FORGE RIVER WATERSHED MANAGEMENT PLAN

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The Town of Brookhaven

Prepared by

CAMERON ENGINEERING & ASSOCIATES, LLP

In Association with

CH2MHILL

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1 Executive Summary

1.1 Introduction

The Forge River has been a distressed estuary since the early part of the 20^{th} century. Extensive duck farming in the 20^{th} century along the banks of the Forge River and high-density residential development contributed to the high-nitrogen sediment load that remains. Residential development booms the Mastic Beach area in the early 20^{th} century and on the peninsula in the mid-20^{th} century added thousands of onsite wastewater treatment systems (cesspools and septic systems) inside the Forge River watershed. Residents of the Forge River watershed continue to report malodorous conditions and fish kills while local scientists report hypoxic and anoxic conditions that are inhospitable to aquatic life.

1.2 Watershed Characterization and Subwatershed Prioritization

Several initial studies detailed the background necessary to establish management strategies that would improve water quality in the Forge River estuary. The Forge River groundwater and stormwater contributing areas comprise the 'watershed' for the purpose of the study. Each of the Forge River creeks drains its own subwatershed. The initial *Watershed Characterization* report includes descriptions of the geographic setting (topography, hydrology, infrastructure, etc.), existing and projected land use, land cover, and socioeconomics. The report covered living resources for the estuary and adjacent upland area, described the quality of the sediments and the history of dredging, and summarized the available water quality data (Coliform bacteria, chlorophyll, dissolved oxygen, and nitrogen). The Characterization includes detailed information on nitrogen sources and loading and the impacts on water quality and living aquatic resources derived in large part from research conducted by SUNY Stony Brook's School of Marine and Atmospheric Sciences.

Nitrogen loading, in order of quantity delivered to the estuary, is from residential septic systems, the duck farm, private treatment plants, release from the sediments, residential and agricultural fertilizer use, and to a lesser extent atmospheric deposition and stormwater. The Characterization report concludes that the severe dissolved oxygen depletion in the Forge River is primarily due to algal blooms fed by exceptionally high nitrogen. The majority of the nitrogen entering the estuary is from groundwater that is years or tens of years old and therefore reflects historic inputs. Groundwater continues to receive nitrogen from septic systems and fertilizer use. Dense algal blooms will recur annually, particularly during the summer, as long as new and historic nitrogen loading and circulation remains unchanged.

Stormwater–borne sediments, years of accumulated duck waste and organic matter from decades of decayed algal blooms, and leaf fall have shallowed the estuary and restricted circulation. Poor circulation further degrades water quality. Muddy, anoxic bottom conditions preclude habitation by most estuarine organisms. Only highly mobile benthic organisms and pelagic species can avoid the low oxygen conditions. Tidal wetlands are limited to areas with no shoreline hardening and are more prevalent in the lesser developed southern reaches of the estuary. Large stands of Phragmites have invaded portions of the estuary.

Another report, the Subwatershed Prioritization, examined data for each of the Forge River's 14 subwatersheds to quantify the degree of impairment experienced by each. The report established weighted values for land cover, land use, stormwater, nitrogen loading, habitat, and ecological conditions. Wills Creek, West Mill Pond, and Poospatuck Creek subwatersheds are the most impaired.

The Management Plan identifies solutions that address the highest priority impairments in the highest priority locations. Based on the characterization of the waterbody and its watershed, an evaluation of the regulatory and programmatic environment affecting the management of the Forge River estuary, and a prioritization of the subwatersheds, watershed-based management strategies are identified to protect and restore the resources of the Forge River and its watershed.

1.3 Evaluation and Ranking of Management Strategies

The Town, the County, and other responsible parties can phase in the management strategies over the short-term, mid-term, and long-term. The phases, in general, also reflect lower, moderate, and higher costs, respectively. The broad classification of strategies includes:

- Land use management
- Stormwater management
- Nitrogen reduction
- Water quality improvements and habitat restoration
- Research and data collection
- Training, education and stewardship programs

Each strategy has four associated factors that help measure its potential for achieving water quality improvements for the Forge River. The factors have the following parenthetical weightings based on their significance in improving water quality in the Forge River:

- Water quality benefits (4)
- Cost (3)
- Acceptance by the public (2)
- Technical and legal implementation difficulty (1)

The full Forge River Management Strategies report prioritizes all the strategies according to these and other criteria. The Jurgielewicz Duck Farm ceased operations just prior to the publication of this report. Consequently, nitrogen loading and recommendations concerning nitrogen continue to reference the duck farm. Nitrogen loading will be re-calculated as part of the formulation of the TMDL without the input from the duck farm.

1.4 Short-Term Management Strategies

1.4.1 Land Use Management

- **(S1) - Establish a Forge River Protection Overlay District (FRPOD)** for properties inside the 50-year contributing area. The FRPOD would enable the Town to implement special regulations inside the district to protect and improve water quality in the estuary.
- **(S2) - Explore potential dedicated funding sources such as a FRPOD fee to provide water quality improvement services to property owners** based on water usage and assessed value. Such a fee could be added to property owners' tax bills. Property owners already connected to private STPs would be assessed a lower fee.
- **(S3) - Create a Forge River Protection (FRP) Fund for program expenditures, green infrastructure, and loans** to property owners for eligible improvements.
- **(S4) - Establish a low-interest loan program for property owners** for onsite wastewater treatment system (OWTS) improvements with initial funding potentially from the FRP Fund. Property owners could repay the loans through their tax bill. Loans would survive changes in property ownership and stay with the property.
- **(S5) - Identify properties for acquisition or purchase of development rights** based on location and environmental resources. Reducing future development opportunities can lower future nitrogen generation and release.
- **(S6) - Acquire and remediate the Jurgielewicz Duck Farm and consider acquisition and cleanup of the Barnes Road and Titmus duck farms to protect Forge River water quality**.
- **(S7) - Impose stricter clearing limits** inside the FRPOD to retain existing native, non-fertilizer dependent vegetation.

1.4.2 Stormwater Management

- **(S8) - Replace direct discharge stormwater systems** by incorporating new technology including, where appropriate, catch basin inserts and end-of-pipe equipment that removes pollutants before they are discharged to the estuary. Utilize preferentially and where possible vegetated swales, rain gardens and other 'green' treatments. Green alternatives increase infiltration and degradation by soil bacteria.
- **(S9) - Adopt a 'Green Streets' policy** to improve roadway design to capture, treat, and improve stormwater management.
- **(S10) - Develop a demonstration low-impact stormwater management site** at a Town-owned facility to demonstrate to builders and homeowners methods for improved stormwater management.

