

NYS RISE Resiliency Institute for Storms & Emergencies

Research Work Unit 2.3 Flooding Impacts on Wastewater Infrastructure





Cornell University

Leader: Collaborators:

Students:

Cornell

University

Haralambos (Bob) Vasiliadis, NYU-Poly Thomas Dennis O'Rourke, Cornell Rae Zimmerman, NYU Carlos Restrepo, NYU Jeong Eun Ahn Omkarlakshmish N Hegde



Scope of Work

Inventory, mapping, and performance reviews of sewage treatment plants and pumping stations relative to storm surge levels, characteristics of plant damage, and loss of service at pump stations will be evaluated through a review of publicly available documents and information from government agencies and experts.

The most vulnerable treatment equipment and conveyance system components will be identified. Measures for plant protection and conveyance system improvements will be evaluated, and ranked on the basis of cost/benefit analysis. Temporal and spatial distributions of wastewater spills and dispersions in past storms.

Working with US-EPA, NYS-EFC, NYS-DOS, NYS-DEC and NYC-DEP to make recommendations on preventing future plant failures and mitigating environmental damages.

Cornel

Iniversity



940 mb

WWTPs in NYC

RISE

RESILIENCY INSTITUTE FOR STORMS AND EMERGENCIES

N/Y S



Cornell

University

NYSRISE RESILIENCY INSTITUTE FOR STORMS AND EMERGENCIES

Coney Island WWTP, Brooklyn NYC

| | | | | | Risk assessment and analysis | | | | | | | | | | | | |
|---|--------------------|---------------|---|------------------------------|--|--------------|---------------|---------------------------|-------------------------------|-------------------------|--|--|--|--|--|--|--|
| 🇳 NYU | | | | Work Unit 2.2 | Number of resident | s served | (population | in | FOC DC | | | | | | | | |
| POLYTECHNIC SCHOOL OF ENGINEERING | 1 | I Y S | R I S E | WORK UNIT 2.3 | affected areas): | | | | 596,326 | | | | | | | | |
| Resiliency Institute for Storms and Emergencies | | | ms and Emergencies | | Number of critical fa | icilities i | n affected ar | ea:Hospitals | HospitalsSchoolsPublic safety | | | | | | | | |
| Flooding risks on Wastewater Infrastructure | | | | | Critical 100-year flood elevation (+30 inches of sea | | | | | | | | | | | | |
| Facility: Coney Island Wastewater Treatment Plant | | | | | | level rise]: | | | | | | | | | | | |
| | | | High likelihood to in | npact be | aches: | Yes No | | | | | | | | | | | |
| | | Coordinates | | | | | | | | | | | | | | | |
| Leading agency: NYLDEP Coordinates Address: Knapp St 40 5007225 N | | | | | | - | | Potential flood pa | thways | | | | | | | | |
| City State Zin code: Brooklyn, NY 11235 | | | | 73 933635 W | Rollup doors: | Ves | | Location and description: | | | | | | | | | |
| | | | | 73.555055 W | Doorways: | Ves | | Location and description: | | | | | | | | | |
| Wastewa | ter Treatment or W | ater Pollut | ion Control Plant (WWTP/WPCP) | | Are purpusi | | | Location and description: | | | | | | | | | |
| | Description | and physic | al characteristics | | Tunnels: | | | Location and description: | | | | | | | | | |
| | Activated sludge | ina priysia | | | Grates: | ☐ Yes | | Location and description: | | | | | | | | | |
| | | | | | Electrical conduits: | ☐ Yes | | Location and description: | | | | | | | | | |
| WWTP/WPCP type: | | | | | Manholes: | Yes | No | Location and description: | | | | | | | | | |
