beyond the detection limits of our testing system.

REGIONAL VIEWS AND SITE DATA

CAPITAL DISTRICT

	% Beach Advisory	% Acceptable	GM	STV	MIN	MAX
1. Hudson above Mohawk River	20	80	24.0	17%	<1	>2420
2. Mohawk River at Waterford	66	34	169.7	57%	4	>2420
3. Hudson River above Troy Lock	62	38	105.4	35%	4	>2420
4. Congress St. Bridge- Troy	39	61	71.2	26%	6	>2420
5. Albany Rowing Dock	42	58	68.6	28%	3	>2420
6. Dunn Memorial Bridge- Albany	55	45	97.7	39%	3	>2420
7. Island Creek/Normans Kill	49	51	86.9	40%	2	>2420
8. Bethlehem Launch Ramp	22	78	28.1	14%	1	>2420
9. Castleton	29	71	27.7	23%	<1	1733
10. Coeymans Landing	22	78	21.1	19%	<1	1986





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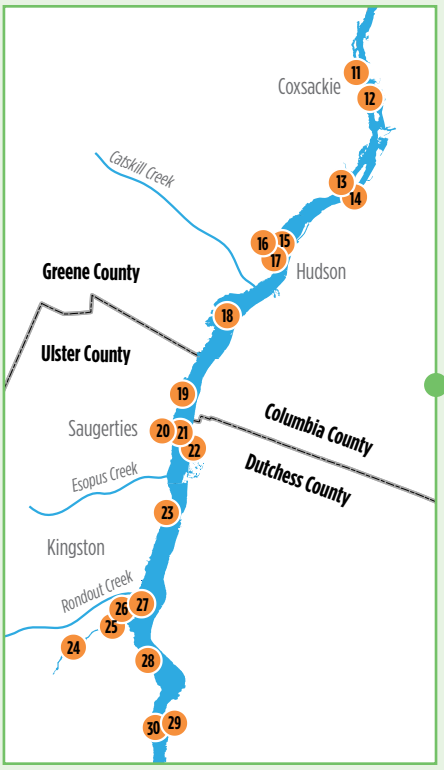
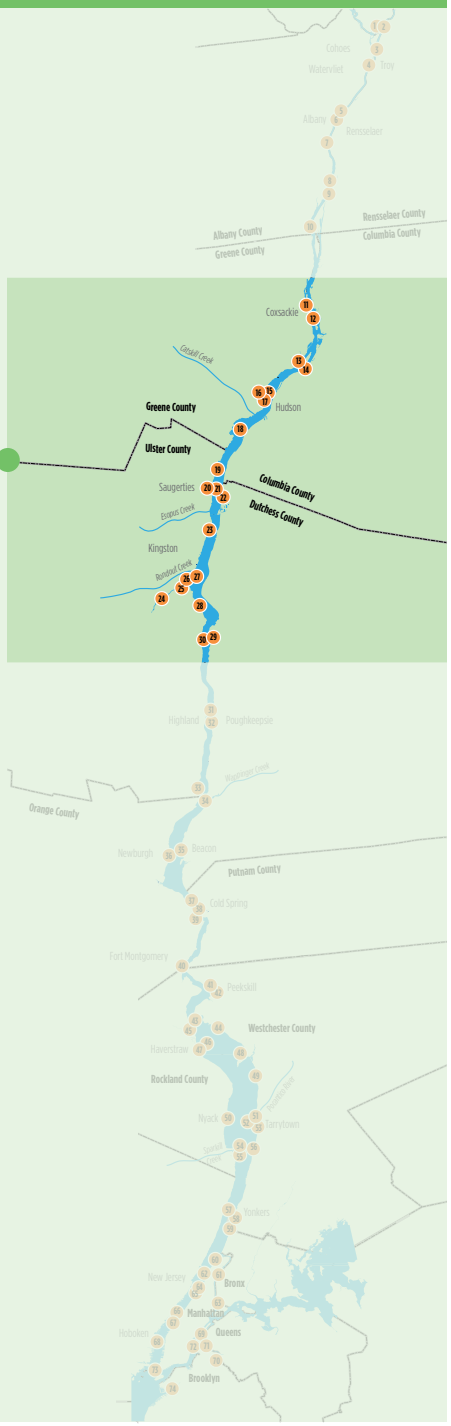
Min = The lowest Entero count recorded at this site.
Max = The highest Entero count recorded at this site.

CATSKILLS

			GM	STV	MIN	MAX
11. Coxsackie Waterfront Park	24	76	24.2	15%	<1	2420
12. Gay's Point mid-channel	19	81	17.4	19%	1	2420
13. Athens	34	66	39.8	14%	5	>2420
14. Hudson Landing Ramp	30	70	27.4	16%	4	>2420
15. Catskill Creek– First Bridge	27	73	24.8	27%	<1	>2420
16. Catskill Creek– East End	24	76	25.0	21%	1	>2420
17. Catskill Launch Ramp	16	84	16.7	16%	1	>2420
18. Inbocht Bay	8	92	10.8	8%	<1	>2420
19. Malden Launch Ramp	11	89	16.3	11%	1	1986
20. Esopus Creek West	21	79	22.6	13%	<1	>2420
21. Esopus Creek Entrance	18	82	19.1	15%	<1	>2420
22. Tivoli Landing	11	89	6.9	11%	<1	>2420
23. Ulster Landing Beach	14	86	8.2	8%	<1	2420
24. Rondout- Eddyville Anchorage	23	77	37.0	18%	1	>2420
25. Rondout- Kingston Public Dock	44	56	66.1	38%	5	>2420
26. Kingston STP Outfall	53	48	102.2	36%	2	>2420
27. Kingston Point Beach	16	84	9.7	8%	<1	219
28. Port Ewen Drinking Water Intake	8	92	5.3	8%	<1	1733
29. Norrie Point Yacht Basin	19	81	21.3	17%	1	>2420
30. Norrie Point mid-channel	8	92	3.9	6%	<1	1203