1.4.3 Nitrogen Reduction

- **(S11) - Impose strict limits of nitrogen fertilizer use** to the month of April for all land uses except agriculture.
- **(S12) - Develop installation requirements for replacement OWTS** using SCDHS standards as guidelines.
- **(S13) - Require inspections of all OWTS** at no cost to the property owner. Property owners would be required to make improvements to systems that do not meet new Town requirements within three years of the initial inspection. A FRPOD fee would cover the cost of the inspection. Utilize low interest loans from the FRP Fund for replacement systems. Improvements might include replacement of cesspools with modern septic systems, installation of leaching fields for properties with high groundwater and other improvements required through inspections.
- **(S14) - Enact ordinance requiring pump-outs for all OWTS every five years.** A FRPOD fee would cover the cost of the service. Pump-outs would extend the life and improve the efficiency of OWTS.
- **(S15) - Require all OWTS to meet new Town requirements on sale of property.** Require inspections of all OWTS prior to the sale of property with fee paid by seller. Systems that do not meet new Town OWTS requirements would need to be improved prior to sale of the property (similar to existing Wetland and Waterways requirement for building extensions).
- **(S16) - Reduce residential water use** to reduce wastewater volume and increase residency time and treatment efficiency in OWTS. Require dual flush toilets for all new bathroom installations or remodels. Require low flow faucets for all new or remodeled bathrooms and kitchens.
- **(S17) - Provide water conservation kits** to homeowners with funding from the FRPOD fee.

1.4.4 Water Quality Improvements and Habitat Restoration

- **(S18) - Encourage riparian area restoration** by offering tax rebates to property owners for voluntary restoration of the wetland buffer in the absence of a building permit or by offering grants from the FRP Fund to qualified property owners.
- **(S19) - Encourage use of indigenous landscape plants** by offering tax rebates to property owners for installing new landscaping that limits nonindigenous vegetation to no more than 15 percent of the lot area in properties adjacent to wetlands. Alternately, offer grants from the FRPOD Fund to qualified property owners for voluntarily limiting nonindigenous vegetation.
- **(S20) - Install an oyster grow-out system for algal bloom control** in priority subwatershed creeks. Oysters can filter 10 liters an hours and convert algae into oyster tissue. Algal bloom control is important to maintaining dissolved oxygen for aquatic organisms. Transfer of oysters grown in the Forge River to certified waters would be required.
- **(S21) - Install surface and water-column creek aerators** in priority subwatershed creeks to improve dissolved oxygen concentrations and help support aquatic organisms.

1.4.5 Research and Data Collection

- **(S22) - Collect additional groundwater data to determine groundwater nitrogen types, vertical and horizontal concentrations, and travel time**. Additional information is needed on the fate of the different forms of nitrogen reaching groundwater. Specifically, research is needed to determine how inorganic and organic nitrogen concentrations and forms (nitrate, nitrite, ammonia, etc.) change over time (if at all) in groundwater.

- **(S23) - Continue research on benthic nitrogen flux** to determine the flux of nitrogen from sediments into the water column. A better estimate of the contribution of sediment nitrogen is necessary to determine the value of extensive long-term dredging in the Forge River before such long-term dredging is funded and undertaken.

1.4.6 Training, Education, and Stewardship Programs

- **(S24) - Develop methods to reduce agricultural fertilizer use and stormwater runoff.** Work with farmers on strategies including changing fertilizer types, crops, and practices. Organic fertilizers typically release nitrogen more slowly allowing increased uptake by plants. For example, grapes require very little nitrogen, whereas potatoes require large quantities. Stormwater controls can contain high nitrogen runoff.
- **(S25) - Provide educational programs for property owners on implementation of Forge River management strategies**. Public acceptance and participation improve with increased outreach to the community.

1.5 Mid-Term Management Strategies

1.5.1 Land Use Management

- **(M1) - Acquire selected open space and direct development to developed areas outside the FRPOD or to future sewered areas** in the watershed through the Town Transfer of Development Rights (TDR) program. Utilize the FRPOD as a 'Sending Area,' and designate selected hamlets and commercial areas outside the FRPOD as 'Receiving Areas.' The Town's long-term land use strategy encourages development in hamlet centers and commercial areas to preserve green space and the character of single-family neighborhoods. The TDR program provides a mechanism to incentivize development in designated mixed-use centers.
- **(M2) - Purchase development rights for existing farms in the Forge River watershed**. The Town and County recognize the value of existing farms to Long Island and have purchased the development rights for thousands of acres of existing farms, including the duck farm properties of the Forge River. Encourage organic farming and IPM to reduce fertilizer and pesticide use. Permit well-managed and regulated greenhouse farming that has zero fertilizer and pesticide discharge. Restrict lot coverage and provide a vegetated buffer to maintain the aesthetic appeal of open space acquired through the purchase of development rights program.
- **(M3) - Prepare land use plans for the duck farm properties** that include riparian and upland restoration.

1.5.2 Stormwater Management

- **(M4) - Provide stormwater treatment systems at selected creek heads**. There are opportunities to construct wetlands and other stormwater treatments at the heads of Wills and Poospatuck Creeks and potentially others. Acquisition of undeveloped property may be necessary depending on the preferred treatment.
- **(M5) - Provide stormwater treatment for runoff into the East and West Mill Ponds and the Forge River** from Montauk Highway. Treat stormwater to remove sediments and associated contaminants prior to its release into the waterbodies.

1.5.3 Nitrogen Reduction

- **(M6) - Determine the Total Maximum Daily Load** (TMDL) for nitrogen that allows for a dissolved oxygen concentration in the estuary above 4.8 mg/L (the DEC standard). The Town prepared a Request for Proposals for a consultant to prepare the TMDL. The TMDL is critical, as it will set the maximum number of pounds of nitrogen that can be loaded into the Forge River from all sources. The TMDL consultant will develop allocation scenarios for each of the various loads. The TMDL will help determine the most appropriate mid- and long-term management strategies necessary to achieve the nitrogen reduction. It may be possible to achieve the required nitrogen reductions by applying multiple smaller (and less expensive) strategies than fewer and more expensive techniques.
- **(M7) - Develop a TMDL implementation plan based on the preferred allocation scenario**. The Town should have an implementation plan prepared for the selected allocation scenario that provides preliminary engineering/phasing plans that detail how each of the reductions could be implemented and where. The implementation plan would include cost estimates, locations, and type of sewering, if any, required within the FRPOD.
- **(M8) - Evaluate the need and locations for a regional wastewater treatment plant**. If the Town or County determines that regional sewering is the best option for meeting the nitrogen TMDL, then a suitable location must be identified. The Barnes Road or Titmus duck farms may be good candidates as they are centrally located, sufficiently large, already disturbed, and have few residential neighbors. The properties are sufficiently large to permit a substantial riparian restoration and open space set aside. Other potential sites might include the Brookhaven Airport or one of several undeveloped parcels in the watershed, and an expansion of the Town's Sewer District #2. Regionalization may include the adjacent hamlet of Center Moriches.
- **(M9) - Impose stricter nitrogen limits on STPs within the FRPOD** based on the nitrogen TMDL. The nitrogen discharge limit for new and existing STPs should be lowered from current County requirements if required by the TMDL.