| | | | | | Mechanical: | Yes | No No | Location and description: | | | | | | | | | |
| | _ | | | | | | | | | | | | | | | | |
| Dewatering facilities: | | | | | | | | Resiliency strat | tegy | | | | | | | | |
| | | | | | Elevate equipment: | 🗌 Yes | No No | Location: | | | | | | | | | |
| Local grade (Range as per Google Earth): | 1~11 | feet | | | lustell flaged suggef | | | | | | | | | | | | |
| Elevation of the lowest electrical | 8.5 | feet | | | Install flood-proof | 🗌 Yes | No No | Locationimmary of Estimat | ed Costs for Wastewater Inf | rastructure | | | | | | | |
| control: | | | | | equipment. | | - | | | | | | | | | | |
| Elevation of the lowest mechanical | 8.5 | feet | | | Install static barrier: | Yes 🗌 | No | | | \$2.5 B | | | | | | | |
| device. | | | Seal building: | Yes | \$2.5 | 3 | | | | | | | | | | | |
| | cteristics | | Install temporary | Vac | | | | | | | | | | | | | |
| Design dry weather flow: | 110 | MGD | Notes: (i) The plant has a relative | ely flat terrain, most plant | sandbags: | | J \$2.0 t | | | | | | | | | | |
| Maximum wet weather flow: 220 MCD buildings would be flooded b | | | buildings would be flooded by th | nree or more feet of water | Install backup | Yes | S158 | 2 | | | | | | | | | |
| | 220 | MOD | during the critical flood event. | | power: | _ | 01.01 | , | \$1.1 B | | | | | | | | |
| Discharge waterbedw | Jamaica B | | (iii)There is a total of 1,204 target pieces of equipment lo-cated in these at-risk facilities that are below the critical flood elevation and are at risk of flooding. (iii) Given that Coney Island is susceptible to flood damage | | | | \$1.0 E | 3 (| | | | | | | | | |
| Discharge waterbody. | Janiaica D | зу | | | Survey was | NAME: | | | | | | | | | | | |
| | | | | | conducted by: | NAME: | \$500 N | \$315 M | | | | | | | | | |
| Critical flood elevation: | 15.5 | ft (NAVD 88) | from an interconnected tunnel se | | NAME: | | | | | | | | | | | | |
| Lurrisons Condu | 10.1 | 6 4 | (iv) During the peak of the sandy | , water from the adjacent | | NAME: | \$ | Cost of Protostivo | Damage Cost for Critical | Cumulativo Rick Avoided | | | | | | | |
| numcane sanuy. | 10.1 | IL (INAVD 88) | Rockaway Inlet/Shell Bank Creek | overtopped the banks behind | Contact person(s) | NAME: | | Measures | Flood without Protection | Over 50 Years | | | | | | | |
| | | | the Sludge and Digester building complex, flooded Khapp Street and flowed through the main wastewater treatment | | and affiliation(s): | NAME: | | Pumping Stations | Wastewater Treatment Pla | ants 📕 Total | | | | | | | |
| Contributing area: | | acres | plant parking lot and into low-lyi | ng buildings. | | NAME: | | | AFFILIATION: | | | | | | | | |
| | • | • | • | | | | | | ÷ ÷ | | | | | | | | |
| | rmation | | | | <u> </u> | | | | | | | | | | | | |
| Hurricane Sandy flood damage: | | | | | | | Lost c | of Protective Mea | sures: \$15.48M | | | | | | | | |
| Historic flooding: I Yes No if yes, describe: NA | | | | | | ле Со | ost for | Critical Flood wi | ithout Protection | \$84 95M | | | | | | | |
| Historic loss of power: | Yes No | if yes, de | scribe: NA | | | | | | | | | | | | | | |
| Affected by Hurricane Sandy: | Yes No | if yes, de | scribe: see note iv. | | { C1 | umu | lative | Kisk Avoided ove | er 50 years: \$349. | .81M | | | | | | | |
| beauralletteu. | SUIDE. NA | | 1 | | | | | | | | | | | | | | |