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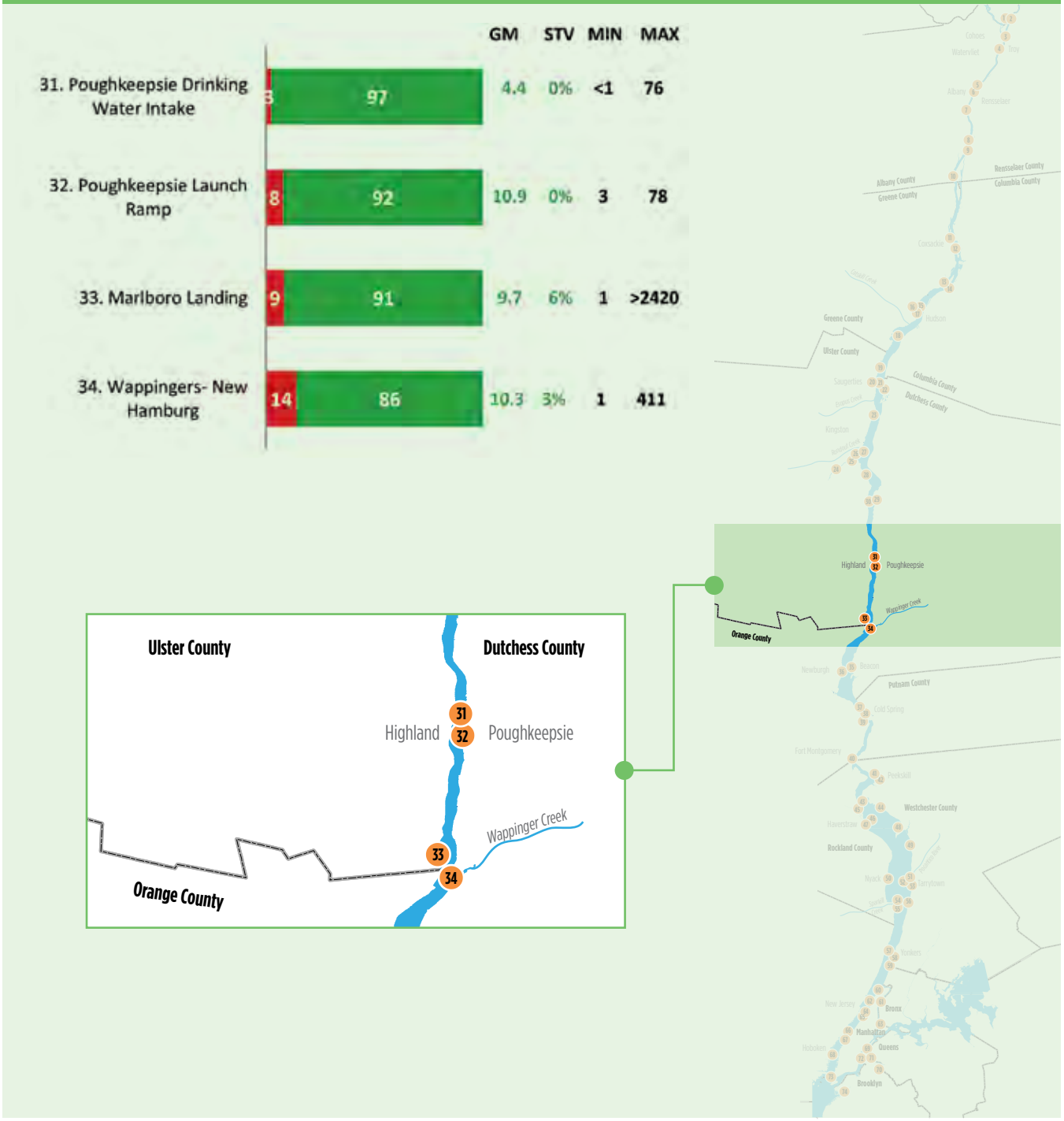
MID HUDSON



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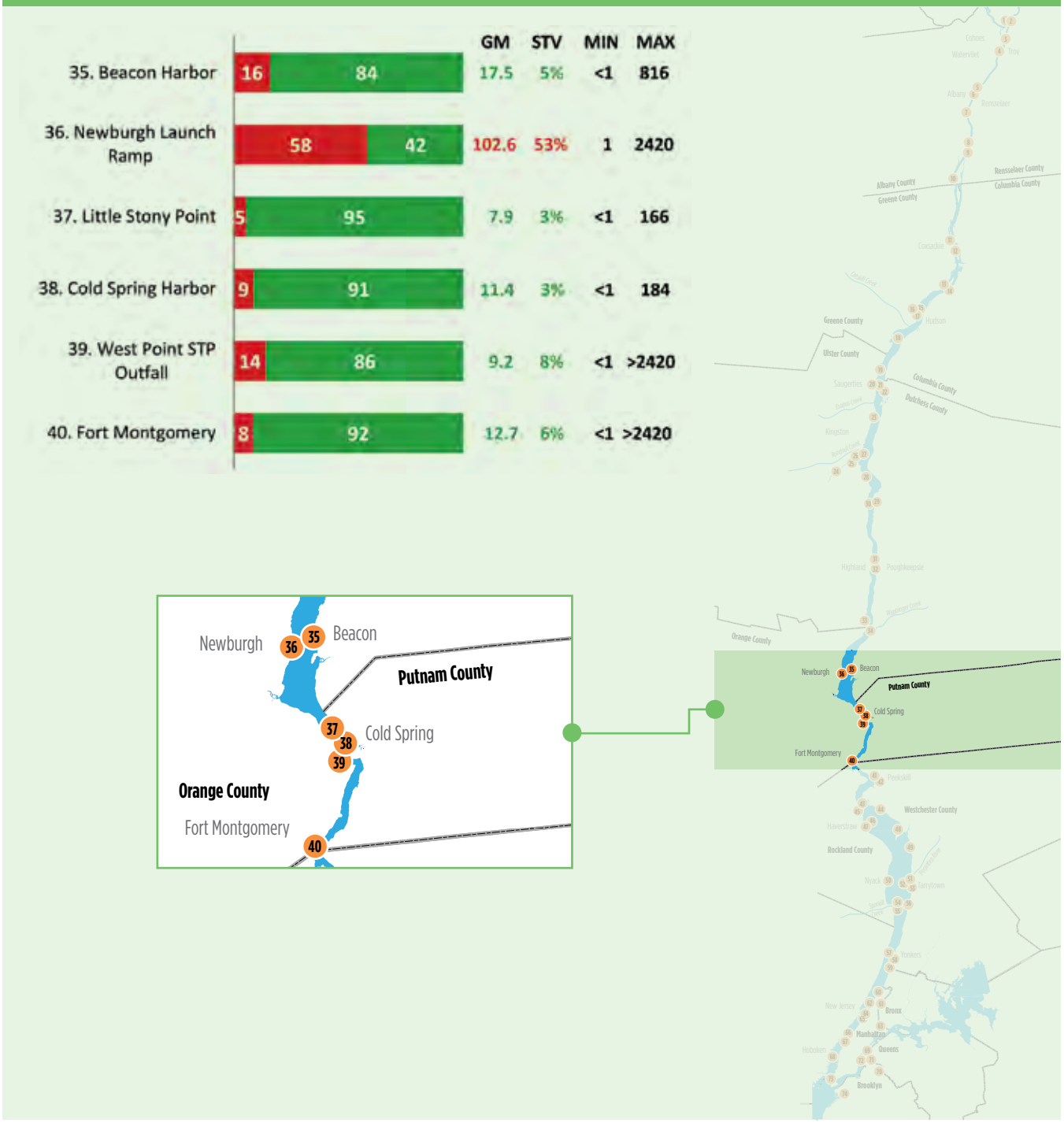
HUDSON HIGHLANDS



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REGIONAL VIEWS AND SITE DATA

LOWER HUDSON

			GM	STV	MIN	MAX
41. Annesville Creek	21	79	11.8	13%	<10	958
42. Peekskill Riverfront Green Park	21	79	16.2	11%	<10	4352
43. Stony Point mid-channel	3	97	3.6	0%	<10	86
44. Furnace Brook	21	79	10.1	16%	<10	4106
45. Cedar Pond Brook	18	82	10.0	18%	<10	3654
46. Haverstraw Bay mid-channel	5	95	3.0	0%	<10	86
47. Emeline Beach- Haverstraw	8	92	6.9	8%	<10	10462
48. Croton Point Beach	3	97	3.7	3%	<10	169
49. Ossining Beach	16	84	8.8	14%	<10	4611
50. Nyack Launch Ramp	24	76	10.0	16%	<10	663
51. Kingsland Pt. Park- Pocantico River	22	78	15.1	22%	<10	>24196
52. TZ Bridge mid-channel	3	98	2.1	3%	<10	142
53. Tarrytown Marina	48	52	59.6	26%	<10	>24196
54. Piermont Pier	20	80	14.3	12%	<10	1248
55. Orangetown STP Outfall	41	59	32.8	28%	<10	10112
56. Irvington Beach	6	94	3.5	6%	<10	464
57. Yonkers mid-channel	5	95	3.3	3%	<10	410
58. Saw Mill River	55	45	102.8	54%	<10	>24196
59. Yonkers STP Outfall	5	95	5.8	0%	<10	85