1.5.4 Water Quality Improvements and Habitat Restoration

- **(M10) - Dredge sills at mouths of creeks and accumulation at the mouth of the Forge River**. Removal of the deposits at the mouths of selected creeks will increase circulation in the creeks and improve water quality.
- **(M11) - Remove stormwater-borne sediments** in the waters just south of Montauk Highway including *Phragmites*. Removal of these deposits will increase circulation in this portion of the estuary. Removal of the invasive reed *Phragmites* will increase available open water and tidal wetland habitat.
- **(M12) - Dredge by the LIRR trestle** to improve flushing of the Forge River estuary north of the railroad trestle. Increased flushing north of the trestle will increase salinity and reduce the growth of *Phragmites.*
- **(M13) - Deepen Ely Creek** to improve tidal circulation and reduce *Phragmites* growth. The shallow depth of Ely Creek (much is a mud flat at low tide) severely limits circulation and thus degrades water quality.
- **(M14) - Harvest and dispose of *Ulva*** to remove the assimilated nitrogen and avoid the aesthetic and water quality problems engendered by its decay.
- **(M15) - Restore native riparian vegetation** including tidal wetlands and high marsh on public property. Reduce road width where possible to expand riparian area. Additional vegetated riparian areas will help capture contaminants and will create new wildlife habitat.

1.5.5 Research and Data Collection

- **(M16) - Measure nitrogen removal by *Phragmites*, *Spartina*, and mudflats**. Identify the quantity of nitrogen removed by plant roots and the bacteria associated with them. Bacteria in mudflat soils may remove more nitrogen than vegetated tidal areas. *Phragmites*, if an effective nitrogen remover, might be harvested annually to remove the nitrogen from the estuary.
- **(M17) - Test permeable reactive barriers (PRBs) for their effectiveness in removing nitrogen from groundwater** in a high-nitrogen subwatershed, preferably in a riparian conservation easement. Permeable reactive barriers are groundwater treatment systems installed in a trench upgradient of the shoreline that utilize non-toxic materials like wood chips and vegetable oil as a substrate for bacteria to remove nitrogen from groundwater. If as effective as reported, PRBs could significantly reduce nitrogen loading from groundwater into the estuary.
- **(M18) - Test nitrogen reduction by septic system bio-augmentation** to improve OWTS efficiency. Injection of selected bacteria into septic systems has been shown to improve their effectiveness in degrading nitrogen. Modifications to septic systems may increase bio-augmentation effectiveness.
- **(M19) - Test nitrogen reduction by groundwater bio-augmentation** and carbon source injection for nitrogen removal. Nitrogen removal from groundwater by selected non-toxic bacteria fed a non-toxic carbon source may be possible. Test various bacterial species and carbon sources for their effectiveness in removing groundwater nitrogen.

1.6 Long-Term Management Strategies

1.6.1 Land Use Management

- **(L1) - Implement the land use plan for the Jurgielewicz Duck Farm** for the uses determined by the Town and community to be most appropriate for the restoration of the estuary.

1.6.2 Nitrogen Reduction

- **(L2) - Install permeable reactive barriers** if proven effective, in the riparian area of all high priority creeks to remove historic groundwater nitrogen. This would require securing conservation easements for the installation, monitoring, and maintenance of the systems from property owners.
- **(L3) - Pump groundwater to treatment locations** such as wetlands or denitrification reactors. The cost and feasibility of moving and treating large volumes of water would need to be measured against the costs of other treatment options.
- **(L4) - Improve the operation of private STPs**. The three existing wastewater treatment plants in the Forge River watershed could be upgraded for additional nitrogen removal or could be converted to pump stations connected to a future regional STP.
- **(L5-L8) - Sewer part or all of the FRPOD**. Engineering studies in progress now will help determine the most advisable sewering strategy for the Forge River watershed and or adjacent communities. Since the TMDL implementation plan will identify the need for and extent of sewering needed, design plans for reaching the TMDL will be required and may include the following options: a) construct a conventional collection system and treatment plant, or b) construct advanced onsite systems for individual FRPOD parcels to avoid collection system cost, or c) collect septic system effluent from all FRPOD parcels and

treat it at a centralized community STP, or d) incorporate adjacent areas in the Mastic and Shirley peninsulas and parts of Center Moriches into the sewer district as these all contribute nitrogen to Moriches Bay and their inclusion could reduce per parcel cost and expand environmental benefits.

1.6.3 Water Quality Improvements and Habitat Restoration

- **(L9) - Pump bay water to head of the Forge River and into priority creeks** to increase circulation and increase dissolved oxygen to support marine life. Increased circulation can improve water quality for aquatic organisms, but will require a substantial investment in pumping equipment and operational costs.
- **(L10) - Dredge to remove accumulated organic matter from estuary.** Institute a long-term dredging operation if benthic flux studies determine that the strategy could be effective. Many feet of duck farm waste and decaying algal blooms accumulated in the Forge River and could contribute substantial nitrogen to the water column. Consider use of the Barnes Road or Titmus duck farms for temporary dredged material management if acquired for public use.
- **(L11) - Fill creek depressions** with sand to eliminate stagnant anoxic areas. Eliminating these areas would help improve circulation in the affected creeks. Such filling would require a tidal wetland permit and special approval from the DEC.
- **(L12) - Conduct long-term maintenance dredging of Moriches Inlet** to improve flushing of Moriches Bay and the Forge River. Improved inlet water flow would increase the tidal range in Moriches Bay and the Forge River and therefore increase circulation.

1.7 Phasing of Management Strategies

1.7.1 Introduction

This portion of the plan prioritizes the proposed management strategies and recommends their phasing in order to achieve water quality improvement and habitat restoration goals. The categorization of the management strategies by short-, mid- and long-term implementation periods, as provided in Section 4 through 6 above, establishes an initial phasing of the strategies. The scoring of each of the strategies according to the four evaluation criteria, however, permits a ranking, or prioritization, of the strategies within the short-, mid- and long-term strategy categories. Thus, the strategies that received the highest scores should be considered for earliest implementation. Furthermore, depending upon the availability of funding, it may be possible to implement only a portion of the management strategies. Under such conditions, the highest ranked strategies would offer the greatest benefit for the available funding.

In addition to phasing, certain strategies require sequencing within or across the short-, mid- and long-term management periods. For example, the efficacy of certain long-term strategies for nitrogen removal must be proven through either short- or mid-term strategies that involve research and testing. There is also a group of short-term strategies that share a degree of interdependence, *i.e.*, the implementation of one short-term strategy requires the completion of a related strategy. The selection of appropriate long-term management strategies is also highly dependent upon the preferred allocation scenario to be defined by the TMDL development, a mid-term management strategy. The phasing of the management strategies – which includes their proper sequencing where applicable is summarized in Sections 7.2 through 7.4 below for the short-, mid-, and long –term strategies.

1.8 Phasing of Short-Term Management Strategies

The short-term strategies are ranked in descending order in Table 7.1 according to their scores which range from 33 to 62.