Cornell

University



WWTPs in Rockland, Orange and Putnam Counties of NY



Jniversity

Pumping Stations in NYC

I S E

R **RESILIENCY INSTITUTE FOR** STORMS AND EMERGENCIES

S



University



Paerdegat PS, Brooklyn NYC

| | | | | | | Risk assessment and analysis | | | | | | | | | |
|--|-------------|-------------|----------------------------|-----------------------|----------------------|---|---------------------|----------------|--------------------|-------------------------|--------------------------|---------------------|------|--|--|
| | | | S RISE W | | ork Unit 2.3 | Number of resident affected areas): | s served | (population i | n | 128,903 | | | | | |
| Resiliency Institute for Storms and Emergencies | | | | Number of critical fa | acilities i | n affected ar | ea: | 83 | | | | | | | |
| Flooding risks on Wastewater Infrastructure | | | | | | Critical 100-year floo | od elevat | tion [+30 inch | es of sea | | | | | | |
| Facility: Paerdegat Pumping station | | | | | L d pc | level rise]: | | | | 14.5 feet NAVD88 | | | | | |
| | | | | | | High likelihood to ir | npact be | aches: | | ✔ Yes 🗌 No | | | | | |
| | Coordinates | _ | | | | | | | | | | | | | |
| Leading agency: NYCDEP | | | | | coordinates | Potential flood pathways | | | | | | | | | |
| Address: 6016 Flatlands Avenue | | | | | 40.633062 N | Rollup doors: | Yes | No No | Location | and description: | | | | | |
| City State Zip code: Brooklyn NY 11234 | | | | | 73.9170446 W | Doorways: | Ves | No | Location | and description: | | | | | |
| | | | | | | Windows: | Ves | No No | Location | and description: | | | | | |
| | Pur | nping Stati | on (PS) | | | Areaways: | ∐ Yes | | Location | and description: | | | | | |
| | Description | and physics | d characteristics | | | Cratas: | | | Location | | | | | | |
| | Description | | Note: (i) The recommend | ed strategy | at Paer- degat is to | Electrical conduits: | | | Location | and description: | | | | | |
| | Combined | | construct a barrier around | the station | 1. | Manholes: | | | Location | and description: | | | | | |
| Pump Station type: | Storm Water | Storm Water | | | | Mechanical: | | | Location | and description: | | | | | |
| | Sanitary | | | | | Wie entanieur. | | | Location | and description. | | | | | |
| | | | | | | | Resiliency strategy | | | | | | | | |
| Submersible | | | | | F 1 | | | 1 | • | 07 | | | | | |
| Non-Submersible | | | | Elevate equipment: | L Yes | | Location | | | | | | | | |
| Local grade: | 12 | ft (NAVD88) | | | | Install flood-proof | | No | Location | | | | | | |
| Elevation of the lowest electrical | 14.1 feet | | | | equipment: | | | Location | immary of Estimate | ed Costs for Wastewater | Infrastructure | | | | |
| control: | 14.1 | Teet | | | | Install static barrier: | ☐ Yes | No | | | | co. | 6 P | | |
| Elevation of the lowest mechanical | -11.6 | feet | | | | | _ | \$2.5 | 3 | | | \$2.5 | | | |
| device: | | | | | | Seal building: | ∐ Yes | Nowee es | | | | | | | |
| Hydraulic characteristics | | | | | | Install temporary | Yes | S2.0 8 | 3 | | | | | | |
| Operating capacity: | 57.00 | MGD | | | | Install backup | - | | | | | | - | | |
| | | | | | | nower. | 🗌 Yes | S1.5 8 | 3 | | | | | | |
| Maximum allowable capacity: | | MGD | | | | ponen | | | | | \$1.1 B | | | | |
| Connected to other stations: | Ves | □ No | | | | | NAME: | \$1.0 8 | 3 | | | | | | |
| | | _ | | | | Survey was | NAME: | | | | | | | | |
| Critical flood elevation: | 14.5 | ft (NAVD88) | | | | conducted by: | NAME: | \$500 N | 1 | \$315 M | | | | | |
| Hurricane Sandy: | NA | ft (NAVD88) | | | | | NAME | | | | | | | | |
| Affected area: | 2226 | acres | | | | | | \$ | | Cost of Protective | Damage Cost for Critical | Cumulative Risk Avo | ided | | |
| | | | | | | and affiliation(s) | NAME: | | | Measures | Flood without Protection | Over 50 Years | | | |
| Historical information | | | | | | | NAME: | | | Pumping Stations | Wastewater Treatment | Plants Total | | | |
| Hurricane Sandy flood damage: Catastrophic L Major Significant/Noticeable Minor/Limited V None | | | | | | NAME: | | | | AFFILIATION: | | | | | |
| Historic flooding: | ∐ Yes 🔽 No | if yes, des | scribe: | | | _ | | C | CD | Lead A | ¢1(0()) | | | | |
| Historic loss of power: | ∐ Yes ✔ No | 4 | | LOSE | or Pro | tective Mea | sures: \$16.96M | | | | | | | | |
| Anected by number samuy. If yes V No II yes, describe: | | | | | | Dama | ige C | ost for | Criti | cal Flood wi | thout Protection | า: \$15.41M | | | |
| | | | | | | Dumage cost for critical riood without riotection. \$15.41M | | | | | | | | | |