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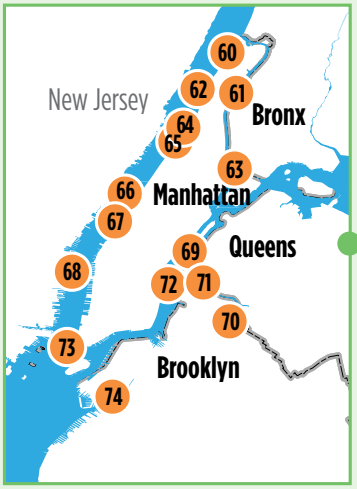
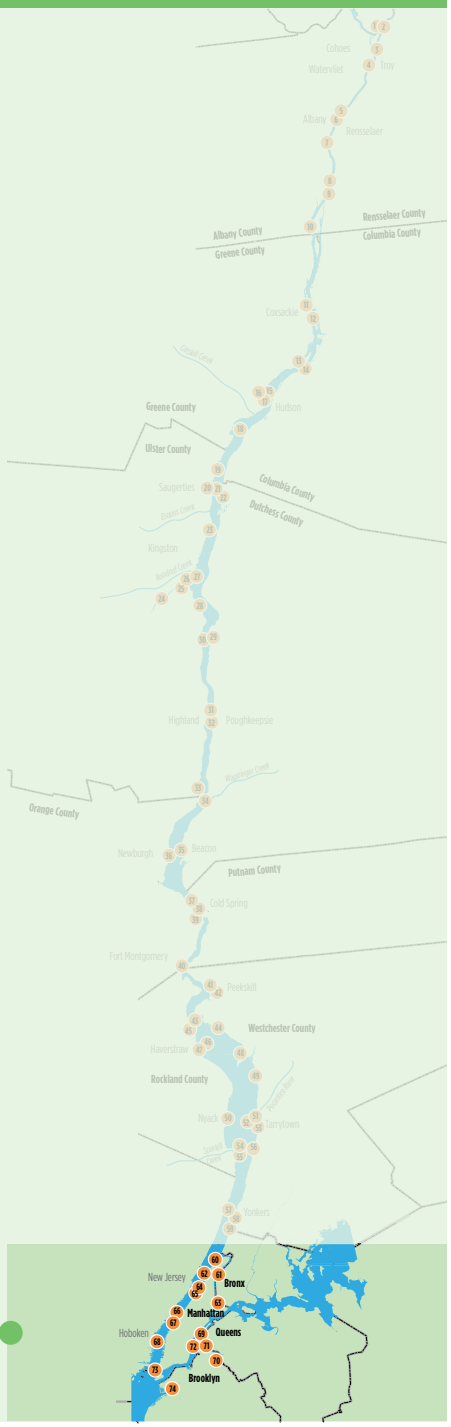
NEW YORK CITY

	% Beach Advisory	% Acceptable	GM	STV	MIN	MAX
60. Dyckman Street Beach	14	86	8.6	3%	<10	144
61. Harlem River- Washington Bridge	32	68	20.8	14%	<10	1670
62. GW Bridge mid-channel	8	92	4.3	3%	<10	134
63. Harlem River- Willis Ave. Bridge	26	74	15.6	21%	<10	5635
64. North River STP @145th	35	65	31.2	24%	<10	2987
65. 125th St. Pier	27	73	13.0	16%	<10	272
66. 79th St. mid-channel	8	92	5.5	3%	<10	161
67. Pier 96 Kayak Launch	21	79	7.7	5%	<10	331
68. Castle Point, NJ	11	89	9.5	8%	<10	231
69. East River at Roosevelt Island	24	76	6.4	11%	<10	275
70. Newtown Creek- Metropolitan Ave. Bridge	53	47	94.3	44%	<10	>24196
71. Newtown Creek- Dutch Kills	38	62	26.7	31%	<10	>24196
72. East River mid-channel at 23rd St.	14	86	6.2	10%	<10	399
73. The Battery mid-channel	8	92	5.0	3%	<10	134
74. Gowanus Canal	57	43	114.5	47%	<10	>24196





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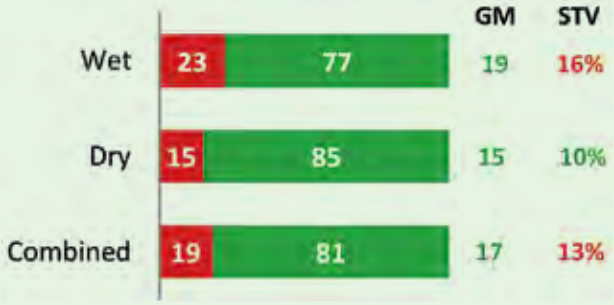
WET WEATHER IMPACTS BY REGION

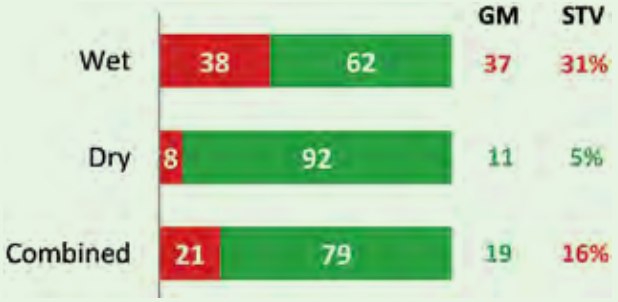
Riverkeeper defines wet weather as at least 1/4 inch of cumulative rainfall in the three days prior to sample collection. By this standard 49% of our samples from 2008 – 2013 were "wet weather" samples and 51% were "dry weather" samples.[13]

Capital District

Hudson Highlands



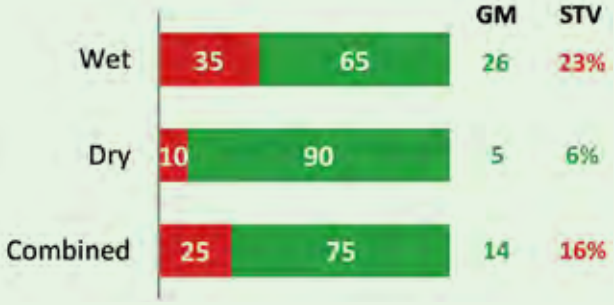
Catskills



Lower Hudson

Mid Hudson

New York City



■ % Beach Advisory ■ % Acceptable

SAMPLING SITE DESCRIPTIONS: NORTH TO SOUTH

No.	Name	Description	Observed Uses
1	Hudson above Mohawk River	The Hudson River, above the lock at Troy, is not part of the tidal estuary.	Boating, recreational and subsistence fishing and occasional swimming
2	Mohawk River at Waterford	The Mohawk River is the Hudson River's largest tributary.	Boating, recreational and subsistence fishing, and occasional swimming
3	Hudson River above Troy Lock	Outside the tidal estuary. The Waterford drinking water intake is nearby (but water is drawn from Troy during PCB dredging).	Boating and fishing
4	Congress St. Bridge, Troy	The tidal Hudson River estuary begins here, below the Troy dam.	Boating, kayaking and recreational and subsistence fishing near Troy Riverside Park and Watervliet's Hudson Shores Park.
5	Albany Rowing Dock	The dock and a public boat launch are located at the Corning Preserve.	Team rowing, kayaking, boating and fishing
6	Dunn Memorial Bridge, Albany	This site is in the heart of the Port of Albany.	Team rowing, swimming from boats, and fishing
7	Island Creek/ Normans Kill, Albany	The two creeks enter the here in the industrial portion of the Port of Albany.	Boating
8	Bethlehem Launch Ramp	Henry Hudson Park was identified by NY as a potential swimming beach.	Boating, and fishing from both boat and shore
9	Castleton	Near the mouth of Vlockie Kill.	Boating, and fishing from both boats and shore
10	Coeymans Landing	Village park has a fishing pier, marina and a launch ramp.	Kayaking
11	Coxsackie Waterfront Park	Riverside Park has an unofficial beach, launch ramp and fishing area.	Boating and casual water contact
12	Gay's Point mid-channel	A relatively undeveloped part of the estuary west of Hudson Islands State Park.	Boating and swimming
13	Athens	The STP outfall is near the State Boat Launch and Athens Riverfront Park.	Kayaking, boating, stand-up paddleboarding and fishing
14	Hudson Landing Ramp	A boat club is nearby the launch ramp at Hudson Waterfront Park.	Kayaking, fishing, boating and swimming
15	Catskill Launch Ramp	Dutchman's Landing park has a trailered boat launch.	Casual water contact, boating and fishing
16	Catskill Creek – First Bridge	Marinas line the creek near the Bridge Street crossing.	Boating, fishing and swimming
17	Catskill Creek – East End	Marinas line the shore near the entrance of creek.	Boating, fishing and swimming
18	Inbocht Bay	Across the river from Lasher Memorial Park, Germantown.	Boating and fishing
19	Malden Launch Ramp	STP outfall is nearby.	Boating, kayaking and jet-skiing
20	Esopus Creek West	STP outfall is nearby, as is a kayak launch at Tina Chorvas Park.	Boating, kayaking, fishing and occasional swimming
21	Esopus Creek Entrance	Near the Saugerties Lighthouse.	Boating, fishing, kayaking and occasional swimming
22	Tivoli Landing	Tivoli Boat Launch is located here.	Kayaking, boating and fishing