Recommendation. Implement the first-tier strategies, *i.e.*, S21, S11, S20, S13, S14, and S23 immediately; these have the greatest potential for short-term water quality improvement benefits at reasonable cost to implement, *i.e.*, are the most cost-effective strategies. The first-tier short-term strategies also require the long lead times for implementation, providing an additional justification for their early project initiation. Strategies S24, S1, S4, S3, S12, S2, S15, S5 S22 and S6 offer significant water quality benefits – though less than the first tier – and at reasonable cost. However, moderate to minimal public support combined with technical and administrative challenges to implementation relegate these strategies to secondary importance; their implementation should follow the first-tier strategies. Third-tier strategies, *i.e.*, S25, S18, S9, S16, S7, S19, S17, S8 and S10, are easy to implement but offer less significant benefits; their implementation should follow the second-tier strategies.

Table 1-1. Ranking of short-term management strategies by weighted total

	Management Strategy	Water Quality Benefit	Cost	Technical & Legal Difficulty	Public Acceptance	Weighted Total
S21	Install surface and water column creek aerators in priority subwatershed creeks	7	4	8	7	62
S11	Impose strict limits on nitrogen fertilizer use, allowing fertilizer application only in the month of April	4	8	9	5	59
S20	Install oyster grow-out system for algal bloom control in priority subwatershed creeks	5	6	8	6	58
S13	Require inspections of all OWTS	4	9	10	2	57
S14	Require pump-outs for all OWTS within the FRPOD every five years through Town ordinance	4	8	8	3	54
S23	Continue research on benthic flux to determine nitrogen contribution from sediments to water column	4	6	6	7	54
S24	Develop methods to reduce agricultural fertilizer use and runoff and work with farmers to implement them	3	8	5	6	53
S1	Establish FR Protection Overlay District (FRPOD) for properties inside 50-yr contributing area	3	7	8	6	53
S4	Establish a low-interest loan program for property owners for OWTS improvementswith FRP Fund. Loans repaid via tax bill and stay with property.	4	8	5	4	53
S3	Create a Forge River Protection (FRP) Fund for program	4	5	9	6	52
S12	Develop OWTS installation requirements for replacement systems using Suffolk County Department of Health Services standards as guidelines	4	7	8	3	51
S2	Explore potential dedicated funding sources such as a FRPOD fee to provide water quality improvement services to property owners	3	8	5	5	51
S15	Require all OWTS to Meet new Town Requirements	4	8	7	1	49
S5	Identify properties for acquisition or purchase of development rights based on location and environmental resources	1	8	5	8	49
S22	Collect additional groundwater data for determining nitrogen types, concentrations and travel time	3	6	6	6	48
S6	Acquire duck farm properties, conduct environmental assessment and prepare remediation plan*	4	5	6	5	47
S25	Provide educations programs for property owners on	1	7	7	7	46
S18	Encourage riparian area restoration by offering tax rebates to property owners for voluntary restoration of the wetland buffer.	2	8	6	3	44
S9	Adopt a Green Streets policy	1	8	5	5	43
S16	Reduce residential water use by requiring dual flush toilets and low-flow faucets for all new bathroom installations or remodels.	1	9	7	2	42
S7	Impose stricter clearing limits inside the FRPOD to retain existing native, non-fertilizer dependent plants	1	9	5	3	42
S19	Encourage use of indigenous landscape plants by offering tax rebates for their installation	1	8	7	3	41
S17	Provide home owners with free water conservation kits	1	6	8	5	40
S8	Replace direct discharge stormwater systems with vegetated swales, and other 'green' treatments	1	4	8	7	38
S10	Develop one or more demonstration low-impact stormwater management site	1	5	4	5	33

1.9 Phasing of Mid-Term Management Strategies

The mid-term strategies are ranked in descending order in Table 7-2 according to their scores which range from 28 to 71. Three strategies, (M14, M10 and M12) received very high scores and stand out demonstrably among the 19 mid-term strategies, particularly for their water quality benefits and expected ease of implementation. Strategies M6 and M7 – which comprise the TMDL development process –are absolutely essential to the proper selection of appropriate long-term management strategies as well as some of the mid-term strategies. These five highest-ranked strategies comprise the top quarter of the mid-term strategies and are grouped into the first tier of recommended mid-term strategies.

Recommendation. Implement the first-tier mid-term strategies, (M6, M7, M10, M12 and M14) immediately. These have the greatest potential for mid-term water quality improvements. The first-tier mid-term TMDL strategies, (M6 and M7), are key to the implementation of long-term strategies and should be expedited. The second-tier, mid-term strategies (M9, M13, M11, M17, M16, M5, M4, M8, M18, M3, and M19) that provide data on potential long-term strategies should also be initiated, as soon as is feasible in order to support the development of the TMDL preferred allocation scenario. The implementation of third-tier mid-term strategies (M15, M2 and M1) should follow that of the second-tier strategies.

Table 1-2. Ranking of mid-term management strategies by weighted total

Management Strategy		Water Quality Benefit	Cost	Technical & Legal Difficulty	Public Acceptance	Weighted Total
M14	Harvest and dispose of Ulva to remove assimilated nitrogen and its associated water quality problems	8	5	6	9	71
M10	Dredge sills at mouths of creeks and accumulation at mouth of Forge River	8	3	8	10	69
M12	Dredge in vicinity of LIRR trestle to improve flushing of waterbody north of trestle.	6	5	8	10	67
M7	Develop a TMDL implementation plan based on the preferred allocation scenario	8	5	2	5	59
M6	Determine TMDL for nitrogen	6	5	5	5	54
M9	Impose stricter nitrogen effluent limits on STPs within FRPOD based on nitrogen TMDL	4	8	3	5	53
M13	Deepen Ely Creek to improve tidal circulation and reduce Phragmites growth.	5	3	5	9	52
M11	Remove deposits downstream of East and West Mill Pond discharges including Phragmites.	5	3	6	8	51
M17	Test permeable reactive barrier pilot system in high nitrogen subwatershed, preferably in riparian conservation easement	6	5	3	4	50
M16	Measure groundwater nitrogen removal by Phragmites, Spartina, and a mud flat.	3	7	7	5	50
M5	Provide stormwater treatment for runoff into the Mill Ponds and FR from Montauk Highway.	4	5	5	7	50
M4	Provide stormwater treatment systems at creek heads - may require property acquisitions	4	4	5	7	47
M8	Evaluate need and locations for a regional wastewater treatment plant	4	7	3	2	44
M18	Test bioaugmentation in septic systems to improve OWTS efficiency	3	6	4	5	44
M3	Prepare engineering plans for restoration of duck farm properties. Consider property for regional STP.	3	4	4	6	40
M19	Test groundwater bioaugmentation and carbon source injection for nitrogen removal effectiveness	3	5	3	5	40
M15	Restore riparian vegetation including tidal wetlands and high marsh on public property and reduce road width where possible to expand riparian area.	2	5	5	5	38
M2	Purchase development rights for farms in watershed. Allow greenhouse farming with lot coverage limits.	2	3	5	7	36
M1	Acquire selected open space and direct development to developed areas outside FRPOD or to future sewered areas in watershed through TDR program. FRPOD as 'Sending Area,' downtowns & commercial areas outside FRPOD as 'Receiving Areas.'	2	4	2	3	28

1.10 Phasing of Long-Term Management Strategies

The long-term management strategies are ranked in descending order in Table 7.3 according to their scores which range from 38 to 62. There are twelve management strategies – considered here – whose implementation would occur in the long-term. Upon evaluation per Table 7-3, two strategies, (L10 and L3), stand out among the set of long-terms strategies with the highest values of 62 and 56, respectively. Strategy L10 provides for the long-term dredging of the estuary to remove accumulated organic matter while L3 offers a solution that would remove past, present and future nitrogen loads from groundwater, a major contributor to poor water quality in the estuary.