Cumulative Risk Avoided over 50 years: \$19.21M

Cornell University



Ŷ

Work Status

| Tais Deci Dot Nov Deci Jan Feb Mar Apr Mar Jan Apr Jan Jan Apr Jan Jan Apr Jan Jan Apr Jan Jan< | WU 2.3 Assessment of Base Plans | | 2013 | | 2014 | | | | | | | | |
|---|---|--------------|----------|----------|------------|------------|-------------|-------------|-------------|------------|------------|------------|-------|
| Work unit technical management 54,14.27 10% < | Tasks | Budget | Oct | Nov | Dec | Jan | Feb | Mar | Apr | Мау | Jun | Jul | Aug |
| Uterature review Oth DN | Work unit technical management | \$4.141.27 | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | |
| Inventory, mapping, and performance review of WVTPs 515,056.07 20% | Literature review | \$4.141.27 | 10% | 10% | 20% | 40% | 20% | | | | | | |
| Working with YNY EFC, LOS, DEC and WC DEP 512.423.80 Image: Construction of the second secon | Inventory, mapping, and performance review of WWTPs | \$16,565,07 | | | 10% | 20% | 30% | 40% | | | | | |
| Select ample Counties 54,412.2 Image: Counties Status Statu | Working with NYS FEC. DOS. DEC and NYC DEP | \$12,423,80 | | | | | 20% | 50% | 30% | | | | |
| WWTP performance and vulnerability evaluation 520, 76, 33 V 20% 2 | Select sample Counties | \$4.141.27 | | | | | 50% | 50% | | | | | |
| Drift regortion 8. submission 512.24.38 Image: Control of the submission Size 2.38 | WWTP performance and vulnerability evaluation | \$20,706.33 | | | | | 20% | 20% | 20% | 20% | 20% | | |
| Becommendations and ranking on the basis of cost/benefit analysis 55.14.1.27 Image of the table of the table of the table of the table of ta | Draft report preparation & submission | \$12,423,80 | | | | | 30% | | 70% | | | | |
| Enal report Skill 127 Image: Construction of the | Recommendations and ranking on the basis of cost/benefit analysis | \$4.141.27 | | | | | | | 50% | 50% | | | |
| TOTAL 55282.53 Control Control <thcontrol< th=""> Control <thc< td=""><td>Einal report</td><td>\$4.141.27</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>20%</td><td>30%</td><td>50%</td><td></td></thc<></thcontrol<> | Einal report | \$4.141.27 | | | | | | | | 20% | 30% | 50% | |
| Projected Earned Value 9828 22 5828 25 5828 26 5828 26 5828 26 5828 26 5828 27 286 98 777 286 75 286 75 | TOTAL | \$82,825.34 | | | | | | | | 20/0 | 5070 | 5070 | |
| 100100 100100 100100 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1001000 1000000 1000000 1000000 1000000 10000000 10000000 100000000 1000000000 100000000000 1000000000000000000000000000000000000 | Projected | Earned Value | \$828,25 | \$828,25 | \$2,898.89 | \$5,383.65 | \$18,635,70 | \$19,463.95 | \$19,049.83 | \$7,454,28 | \$5,797.77 | \$2,484,76 | |
| BCWS 13% 22% 60% 128 35% 58% 81% 90% 97% 100% BCWP 13% 22% 60% 55% 22% 45% 50% 97% 100% K 13% 13% 22% 65% 52% 25% 25% 05% | | % | 1% | 1% | 4% | 7% | 23% | 24% | 23% | 9% | 7% | 3% | |
| BXWP 1% 2% 6% 20% 45% 000 50% 10% 10% 10% 10% 12% 2% 6% 0.00 | | BCWS | 1% | 2% | | 12% | 35% | 58% | 81% | 90% | 97% | 100% | |
| No. 1% 1% 1% 1% 12% <th12%< th=""> <th12%< th=""> <th12%< th=""></th12%<></th12%<></th12%<> | | BCWP | 1% | 2% | 4% | 9% | 20% | 45% | 01/0 | 5070 | 5770 | 10070 | |
| Actual Earned Value 5828.25 5828.25 51,242.38 54,141.27 59,564.35 50,00 <t< td=""><td></td><td>%</td><td>1%</td><td>1%</td><td>2%</td><td>5%</td><td>12%</td><td>25%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></t<> | | % | 1% | 1% | 2% | 5% | 12% | 25% | 0% | 0% | 0% | 0% | 0% |
| Tasks Budget Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Work unit technical management \$4,141.27 10% | Actual | Earned Value | \$828.25 | \$828.25 | \$1,242,38 | \$4,141,27 | \$9,524,91 | \$20,706,33 | \$0.00 | \$0.00 | \$0.00 | \$0.00 | */- |