SAMPLING SITE DESCRIPTIONS: NORTH TO SOUTH (CONTINUED)

No.	Name	Description	Observed Uses
23	Ulster Landing Beach	Official Ulster County beach, adjacent to a boat launch.	Swimming, fishing, boating and kayaking
24	Rondout Creek at Eddyville Anchorage	Marinas and boat clubs line the creek.	Boating, rafting, kayaking, swimming and fishing
25	Rondout Creek at Kingston Public Dock	West Strand Park has a marina. At the site of a CSO outfall.	Boating and fishing
26	Rondout Creek at Kingston STP Outfall	The Kingston STP discharges into Rondout Creek here.	Boating, tubing, team rowing, kayaking and fishing
27	Kingston Point Beach	This official City of Kingston beach also has a boat launch.	Swimming, fishing, kayaking and boating
28	Port Ewen Drinking Water Intake	The drinking water intake serves approximately 4,500 people.	Fishing from boats and from shore, boating and swimming
29	Norrie Point Yacht Basin	The yacht basin is located at the mouth of a small tributary.	Boating and fishing
30	Norrie Point mid-channel	A deep-water site north of Esopus Island.	Boating and fishing
31	Poughkeepsie Drinking Water Intake	The drinking water intake serves approximately 75,000 people.	Team rowing, boating, jet-skiing and fishing.
32	Poughkeepsie Launch Ramp	Waryas Park.	Boating, fishing, jet-skiing and some swimming from boats
33	Marlboro Landing	A marina near a tributary.	Kayaking, fishing and swimming from boats
34	New Hamburg	Near the confluence of the Wappingers Creek.	Swimming from recreational boats, kayaking and fishing
35	Beacon Harbor	Beacon Riverfront Park has both the River Pool and a storm drain.	Boating, kayaking and fishing
36	Newburgh Launch Ramp	A CSO outfall is next to the ramp, and the STP outfall a few hundred yards south.	Team rowing, boating, fishing and jet-skiing
37	Little Stony Point	An unofficial swimming beach at Hudson Highlands State Park.	Swimming, kayaking, boating and fishing
38	Cold Spring Harbor	Near a fishing pier, yacht club and boat launches.	Fishing, kayaking and boating
39	West Point STP Outfall	The sewage treatment plant serves the U.S. Military Academy.	Boating, team rowing and fishing
40	Fort Montgomery	A small STP discharges here.	Boating, fishing and kayaking
41	Annesville Creek, Peekskill	A tributary near Peekskill. Site is near a fishing pier.	Kayaking, fishing
42	Peekskill Riverfront Green Park	Near a boat launch and a beach, where swimming is prohibited.	Boating, fishing and casual water contact
43	Stony Point mid-channel	A deep-water site.	Boating and fishing
44	Furnace Brook	Near confluence with tributary, which flows through Oscawana Park.	Recreational and subsistence fishing, kayaking, and swimming from boats
45	Cedar Pond Brook	Near confluence with tributary, part of a tidal marsh.	Boating and fishing
46	Haverstraw Bay mid-channel	A deep-water site near the ship channel in Haverstraw Bay.	Boating and fishing
47	Emeline Beach, Haverstraw	The park has a beach, where swimming is prohibited.	Casual water contact, fishing from shore, kayaking and boating

No.	Name	Description	Observed Uses
48	Croton Point Beach	An official Westchester County beach.	Swimming, boating and fishing
49	Ossining Beach	Swimming is prohibited. Immediately north of STP outfall.	Casual water contact, fishing and boating
50	Nyack Launch Ramp	Nyack Memorial Park, near village marina and private boat club.	Swimming, boating, jet-skiing and fishing
51	Pocantico River at Kingsland Point Park	Swimming is prohibited at the park beach. A small private boat club beach is nearby.	Boating, fishing and occasional swimming
52	Tappan Zee Bridge mid-channel	A deep-water site.	Boating and fishing
53	Tarrytown Marina	A large marina.	Boating and fishing
54	Piermont Pier	A hand-held boat launch site is located at the pier.	Recreational and subsistence fishing and crabbing, and boating
55	Orangetown STP Outfall	Near two STP outfalls.	Boating and fishing
56	Irvington Beach	Between Matthiessen Park and a boat club, near a CSO outfall.	Kayaking, casual water contact, boating and fishing
57	Yonkers mid-channel	A deep-water site.	Boating and fishing
58	Saw Mill River	Tributary meets Hudson on the Yonkers waterfront, near paddling and rowing club.	Boating, and both recreational and subsistence fishing
59	Yonkers STP Outfall	This STP treats sewage from much of Westchester County.	Boating and fishing
60	Dyckman Street Beach	Inwood Hill Park has a boat launch and a CSO outfall under the pier.	Fishing, team rowing, boating and casual water contact at the beach
61	Harlem River at Washington Bridge	Bridge connects 181st Street in Washington Heights to University Ave. in Morris Heights.	Boating, jet skiing, fishing from shore and team rowing. High Bridge Park and Bridge Park sit on either shore
62	George Washington Bridge mid-channel	A deep-water site.	Boating, jet-skiing and swim events
63	Harlem River at Willis Ave. Bridge	This industrial waterway connects the Hudson and East rivers.	Boating, jet skiing and fishing from the shore
64	North River STP at 145th St.	The STP is located at Riverbank State Park in Harlem.	Boating and fishing
65	125th St. Pier	A CSO outfall is immediately to the south of this access point.	Recreational and subsistence fishing
66	79th St. mid-channel	A deep-water site.	Boating and swim events
67	Pier 96 Kayak Launch	A NYC CSO outfall is nearby.	Kayaking
68	Castle Point, NJ	At the Stevens Institute of Technology's HRECOS research buoy in Hoboken.	
69	East River at Roosevelt Island	Near Queensboro Bridge.	Boating, fishing and swim events
70	Newtown Creek at Metropolitan Ave. Br. Bridge	Newtown Creek is an industrial waterway and a Superfund site separating Queens and Brooklyn.	Kayaking
71	Newtown Creek - Dutch Kills	Dutch Kills is a Queens tributary of the creek with confluence near Newtown Creek Nature Walk.	Subsistence fishing and kayaking
72	East River mid-channel at 23rd St.	A deep-water site near the confluence of the Newtown Creek.	Boating
73	The Battery mid-channel	A deep-water site.	Boating and swim events
74	Gowanus Canal	An industrial waterway and a Superfund site.	Boating, kayaking and canoeing

HUDSON RIVER TRIBUTARY CITIZEN SCIENCE DATA

Each month, Riverkeeper and our science partners sample 16 sites in the tidal portions of tributaries. At these tributary sites, 35% of samples exceeded the EPA-recommended guidelines for safe swimming from 2008-2013. The failure rate increases more than threefold after wet weather.[13]

To understand what is causing contamination in our streams, brooks and creeks, we have initiated several ongoing, multi-year studies in cooperation with citizen scientists to sample monthly in several tributary watersheds – the Sparkill Creek, Pocantico River, Wallkill River, Rondout Creek, Esopus Creek and Catskill Creek. (A seventh, the Sawyer Kill, was also sampled in 2012 and 2013.) In 2013, more than 60 citizen scientists helped sample 84 locations on more than 160 miles of water.