Recommendation. Although strategies L10, L3 and L2 have the highest scores, all of the long-term strategies presented and evaluated here should be included for evaluation in the development of the TMDL preferred allocation scenario.

Table 1-3. Ranking of long-term management strategies by weighted total

	Management Strategy	Water Quality Benefit	Cost	Technical & Legal Difficulty	Public Acceptance	Weighted Total
L10	Institute long-term dredging operation to remove accumulated organic matter from estuary if determined effective by benthic flux studies.	7	5	3	8	62
L3	Pump groundwater to treatment location which may be a wetland or denitrification reactor (large volumes of water are involved)	10	1	3	5	56
L2	Install permeable reactive barriers (if proven effective) in riparian area of all high priority creeks to remove historic groundwater nitrogen.	10	1	2	2	49
L6	Construct advanced onsite systems for individual FRPOD parcels; avoids collection system cost, but requires regular maintenance **OR**	8	2	4	2	46
L11	Fill creek depressions with sand to eliminate stagnant anoxic areas (presumptively incompatible with wetland permit - requires DEC approval)	4	5	3	5	44
L4	Improve operation of private STPs by upgrading for additional nitrogen removal or connect private STPs to future regional STP	4	3	8	5	43
L5	Sewer entire FRPOD. Construct conventional collection system and treatment plant **OR**	8	1	4	2	43
L7	Collect septic system effluent from all FRPOD parcels, treat at centralized community STP **OR**	8	1	4	2	43
L8	Incorporate adjacent areas (Mastic Shirley and Center Moriches) to reduce per parcel cost and expand environmental benefits.	8	1	3	2	42
L12	Conduct long-term maintenance dredging of Moriches Inlet to improve flushing of Moriches Bay and FR.	5	3	1	5	40
L1	Implement the land use plan for the duck farm properties to support restoration of the Forge River	2	3	4	9	39
L9	Pump bay water to head of Forge River and priority creeks to increase circulation, reduce algal blooms, and increase dissolved oxygen.	4	3	5	4	38

2 Community Involvement

2.1 Community and Advocacy Organization Participation

Mastic and Shirley residents in cooperation with their community organizations played a prominent role in the efforts to restore the Forge River and its tributaries. *Save the Forge River*, a non-profit environmental advocacy organization, was established specifically to address the condition of the River, its tributaries and the greater watershed. They have been instrumental in bringing attention to the plight of the Forge River.

Environmental organizations such as *Ducks Unlimited*, *Peconic Baykeeper*, and others have also contributed to the dialog. The *Poospatuck Indian Nation* borders the estuary. They too have a strong interest in the health of the waters. The Affiliated Brookhaven Civic Organization, Waterways Homeowners Association, Mastic-Shirley Chamber of Commerce, Manor Park Civic Association, and the William Floyd Community Summit have all been involved in the efforts to address Forge River problems and find solutions.

2.2 Watershed Advisory Committee

The Forge River Task Force, formed in 2005 by the Town of Brookhaven included local lawmakers, state and local officials, environmentalists and advocacy group representatives. The Task Force was instrumental in developing a strategy to restore Forge River health. It worked with the NYS DEC to place the estuary on the State's Impaired Waters List and, along with *Save the Forge River*, played an advocacy role in securing federal funding for the river.

The Forge River Task Force is chaired by the NYS DEC Regional Director, Peter Scully, and provided oversight for watershed research activities including the SUNY Stony Brook sediment and characterization study and a stormwater remediation project along Montauk

Highway. In its 2007-2008 year, the Forge River Task Force provided oversight for a hydrographic study and the continuation of various studies including river sediments and a nitrogen budget study. It produced a non-point source guide brochure that was mailed to residents in the summer of 2008. As a result of its continued advocacy efforts and success, the Forge River Task Force was designated as the Watershed Advisory Committee (WAC) for the development of the Forge River Watershed Management Plan.

FORGE RIVER TASK FORCE MEMBERS

- NYS DEC – Chair
- Brookhaven 6th Council District
- Brookhaven Division of Environmental Protection
- South Shore Estuary Reserve
- SC Department of Health Services
- SC Department of Planning
- SC Department of Public Works
- SC Soil & Water Conservation Service
- Suffolk County 3rd Legislative District
- Save the Forge River
- Peconic Baykeeper
- Ducks Unlimited
- Poospatuck Indian Nation
- Waterways Homeowners Association
- Mastic Fire Department
- Representative from the marine trades
- Citizens Campaign for the Environment
- National Parks Service

2.3 Outreach

Regular meetings were held with the Forge River Task Force to review project documents and progress, and to advise the Town and consultant team. Presentations were made to stakeholders and the public at the completion of key project documents (Watershed Characterization, Subwatershed Prioritization, and Draft Management Strategies). A project website was established where all background information, documents, maps, and other relevant information are posted. The draft Forge River Watershed Management Plan was reviewed by the public through the public comment process. Numerous comments were received and changes to this document were made as a result of those comments.

2.4 Support

Funding for the development of the Forge River Watershed Management Plan was provided by the New York State Department of State Division of Coastal Resources under Title 11 of the Environmental Protection Fund, and the Town of Brookhaven. Technical assistance was provided by the US Army Corps of Engineers, New York State Department of Environmental Conservation, Suffolk County Department of Health Services, and SoMAS SUNY Stony Brook.

3 Watershed Characterization Introduction

The Forge River has been a distressed estuary since the early part of the 20^{th} century. The Woods Hole Oceanographic Institution referred to the tributaries of Moriches Bay (Forge and Terrell Rivers) as "objectionable" and "highly contaminated" (Redfield, 1952). Extensive duck farming over many decades along the banks of the Forge River contributed to the high-nitrogen sediment load that remains. Residential development booms in the mid-twentieth century added thousands of onsite wastewater treatment systems (cesspools and septic systems) that have contributed substantial nitrogen to the water body via groundwater.

Although referred to as the Forge 'River,' the water body more closely meets the definition of an 'estuary.' An estuary is usually defined as "*a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which sea water is measurably diluted with freshwater derived from land drainage* (Pritchard, 1967)." No portions of the Forge River are strictly fresh water, like the Peconic River and the Carmans River. The Forge River estuary is a shallow tributary of the Moriches Bay estuary, which is itself part of the larger South Shore Estuary. A number of small tributary tidal creeks feed the central portion of the Forge River estuary. Accumulated sediments at the mouths of some of the creeks have limited tidal flushing. There is a relatively shallow area across the mouth of the Forge River that along with a poor connection to the intracoastal waterway channel limits flushing from the Bay. Changes in inlets from the ocean have also influenced Forge River flushing. Most of the surface water input to the Forge River comes from the East and West Mill Ponds, both of which are highly eutrophic. The West Mill Pond continues to collect runoff and effluent from the remaining duck farm. Nitrogen from sediment, groundwater, and surface water inputs leads to regular and dense phytoplankton and macroalgae blooms. Those blooms die, and the oxygen utilized during microbial decay leads to prolonged anoxic conditions in the water column.