| Work unit technical management 54,141.27 10% | Tasks | Budget | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
| Literature review 54,141.22 10% | Work unit technical management | \$4 141 27 | 10% | 10% | 10% | 10% | 10% | 10% | | | | | |
| Andread of the state of the | literature review | \$4 141 27 | 10% | 10% | 20% | 40% | 10% | 10% | | | | | |
| Working with NYS EFC, DOS, DEC and NYC DEP \$12,423.80 Image: Contest of the status with the status with the status with performance and vulnerability evaluation \$12,423.80 Image: Contest of the status with the status of cost/benefit analysis \$4,141.27 Image: Contest of the status with the status withe status with the status with the status withe status with the sta | Inventory mapping and performance review of WWTPs | \$16 565 07 | 10/0 | 10/0 | 2070 | 1070 | 20% | 30% | | | | | |
| Status WU 2.3 | Working with NYS EEC, DOS, DEC and NYC DEP | \$12 423 80 | | | | | | | | . | | | |
| Binal report 30,706.33 100% Draft report preparation & submission \$12,423.80 100% Recommendations and ranking on the basis of cost/benefit analysis \$4,141.27 10% Final report TOTAL \$82,825.34 80% | Select sample Counties | \$4 141 27 | | | | | | | | Status | WU 2.3 | | |
| Total Descention Descention Prior St2,423.80 00% Recommendations and ranking on the basis of cost/benefit analysis S4,141.27 00% Final report St2,423.80 00% TOTAL St2,423.80 00% 70% 00% 00% 60% 00% 70% 00% | WWTP performance and vulnerability evaluation | \$20,706,33 | | | 100% | | | | | | | | |
| Dract Cept (preparation & start, 42.50) 90% Final report \$4,141.27 TOTAL \$82,825.34 | Draft report preparation & submission | \$12,423,80 | | | | | | | | | | | |
| Content of the construction of the construc | Becommendations and ranking on the basis of cost/benefit analysis | \$4 141 27 | | | 90% - | | | | | | | | |
| TOTAL \$9,41.67 TOTAL \$82,825.34 80% 60% | Final report | \$4 141.27 | | | | | | | | | | | |
| | тоты | \$97,975,24 | | | 80% - | | | | | | | | |
| 70% 60% 50% 40% 20% 20% 10% 50% 20% 20% 20% 20% 20% 20% 20% 20% 20% 2 | IOIAL | J02,023.34 | | | | | | | | | | | |
| 60% 60% 40% 20% 20% 10% 5ep Oct Nov Dec Jan Jan Mar Apr May Mar 2013 | | | | | 70% | | | | | | | | |
| 60% 50% 40% 20% 20% 50% 10% 50% 20% 20% 20% 20% 20% 20% 20% 20% 20% 2 | | | | | 70% | | | | | | | | |
| 50% 40% 40% 20% 10% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 6.001 | | | | | | | | |
| 50% 40% 30% 20% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 60% - | | | | | | / | | |
| 50% 40% 30% 20% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | | / | | |
| 40% 30% 20% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 50% - | | | | | / | | | |
| 40% 30% 20% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | | 1 | | |
| 30% 20% 10% 5ep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 40% - | | | | | | / | | |
| 30% 20% 10% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | / / | | | |
| 20% 10% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 | | | | | 30% - | | | | | // | | | |
| 20% 10% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | | | | |
| 10% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 20% - | | | | / | | | | |
| 10% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | | | | |
| 0% Dec Jan Jan Mar Apr May May 2013 2014 | | | | | 10% - | | | | | | | | |
| 0% Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 2014 | | | | | | | | | | | | | |
| Sep Oct Nov Dec Jan Jan Mar Apr May May 2013 | | | | | 0% | | | | | | | | |
| | | | | | 0% + Se | p Oct | Nov | Dec | Jan | Jan | Mar | Apr Ma | v Ma |
| AU11 | | | | | 20 | 13 | | | 2014 | | | | , 110 |