While the tributary studies were designed to yield data consistent with the Hudson River study, it is important to note that they are different studies.

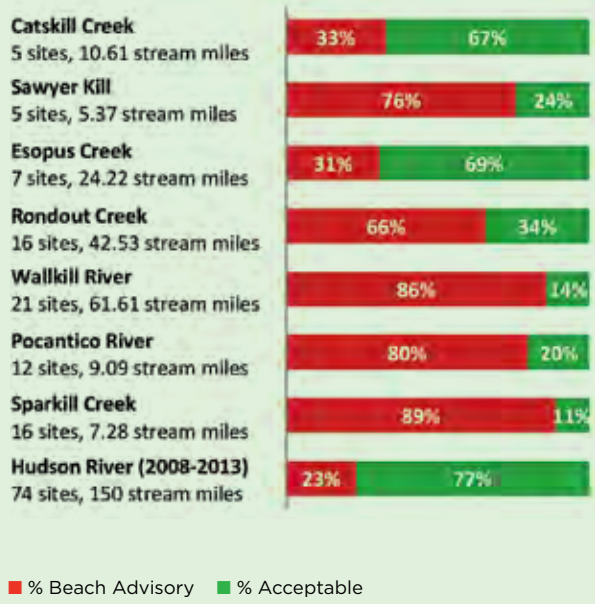
In the non-tidal portion of the tributaries where citizen scientists gather data for processing aboard the Riverkeeper patrol boat, we have documented a higher frequency of fecal contamination than we find in the Hudson, or in the tidal portion of the same tributaries. **Many of these tributaries are more contaminated than the Hudson River, and as such, they are a source of pollution to the river.**

The sources of contamination may be significantly different in some tributary watersheds than in the Hudson itself. Under-designed or unmaintained septic systems, wildlife, agricultural practices or contaminated sediment may be important factors. Low volume and flow may also play a role. While SSO discharges may be a significant source of contamination in some areas, there are few if any CSO outfalls on the non-tidal portions of these tributaries.

Local communities are using this information to find and stop illicit sewage discharges, drive investment in wastewater infrastructure, and notify the public about water quality conditions. We are planning new citizen science partnerships, and will continue to support local efforts to improve water quality.

Sampling began on some of these tributaries in 2010 (Esopus, Pocantico) and 2011 (Catskill, Sparkill). For a clear comparison, the chart below shows only data collected in 2012 and 2013, when monthly sampling was taking place on *all* of the tributaries listed. The tributary data presented here is for the non-tidal portion of these waterways. The tidal portions of tributaries are part of the Hudson River Estuary; samples in the tidal portion of the Catskill, Esopus and Rondout creeks are included within the Hudson River data.

TRIBUTARY SAMPLING DATA



Visit www.riverkeeper.org/water-quality/citizen-data to view data for each site tested.

ACTION AGENDA:
IMPROVING OUR WATER QUALITY

Riverkeeper on patrol near the Bear Mountain Bridge. *Photo by Neale Gulley / Riverkeeper*

There are many actions that government agencies, citizens and others can take to improve water quality in the Hudson River. These are our priorities:

1 REINVEST IN WASTEWATER INFRASTRUCTURE

Address the Source of the Problem in Many Areas

The early gains in water quality that were achieved in the 1970s after the passage of the Clean Water Act are now at risk of being lost because localities have not made up the difference as federal funding available to states for infrastructure has dramatically declined since the 1980s.

According to the DEC's 2008 report, "Wastewater Infrastructure Needs of New York," many wastewater facilities are past their expected useful lives.[14] **Statewide, more than 30% of these facilities are in excess of 60 years old, though they were designed to only last 30 to 40 years.**[15]

Our state and federal governments should provide new mechanisms to fund wastewater infrastructure, and local governments need to recognize the need to invest in regular maintenance and upgrades. In our experience, conversations that focus on the need for clean recreational water are more likely to lead to investments than those that focus solely on cost. Our state agencies and elected officials acknowledge that clean water and efficient wastewater treatment are essential for the future economic health of the Hudson Valley but we have yet to step up and tackle this growing crisis.

A state-led effort to develop an asset management plan to guide communities in the need for ongoing investments is a positive step, and notable progress is being made in some areas:

- New York City is in the early years of a $2.4 billion Long Term Control Plan to reduce sewage overflows and stormwater runoff.
- In the Capital District, Riverkeeper challenged a weak draft Long Term Control Plan for reducing the impact of the 92 combined sewer outfalls that discharge 1.2 billion gallons of raw sewage and stormwater runoff into the Hudson each year. In response, the DEC negotiated a more aggressive $136 million Control Plan, and announced in January 2014 that its goal was to make the waters of the Capital District safe for swimming.
- In Tarrytown, Westchester County has committed to a $9.9 million improvement to address a failing piece of the regional sewer system that has long contaminated the Hudson River.

HOW TO DOCUMENT AND REPORT A SEWAGE PROBLEM

- Take pictures or shoot video to document the discharge, including both wide-angle and close-up shots to demonstrate both context and detail.
- Report the incident to Riverkeeper's Watchdog Hotline. Call 800-21-RIVER x231 or visit www.riverkeeper.org/get-involved/violations/
- Report the incident to the DEC's 24-hour hotline: 800-847-7332.
- If you catch someone in the act of polluting, call 911.

2 ENFORCE EXISTING WATER QUALITY PROTECTION LAWS
Use the Tools at Hand

The Clean Water Act stated the goals of achieving water quality safe for swimming and fishing, and stopping all pollution discharges to rivers by 1985. Many of the tools necessary to achieve these goals are built into the law, but in New York State, we have yet to use all the tools available to clean the water.

The law requires regular assessment of waterways, to understand where water is failing to meet standards. Where water fails to meet standards, regulators are required to act to reduce pollution and achieve better water quality. When a polluter is out of compliance with a permit, regulators can compel compliance through the threat of significant penalties.

Rigorous enforcement of the Clean Water Act means careful assessment of waters, designating uses consistent with existing uses and Clean Water Act goals of achieving swimmable and fishable water, and reduction of both point and non-point sources of pollution. New York needs a well-funded and properly staffed DEC to achieve the water quality that is the public's right.

3 IMPROVE NEW YORK STATE WATER QUALITY STANDARDS
Implement EPA Recommendations

Accurately assessing water quality is essential to effectively protecting the public and managing the Hudson River for recreational use under the Clean Water Act.

New York is updating nearly 30-year-old water quality standards that use fecal and total coliform bacteria and relies only the GM to assess and manage its waterways for fecal contamination. The EPA no longer recommends the use of coliform bacteria as an indicator, nor use of the GM in isolation.

New York should implement the EPA's 2012 Recreational Water Quality Criteria, based on the more protective illness rate of 32 illnesses per 1,000. The EPA recommends frequent sampling for *Enterococcus* at least weekly, and use of three water quality assessment tools – the GM, STV and BAV. *(See further discussion in "Water Quality Guidelines and How Riverkeeper Uses Them," page 11.)*

To illustrate the importance of this point, consider Riverkeeper's data. Of 74 sampling sites in our study period, 23% failed the EPA's recommended GM, and 61% failed the recommended STV criteria. The need for tighter pollution controls would not be as apparent if the GM were analyzed in isolation.

We are also calling for modeling and public notification at public beaches, as well as other near-shore areas that are used for primary contact recreation.