Years of accumulated duck waste and organic matter from decades of decayed algal blooms have shallowed the estuary and created muddy anoxic bottom conditions that preclude habitation by most estuarine organisms. Only highly mobile benthic organisms and pelagic species can avoid the low oxygen conditions.

The estuary shoreline retains some tidal marsh vegetation, but is also bulkheaded along much of its coastline. Turfgrass and ornamental vegetation has replaced marsh vegetation along many shoreline areas and still others are covered by the invasive common reed *Phragmites.*

The Forge River watershed comprises both the groundwater and surface water (stormwater runoff) contributing areas. When compared with stormwater runoff, the groundwater input is more significant as it contributes a large portion of the external loading of the nitrogen to the estuary. Nitrogen enters groundwater primarily from the thousands of residential onsite wastewater treatment systems located adjacent to and up gradient of the Forge River. Ornamental and agricultural fertilizer use is responsible for another fraction of groundwater nitrogen. As groundwater travel-time to the estuary is measured in years or tens of years, nitrogen contributions to the estuary reflect past nitrogen contributions to groundwater that may be years or even decades old. The Forge River contributing area is subdivided into subwatersheds, based on groundwater contributing areas. The subwatersheds are distinctive in terms of their land uses, topography, and contribution to Forge River water quality. Those with high residential housing densities and low elevations are most problematic in terms of nitrogen contributions to the estuary. The East and West Mill Pond subwatersheds contribute large nitrogen loadings via surface water runoff as they collect significant duck farm and other agricultural runoff. Some subwatersheds contribute higher sediment loads via stormwater runoff than others. The types and densities of land uses differ among the subwatersheds, with more commercial, industrial, and agricultural land uses further north and large lot residential in the southernmost subwatersheds. A prioritization of the subwatersheds follows this characterization as the next step in identifying actions to reduce impacts on Forge River water quality.

4 Watershed and Subwatershed Delineations

The watershed and subwatershed boundaries, as delineated in Figure 4-1, provide an essential framework for characterizing the upland areas that contribute flow and contaminants to the Forge River. First, the watershed boundary – in addition to the surface waters of the Forge River estuary – effectively establishes the study area for this watershed plan. Secondly, a host of data for the watershed, such as land use, impervious surface area, density of on-site wastewater systems and population characteristics, are summarized and evaluated according to subwatershed boundaries. These subwatershed summaries will ultimately be employed to prioritize the subwatersheds according to the selection and timing of appropriate watershed management strategies. Section 4.1 below describes the methodology and data sets that were used to delineate the watershed and subwatershed boundaries.

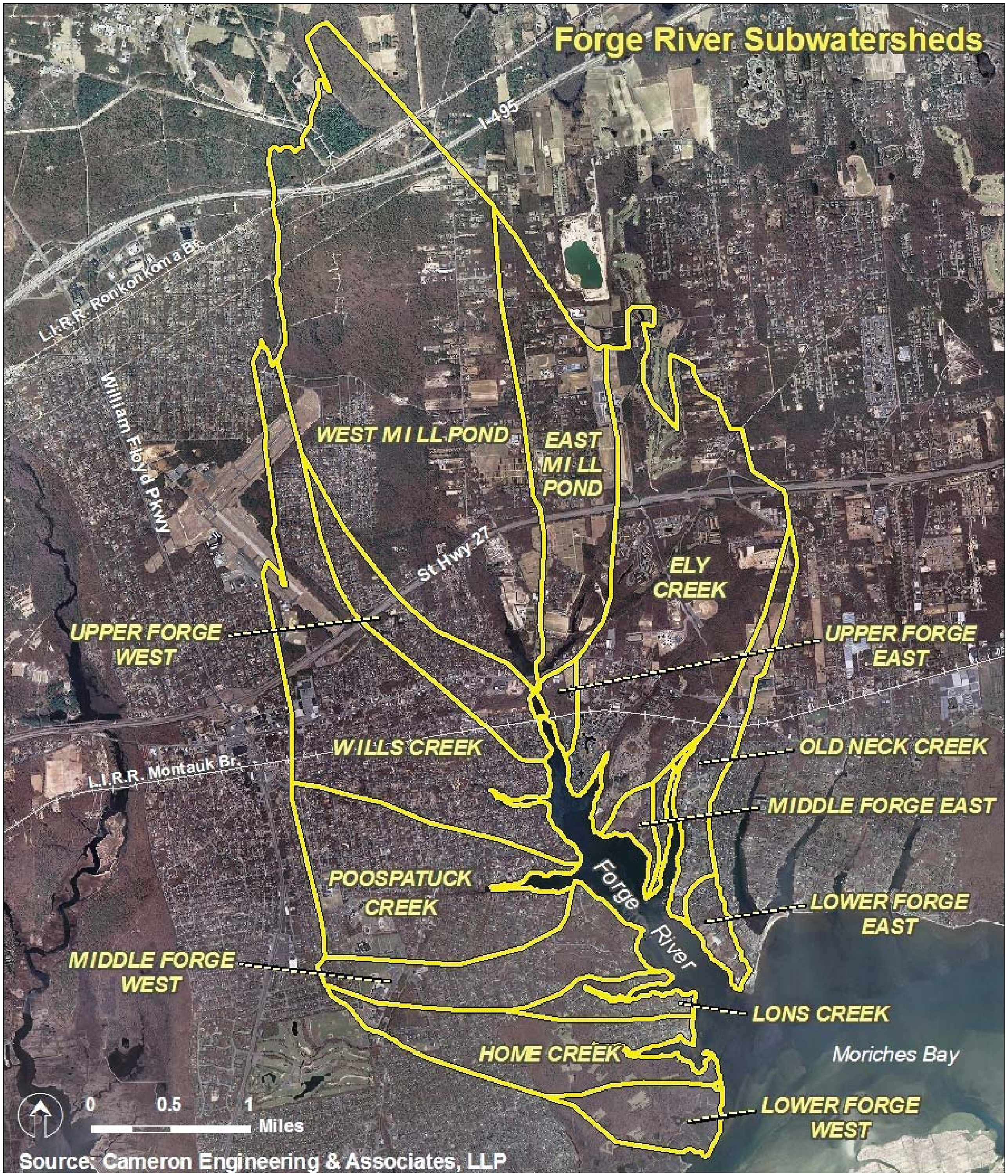
4.1 Delineation Methodology

For the purposes of this study, the overall watershed boundary is equivalent to the groundwater contributing area for the Forge River. The groundwater contributing area for the Forge River was delineated based upon a groundwater model that was developed for Suffolk County (Camp Dresser & McKee, 2009). The Forge River groundwater contributing area, as depicted in Figure 2-2 below, is the extent of the upland area from which groundwater contributes to the base flow of the streams and creeks that are tributary to the Forge River.