Cornell

University



Research Results To Date

• Literature review has been completed

Cornell

Jniversitv

- Approximately 50% of inventory, mapping and performance review of WWTPs and Pumping Stations has been completed
- Gathering of technical information and data from all associated NYS and NYC agencies has been initiated
- Wastewater performance and vulnerability evaluation has been initiated
- Over 30% of wastewater treatment plants review has been completed
- Approximately 20% of review of wastewater treatment plants has been completed.



Deliverables

- A final report will be produced that summarizes the most important causes of damage and component vulnerability during a storm in the wastewater treatment systems in the study region. Analysis of the design, operation and capacity characteristics of the existing wastewater infrastructure system will be performed based on historical data, drawings and characteristics of the wastewater infrastructure. The limitations, deficiencies, potentials and dynamics of each component of the system will be determined and analyzed.
- Recommendations for protection of each system component and improved service (in terms of improvement of the efficiency and capacity of each component) will be developed and ranked on the basis of cost/benefit assessment. Studies of wastewater treatment infrastructure systems in NYC, Long Island (both Nassau and Suffolk Counties), Westchester County, Orange County, Rockland County, and Putnam County will be conducted, the lessons from which can be implemented in the flood prone locations of other counties of New York State, as needed.

Cornell

University



References

- Descriptive Data of Municipal Wastewater Treatment Plants in New York State, Division of Water, January 2004
- NYC Wastewater Resiliency Plan (climate risks assessment and adaptation study), NYC Environmental Protection, October 2013
- Fillos, John and Vasil Diyamandoglu (1995), Sampling and Analysis for Permit Compliance and Process Control at the New York Water Pollution Control Plants, The City College of New York
- Fillos, John, Shafi-ul Huda and Vasil Diyamandoglu [Statistical Consultant: Haralambos V. Vasiliadis] (1997), Evaluation of the Sampling and Analytical Procedures at New York City Water Pollution Control Plants, The City College of New York
- New York City's Wastewater Treatment System, New York City Department of Environmental Protection [http://www.nyc.gov/html/dep/pdf/wwsystem.pdf]
- "Interactive Maps", GeoPower; Web. 15 March 2014, https://geopower.jws.com/ rockland/ ApplicationsPage.jsp
- "ArcGIS Viewer for Flex." ArcGIS Viewer for Flex, 15 March 2014 [http:// ocgis.orangecountygov.com/OrangeCountyBaseMap/index.html]
- "Putnam County New York Zip Code Boundary Map (NY)." Putnam County New York Zip Code Boundary Map (NY), 15 March 2014, [http://www.zipmap.net/New_York/Putnam_County.htm]

Cornell

University







"NYS-RISE will bring together several of our state's top universities to serve as a world-class think tank of research and education on extreme weather and emergency preparedness. We are gathering top academic leaders, policy makers, emergency experts and first responders from across the nation to develop strategies to meet one simple goal – and that is to better protect New York's communities in natural disasters."

Governor Andrew M. Cuomo 11/1/2013

RESILIENCY **I**NSTITUTE FOR

"In our vision of a stronger, more resilient city, many vulnerable neighborhoods will sit behind an array of coastal defenses. ... Water that makes its way inland ... will be absorbed by expanded green infrastructure, or diverted into new high-level sewers. Meanwhile, ... water and wastewater ... networks will operate largely without interruptions, or will return to service quickly when preventive shutdowns or localized interruptions occur. ... We are a coastal city ... and we cannot, and will not, abandon our waterfront. Instead we must build a stronger, more resilient city..."

Cornell

University

Mayor Michael R. Bloomberg 6/11/2013