Riverkeeper represents the public interest on a stakeholder group that advises the DEC as it updates state water quality standards. Riverkeeper will submit comments, and encourage public comments, when DEC drafts new criteria. Readers may sign up for our email alerts www.tinyurl.com/rvk-eml to track this issue and learn when the DEC is accepting public comment on this important decision.

4 ENGAGE CITIZENS IN LOCAL SOLUTIONS

When Riverkeeper's data identifies a local water quality issue, the reaction is almost always the same. People don't turn their backs on the water. They step up and say, "What can we do to fix it?"

For instance, in 2013, a local resident sought Riverkeeper's help when a sewage discharge affected the Twaalfskill, a small tributary of the Rondout Creek. Riverkeeper then helped engage the City of Kingston in a solution that will not only address the immediate problem causing the discharge to the Twaalsfkill, but also improve the rate of sewage treatment during rainfall events, and improve public notification when combined sewage overflows affect the Rondout Creek.

Here are some examples of how local communities and interested individuals can get involved.

Citizen Science

Riverkeeper is fortunate to be working with many committed individuals and groups concerned about water quality – including 60 citizen partners testing the water on more than 165 miles of our tributaries. *For more information, see Hudson River Tributary Citizen Science Date on page 34.*

Green Infrastructure

Green infrastructure is a system of natural landscapes and engineered systems that mimic natural systems, working together to collect and divert stormwater, keeping it out of the storm drains, sewers and waterways. Green infrastructure projects can alleviate pressure on strained sewer systems and divert stormwater from CSOs, reducing the volume of sewage overflows and runoff entering our waters.

In addition to improving water quality, these projects provide other benefits such as reducing urban heat effect and improving air quality. Green infrastructure has been found to often be a more cost effective approach to stormwater management than traditional grey infrastructure[16] (engineered solutions such as holding tanks). Citizens can install green infrastructure projects on their private property, and support their use at work, in their schools and elsewhere in their community.[17]

Water Conservation

Individuals, towns and businesses can further reduce the pressure on their sewer system by reducing water use. After all, it's not only sewage that flows through our wastewater treatment plants, but also water from our sinks, showers and in some instances our storm drains and basement sump pumps. Individuals and businesses need to be educated on the importance of water conservation even in non-drought situations, improve their water usage habits and implement long-term solutions such as low-flow faucets and toilets and grey water systems.

Septic Maintenance

According to the NYS DEC about 25% of New York businesses and residents use onsite sewage treatment systems such as septic tanks and fields.[18] When installed and maintained properly they are an effective and economical wastewater treatment system. However improper installation, the overuse of both small and large systems, an increase in the number of systems per acre, and the widespread lack of proper maintenance has turned these systems into a significant water quality problem, earning them a place on the DEC's "Top 10 Water Quality Issues in NY State" list.[19]

Currently New York State lacks the laws needed to require the inspection and maintenance of private septic systems. As a result, counties are starting to address the problem with county regulations such as the pump-out rule that Westchester County put into effect in March of 2011. More counties need to follow suit and all businesses and homeowners who have septic systems need to do the right thing and conduct regular maintenance.

5 START HIGH-FREQUENCY MONITORING AND PREDICTIVE MODELING

We Can't Manage What We Don't Measure

People want to know if the water is safe when and where they are ready to enter the water. Riverkeeper's study can highlight problems and demonstrate best practices, but it cannot by itself answer this question. The only thing that can is high-frequency monitoring and predictive modeling.

People who enjoy swimming in the Hudson deserve the same protection as their neighbors swimming in the Long Island Sound and the Atlantic Ocean. At these locations local governments regularly test water quality, and close beaches when water quality either fails to meet EPA guidelines for safe swimming or is expected to fail based on historical data and modeling.

High frequency sampling by public agencies should be the standard for all Hudson River swimming areas. But sampling alone isn't enough. Because the standard tests for sewage contamination require an incubation of 24 hours, it's important to develop a *predictive water quality model* for each location.

A good predictive model can take into account various factors, including correlation between rainfall and sewage/pathogen levels, flow rates and water quality of nearby tributaries, turbidity and algae. Combining these factors with historic and ongoing water quality data, our government agencies can make real-time water quality predictions for the Hudson River, anticipating unacceptable swimming conditions and protecting public health.[20]

6 INFORM THE PUBLIC ABOUT SEWAGE CONTAMINATION AND WATER QUALITY DATA

The Public has a Right to Know About Water Quality

One key to turning the tide of sewage pollution in the Hudson is public awareness. In many cases, governments already collect data about both sewage releases to waterways, and water quality testing results at public beaches and elsewhere. This data should be made public, in a form most useful to people making decisions about recreation.

As part of our work to provide better transparency and documentation of sewage overflows, Riverkeeper initiated and lead the effort to pass the Sewage Pollution Right to Know Law, which took effect on May 1, 2013. This state law requires operators of publicly owned wastewater treatment plants, and the collection systems that deliver waste to those plants, to notify the public within four hours of discharges of raw or partially treated sewage into our waterways, including from CSOs. In its first year, the law has produced significant results:

- More than 1,600 SSO discharge events were reported, accounting for hundreds of thousands of gallons of sewage discharged into our waterways. The annual reporting of these discharges is providing a much-needed road map showing where our infrastructure fails most frequently.
- The DEC Division of Water has documented and reported daily SSO discharges in a spreadsheet available online: www.dec.ny.gov/chemical/90321.html.
- The DEC has developed an online map that for the first time publicly shows the location of every CSO outfall in the state and provides stats on the frequency of releases for each: http://goo.gl/maps/RP55T.

The final phase of implementation for this law will give the public access to email or text alerts of sewage discharges. Riverkeeper applauds the strides DEC has made towards the full implementation of the law to date and looks forward to its full implementation.

Children play in the water at Kingston Point Beach in June 2014. *Photo by Dan Shapley / Riverkeeper*

People should be aware, however, that even if implemented aggressively, the law will not notify the public of every type of fecal contamination. Discharges from privately owned systems are not included, and of reported discharges in the first year of the law, only 17% included required reporting on the volume of sewage released – a critical variable for the public evaluating potential health risk. Fecal contamination also comes from sources other than the reportable discharges from public sewer infrastructure. Finally, New Jersey, which has at least 14 CSO outfalls in the Hudson River and many more in waters feeding New York Harbor, passed a Sewage Pollution Right to Know bill; it was vetoed by Gov. Chris Christie in January 2014.