The methodology for delineating the subwatershed boundaries entails the integration of the stormwater collection system areas for the lower reaches of the watershed and the groundwater contributing areas for the upper or outermost reaches of the watershed. In the upper and outermost reaches of the watershed – which comprise mostly undeveloped and low-density areas where drainage infrastructure is limited or absent – the groundwater contributing areas are appropriately segmented to establish subwatershed boundaries. It is noted that, with the exception of farmland, runoff from the vacant and lesser developed portions of a watershed typically contribute far less stormwater volume and contaminants than the more developed areas. The delineation of the subwatershed boundaries in the more developed areas of the watershed, however, depends on the configuration of the stormwater infrastructure (*e.g.*, catch basins and pipes); this is discussed in detail in Section 4.3.2 below.

The subwatershed boundaries are modeled in the project Geographic Information System (GIS) and appropriately labeled according to local geography (*e.g*., Upper Mastic, Poospatuck Creek North, West Mill Pond, etc.). The subwatershed boundaries can be used as the sub-basin framework for the development of a formal Request for Proposal for a Total Maximum Daily Load model for nitrogen.

Figure 4-1. The Forge River Watershed and Subwatersheds



4.2 Groundwater Contributing Areas

As discussed in Section 2.1 above, the watershed boundary is equivalent to the groundwater contributing area for the Forge River. The groundwater contributing area was further divided – via output from the Suffolk County model – into areas that correspond with timeframes for groundwater to reach the Forge River. The groundwater travel timeframes are as follows:

- 0 to 2 years
- 2 to 5 years
- 5 to 10 years
- 10 to 25 years
- 25 to 50 years

The groundwater travel times were extracted from a Suffolk County Department of Health Services (SCDHS) Geographic Information Systems (GIS) database (Figure 4-2). It is important to recognize that the groundwater travel time frames expand outward – in a generally concentric manner – around the creeks and ponds that provide base flow to the Forge River. The areas between these concentric rings are bisected to establish the boundaries between the subwatersheds. This delineation approach is relevant primarily in the uppermost, and lesser-developed, portions of the watershed where stormwater collection infrastructure is limited or absent.

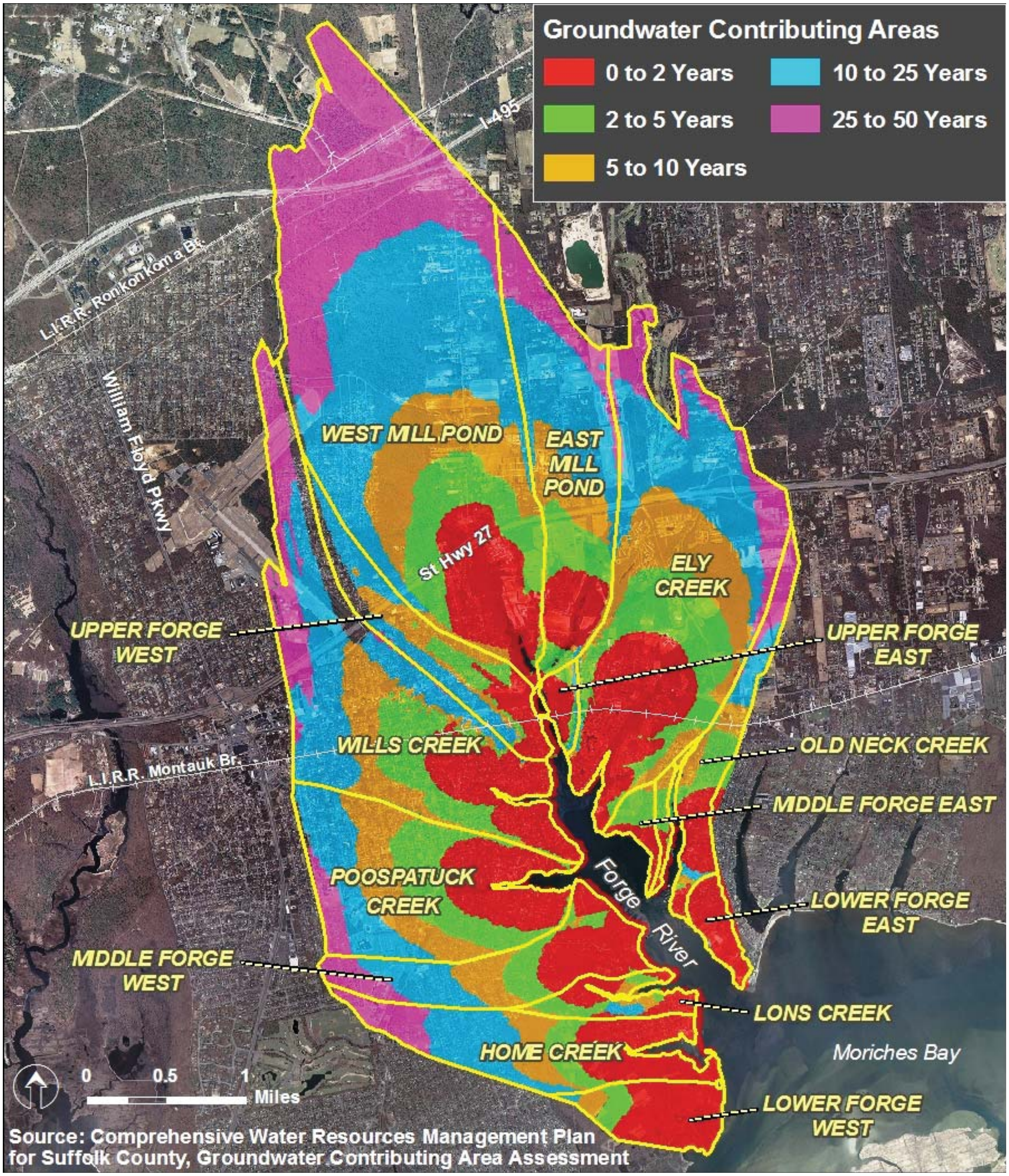
4.3 Stormwater Contributing Areas

4.3.1 Stormwater Collection and Infiltration Systems

An understanding of stormwater drainage infrastructure within the watershed was essential to the subwatershed delineation. (Stormwater infrastructure is discussed in detail in 5.6.1 below). The stormwater collection system within the Forge River's watershed area (as represented by GIS data provided by the Town of Brookhaven) consists of approximately 115 recharge basins, 1,526 drainage leaching structures and a number of other conveyance features (non-leaching catch basins, pipes, etc.). Combined, these stormwater infrastructure components total to more than 3,500 total structures.

Stormwater catch basins collect runoff and direct it to recharge basins that return stormwater to the water table through soil infiltration. Drainage leaching structures – which are not piped to recharge basins – are also utilized. These collect runoff locally and also directly recharge it to the soils beneath and then to groundwater.