7 INVEST IN NEW KNOWLEDGE AND TECHNOLOGY

Old Problems Demand New Solutions

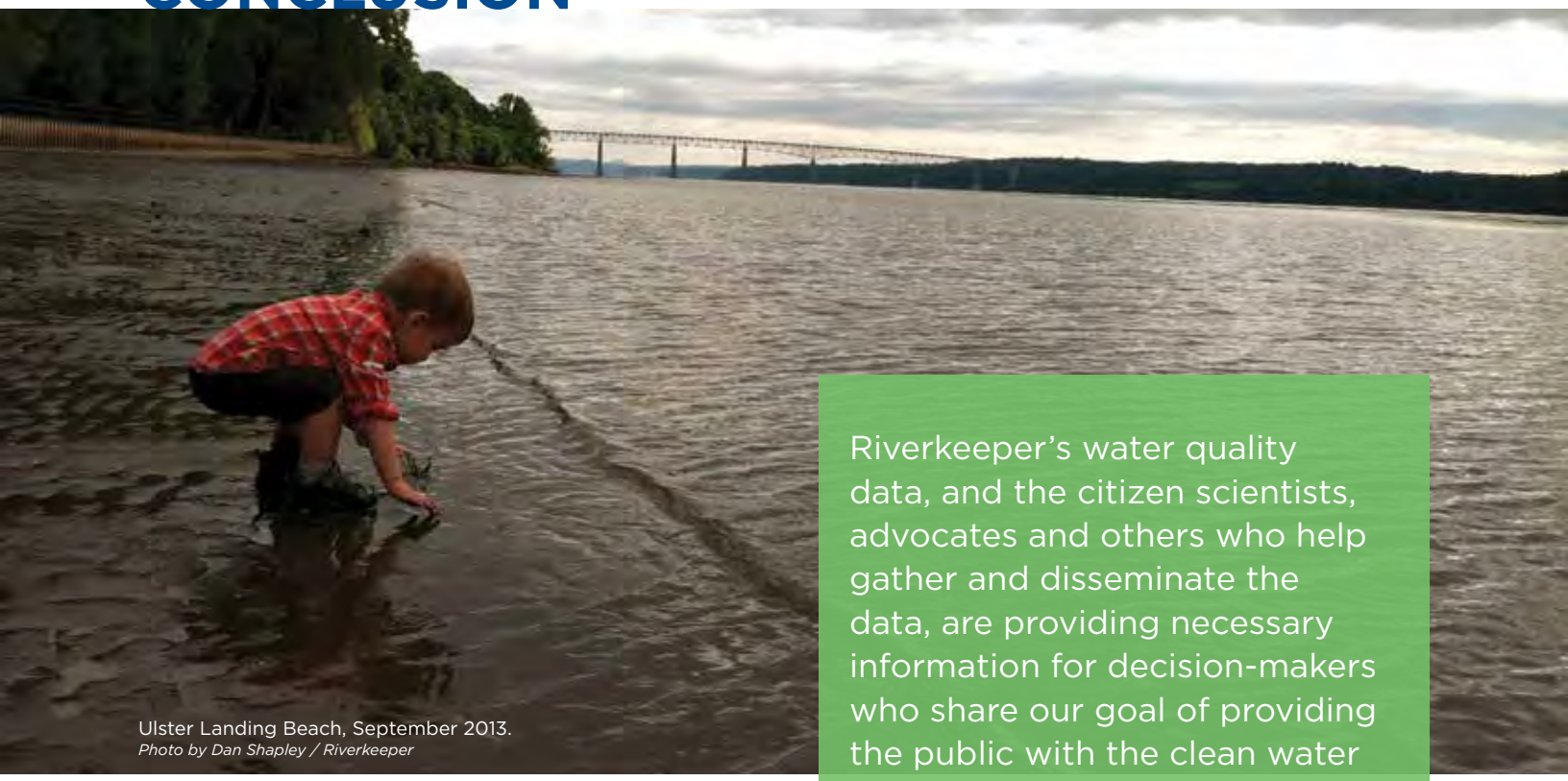
While we know how to solve many of the pollution problems that prevent the Hudson River from being consistently safe for swimming, reaching that goal will benefit from advances in many areas, including but not limited to:

- Rapid and affordable testing protocol: Managers of swimming areas should have access to real-time data on water quality to make management decisions.
- Predictive modeling: Managers of swimming areas should be able to anticipate water quality problems and use testing to confirm them.
- "Smart" CSOs that minimize overflows and simultaneously notify the public when an overflow is occurring.
- Sewage treatment alternatives: Communities that are too dense for septic systems, but not dense enough to make sewers affordable need innovative treatment options.

Riverkeeper is committed to advancing progress on these, and other fronts. For instance, our monitoring program is providing data for an ongoing series of scientific studies including:

- In 2013, Riverkeeper's science partners published a study demonstrating that the abundance of antibiotic-resistant bacteria in the Hudson is connected to sewage pollution and that the levels of these bacteria increased following rainfall, presumably due to the release of untreated sewage through CSOs. The study demonstrated that the abundance of Entero is positively correlated with the abundance of other groups microbes that may harm public health, reinforcing Entero's utility as an indicator of fecal-associated pathogens.[21]
- Our science partners are studying the aerosolization of bacteria, including potential pathogens, from Hudson River waters, as an unappreciated connection between water and air quality. This research is particularly relevant to New York City's proposal to aerate Newtown Creek.[22]
- Riverkeeper's science partners are studying the ability of fecal indicators and pathogens to survive in Hudson River bottom sediments, where they appear to constitute a reservoir that can re-contaminate the water.

CONCLUSION



Ulster Landing Beach, September 2013.
Photo by Dan Shapley / Riverkeeper

Riverkeeper's water quality data, and the citizen scientists, advocates and others who help gather and disseminate the data, are providing necessary information for decision-makers who share our goal of providing the public with the clean water it demands.

More than 40 years after the passage of the Clean Water Act, with its promise of making our waters safe for swimming, fecal contamination often makes portions of the Hudson River and its tributaries unsafe for swimming. Riverkeeper's water quality data, and the citizen scientists, advocates and others who help gather and disseminate the data, are providing necessary information for decision-makers who share our goal of providing the public with the clean water it demands.

Public notification when sewage discharges make water unsafe for swimming, through the Sewage Pollution Right to Know Act, will build public support for necessary investments in our sewage infrastructure.

Notable successes in the past several years mean billions of dollars will be invested to reduce sewage discharges in New York City, the Capital District and some of our smaller river communities where Riverkeeper has documented contamination that often exceeds EPA guidelines for safe swimming.

These investments are critical, and together with past successes, point the way forward.

Join Riverkeeper and Support the Water Quality Program

- ✓ Become a member, take action, volunteer or sign up to receive email updates: www.riverkeeper.org/get-involved/
- ✓ View our water quality data online: www.riverkeeper.org/water-quality/locations/
- ✓ View our archive of monthly reports: www.riverkeeper.org/water-quality/hudson/water-quality-reports/

GLOSSARY

303(d) Listing: When waterways fail to meet state water quality standards based on ongoing assessments, they may be listed as impaired under Clean Water Act section 303(d). Regulators then tighten pollution permit limits and/or require management of non-point sources of pollution to improve water quality.

Beach Action Value (BAV): A non-regulatory guideline recommended by the EPA for use at public beaches and other swimming areas to determine when to close access to protect public health, based on a single water quality sample.

Chlorophyll: Green pigment found in algae and other phytoplankton that allows plants to photosynthesize.

Combined Sewer Overflow (CSO): In communities where stormwater and sewage flow in the same pipes, systems are designed to discharge untreated and partially treated sewage into waterways to avoid overwhelming sewage treatment plants during rain events.

Enterococcus (Entero): Fecal-indicating bacteria that live in the intestines of warm-blooded animals.

Fecal Contamination: Contamination that includes raw or partially treated sewage, septic overflows, contaminated sediment and animal droppings, both wild and agricultural, including manure.

Fecal Indicator: Any measurable quantity that points to an input of feces into a body of water.

Geometric Mean (GM): A weighted average that dampens the effect of very high or very low values, used to calculate bacteria concentrations for assessing water quality over time.

Green Infrastructure: Natural landscapes, and/or engineered systems that mimic natural landscapes, to collect and divert stormwater, reduce flooding and improve water quality.

Grey Infrastructure: Conventional infrastructure such as piped drainage, holding tanks and water treatment systems.

Impervious Surfaces: Impenetrable surfaces, such as asphalt, concrete, stone, roof shingles or compacted urban soils, where rain cannot penetrate the soil but instead runs off.

Pathogens: Any disease-producing agent, especially viruses, bacteria, parasites or other microorganisms.

Predictive Models: Probability models that use past observations to predict future outcomes.

Primary Contact Recreation: Swimming, bathing, surfing, water skiing, tubing, skin diving, water play by children and other activities where ingestion of water is likely

Salinity: The level of dissolved salt in a body of water.

Sanitary Sewer Overflow (SSO): Overflows from sewage systems resulting from infiltration and inflow of groundwater, blockages, line breaks, power failures or other causes.

Statistical Threshold Value (STV): A measure of water quality recommended by the EPA; when 10% or more of samples exceeds the STV, water quality is compromised.

Tributary: A stream or river that flows into s larger waterbody. In this report, most tributaries are creeks and rivers that flow into the Hudson River.

Turbidity: A measure of the suspended solids in a solution, and an indicator of water quality.

Wastewater: Water that has been mixed with waste due to human activity.

Watershed: The geographical area drained by a river and all of its tributaries. For instance, any raindrop that falls into the Hudson River watershed will, eventually, flow into the Hudson River.

APPENDIX
WATERBORNE ILLNESSES AND HUMAN HEALTH

Most waterborne disease-causing microorganisms are found in human and animal feces. A drop of fecal matter can contain millions of microorganisms of many types, some of which are disease-causing pathogens.[23] Exposure to these microbial pathogens can lead to short-term and chronic illnesses.

The most common types of waterborne illnesses are short-term gastrointestinal infections that cause stomachaches and/or diarrhea. The elderly, children, pregnant women and people with compromised immune systems are at greater risk of contracting chronic illnesses from sewage-contaminated water.

A survey by the Center for Disease Control reported over 4,000 documented illnesses from recreational waters in the U.S. in 2005-2006.[24] However this number is assumed to be low because waterborne illnesses are notoriously underreported. People often associate the most common ailments, stomach and digestive system problems, with what they ate for lunch instead of contact with water. Still, reports of illness resulting from swimming are on the rise.

ACUTE AND CHRONIC HEALTH EFFECTS ASSOCIATED WITH WATERBORNE PATHOGENS[25]

TYPE and AGENT	ACUTE EFFECTS	CHRONIC OR ULTIMATE EFFECTS
BACTERIA		
E. coli O157:H7	Diarrhea	Adults: death (thrombocytopenia)
Legionella pneumoniae	Fever, pneumonia	Elderly: death
Helicobacter pylori	Gastritis	Ulcers and stomach cancer
Vibrio cholerae	Diarrhea	Death
Vibrio vulnificus	Skin & tissue infection	Death in those with liver disorders or problems
Campylobacter	Diarrhea	Death: Guillain-Barré syndrome
Salmonella	Diarrhea	Reactive arthritis
Yersinia	Diarrhea	Reactive arthritis
Shigella	Diarrhea	Reactive arthritis
Cyanobacteria (blue-green algae) and their toxins	Diarrhea	Potential cancer
Leptospirosis	Fever, headache, chills, muscle aches, vomiting	Weil's Disease, death (not common)
Aeromonas hydrophila	Diarrhea	
PARASITES		
Giardia lamblia	Diarrhea	Failure to thrive, lactose intolerance, severe hypothyroidism, joint pain
Cryptosporidium	Diarrhea	Death in immune-compromised host
Toxoplasma gondii	Newborn syndrome, hearing and visual loss, mental retardation, diarrhea	Dementia and/or seizures
Acanthamoeba	Eye infections	
Microsporidia, (Enterocytozoon & Septata)	Diarrhea	
VIRUSES		
Hepatitis viruses	Liver infection	Liver failure
Adenoviruses	Eye infections, diarrhea	
Calici-, Norwalk and small round structured viruses	Diarrhea	
Coxsackie viruses	Encephalitis, aseptic meningitis, diarrhea, respiratory disease	Heart disease (Myocarditis), reactive insulin-dependent diabetes
Echoviruses	Aseptic meningitis	

ENDNOTES

[1] Dorfman, M., and K.S. Rosselot, p. 9.

[2] New York Harbor water quality data (http://www.nyc.gov/html/dep/html/harborwater/harbor_water_sampling_results.shtml) and reports (http://www.nyc.gov/html/dep/html/news/hwqs.shtml) are available online.

[3] Riverkeeper survey of County water quality testing in the Hudson River Estuary, 2013.

[4] DEC water quality classifications for Hudson River, http://www.dec.ny.gov/regs/4556.html#16964

[5] Swimming in the Hudson River Estuary: Feasibility Report on Potential Sites, DEC, 2005, http://www.dec.ny.gov/docs/remediation_hudson_pdf/swimhudsonfearpt.pdf

[6] For more information on our science partners visit http://www.riverkeeper.org/water-quality/hudson/our-partners/

[7] USEPA Recreational Water Quality Criteria, 2012, http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/

[8] Ibid.

[9] In fact, the Clean Water Act separately and independently requires that waters must generally be fishable and swimmable in the absence of a state-conducted "use attainability analysis."

[10] USEPA Recreational Water Quality Criteria, 2012, http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/

[11] Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, DEC, http://www.dec.ny.gov/regs/4590.html#16131

[12] Wet weather is defined as 0.25 inches of rain or more during the three days prior to sampling.

[13] Wet weather is defined as 0.25 inches of rain or more during the three days prior to sampling.

[14] New York State ranks "Aging and Inadequate Wastewater Infrastructure" as issue #2 on its "Top 10 Water Quality Issues in New York" list, right after "Urban Stormwater Runoff." The related infrastructure issue of failing sewage treatment systems on personal property, such as septic systems, is also on the list at #10 "Inadequate Onsite Wastewater Treatment." See "Wastewater Infrastructure Needs of New York" NYS DEC, 2008, http://www.dec.ny.gov/docs/water_pdf/infrastructurerpt.pdf

[15] "Wastewater Infrastructure Needs of New York" New York State Department of Environmental Conservation, 2008, http://www.dec.ny.gov/docs/water_pdf/infrastructurerpt.pdf

[16] "Sustainable Raindrops," Riverkeeper, 2008 (http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf) and American Rivers, "Economic Benefits of Green Infrastructure," 2011, and case study, 2014 (http://www.americanrivers.org/newsroom/resources/the-value-of-green-infrastructure)

[17] See examples of green infrastructure (GI) projects in the Hudson Valley and learn how to initiate GI projects in your community at the DEC website <http://www.dec.ny.gov/lands/58930.html>

[18] "Inadequate Onsite Wastewater Treatment." New York State Department of Environmental Conservation. <http://www.dec.ny.gov/chemical/69653.html>

[19] "Top 10 Water Quality Issues in NYS" #10 Inadequate Onsite Wastewater Treatment <http://www.dec.ny.gov/chemical/69653.html>

[20] Predictive water quality models for the Hudson would not be unusual; New York State is already using predictive models to manage beaches on the Atlantic Ocean and the Long Island Sound.

[21] Young S, Juhl AR, O'Mullan GD (2013). Antibiotic resistant bacteria in the Hudson River Estuary linked to wet weather sewage contamination. Journal of Water and Heath. 11: 297-310. Read more about this study at http://www.riverkeeper.org/wp-content/uploads/2013/07/HRE_BLOG_AntibioticForGenPublic_C.pdf

[22] Dueker ME, O'Mullan GD, Juhl AR, Weathers KC, Uriarte M (2012). Local environmental pollution strongly influences culturable bacterial aerosols at an urban aquatic Superfund site. Environmental Science and Technology. 46: 10926-10933; and Dueker, M.E. and G.D. O'Mullan. 2014. Aeration remediation of a polluted waterway increases near-surface coarse and culturable microbial aerosols. Science of the Total Environment. 478:184-189.

[23] Rose, J.B., et al., Microbial Pollutants in Our Nation's Waters: Environmental and Public Health Issues, American Society for Microbiology, Washington, D.C., 1999, p. 8.

[24] Yoder, J., et al., Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic Facility-Associated Health Events, Center for Disease Control, Washington D.C., 2008.

[25] Centers for Disease Control and Prevention. Emerging Infectious Diseases, vol. 3, no. 4, Oct-Dec 1997.

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Riverkeeper is thankful to our members without whom our work would not be possible.

Riverkeeper is an independent environmental organization dedicated to protecting the Hudson River, and its tributaries, and the New York City drinking water supply. Riverkeeper is a founding member of the Waterkeeper Alliance an international organization that works with over 200 Waterkeepers to protect waterways around the globe.