Figure 4-2. Groundwater Contributing Areas by Travel Time to the Forge River



In the neighborhoods where stormwater is directed to recharge basins, the subwatershed boundaries follow the stormwater collection areas. It is recognized that a portion of the rain that falls within stormwater collection areas is directly recharged to groundwater via infiltration through pervious surfaces and thus is not captured by the stormwater collection system. The groundwater contributing area for a given subwatershed is typically coincident with the stormwater collection system area. However, where the stormwater collection system does not match the groundwater contributing area, the stormwater collection system area governs the subwatershed delineation. Other considerations and assumptions employed during the delineation of the subwatershed boundaries are discussed below in Sections 4.3.2 through 4.4 below.

4.3.2 Stormwater Collection and Direct Outfall Systems

In areas directly adjacent to the Forge River and its tributary creeks, runoff is typically collected via a network of catch basins and pipes and then discharged directly to the river via stormwater outfalls. Each storm-sewer-shed represents the drainage area associated with a major outfall or a collection of smaller outfalls to the Forge River. This network of drainage infrastructure – comprising pipes, catch basins, manholes and outfalls – establishes storm-sewer-sheds. These storm-sewer-sheds define the lower reaches of the Forge River subwatersheds. Because this approach does not utilize recharge basins, the storm-sewer-sheds are also termed "no-recharge" areas for the purposes of this study. Stormwater handled in this manner does not receive the additional treatment afforded by percolation through the soil beneath recharge basins. Fortunately, "no-recharge" areas do constitute only a small portion of the Forge River watershed. Figure 4-3 depicts the stormwater outfall collection, or "no-recharge," areas.

4.3.3 Direct Runoff Contributing Areas

In areas that have ineffective or limited existing drainage structures, *i.e.*, direct-runoff-contributing areas, runoff follows the topography and creates overland flow to the Forge River. These areas typically have high impervious cover and are located directly adjacent to the Forge River and its tributary creeks. They are included within the "no-recharge" areas depicted in Figure 4-3. Like areas drained by catch basins and outfalls, the precipitation in these direct-runoff-contributing areas the precipitation in these areas receives little to no treatment before entering the river.

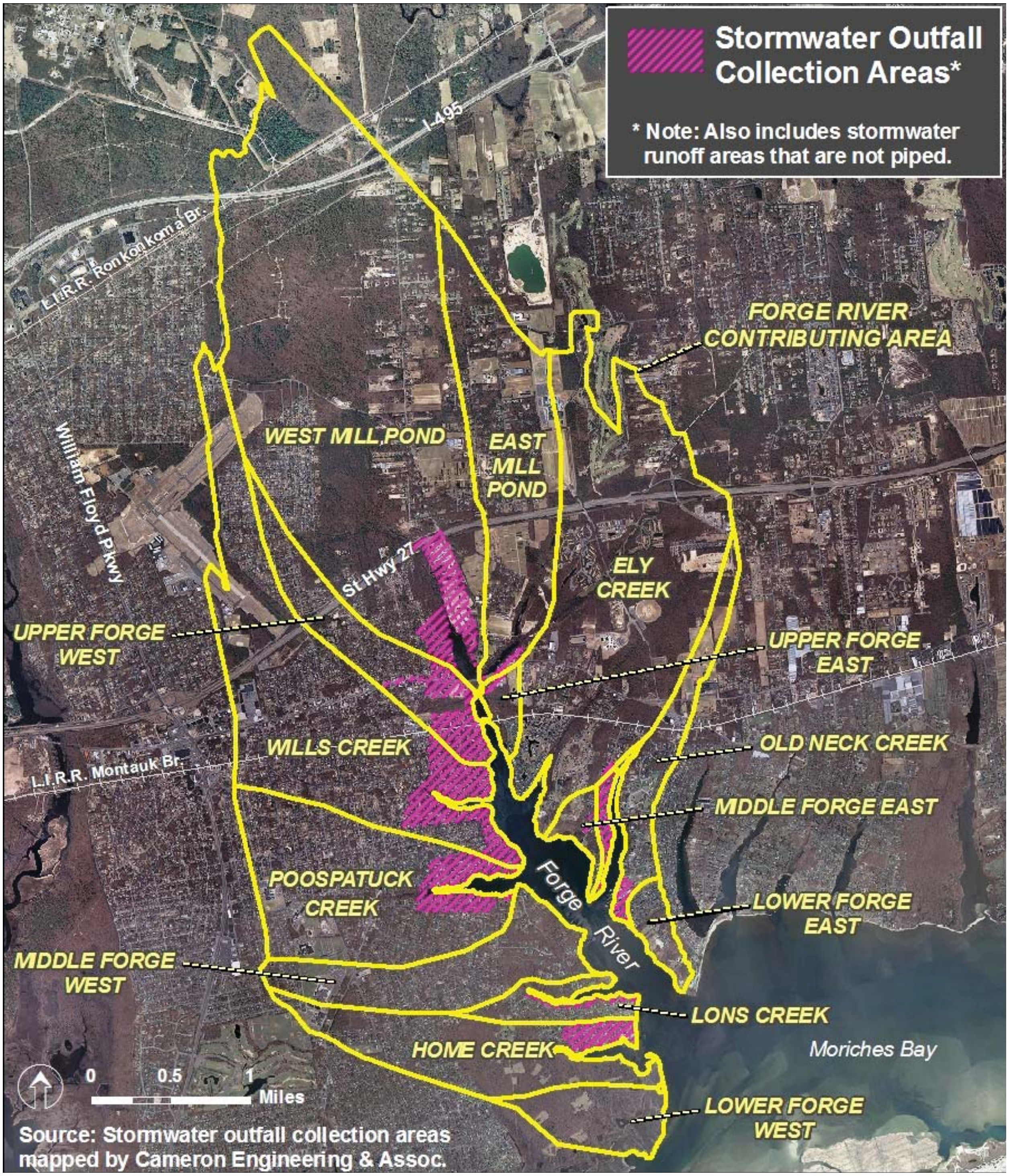
4.4 Subwatershed Areas

The total area of the watershed is approximately 9,450 acres. Of the entire 9,450 acres that comprise the watershed, 8,860 acres are classified as "recharge" areas. The remaining 590 acres are "no-recharge" areas. Table 4-1 below summarizes the area of the subwatersheds.

Table 4-1. Subwatershed Areas.

Subwatershed Name	Area (acres)
Lower Forge West	213.0
Home Creek	523.2
Lons Creek	135.8
Mid Forge West	443.2
Poospatuck Creek	851.6
Wills Creek	1,242.9
Upper Forge West	380.8
West Mill Pond	2,814.9
East Mill Pond	779.0
Upper Forge East	59.0
Ely Creek	1,549.4
Middle Forge East	63.6
Old Neck Creek	310.2
Lower Forge East	84.4
Total	**9,451.0**

Figure 4-3. Stormwater Outfall Collection Areas (No-Recharge Areas)



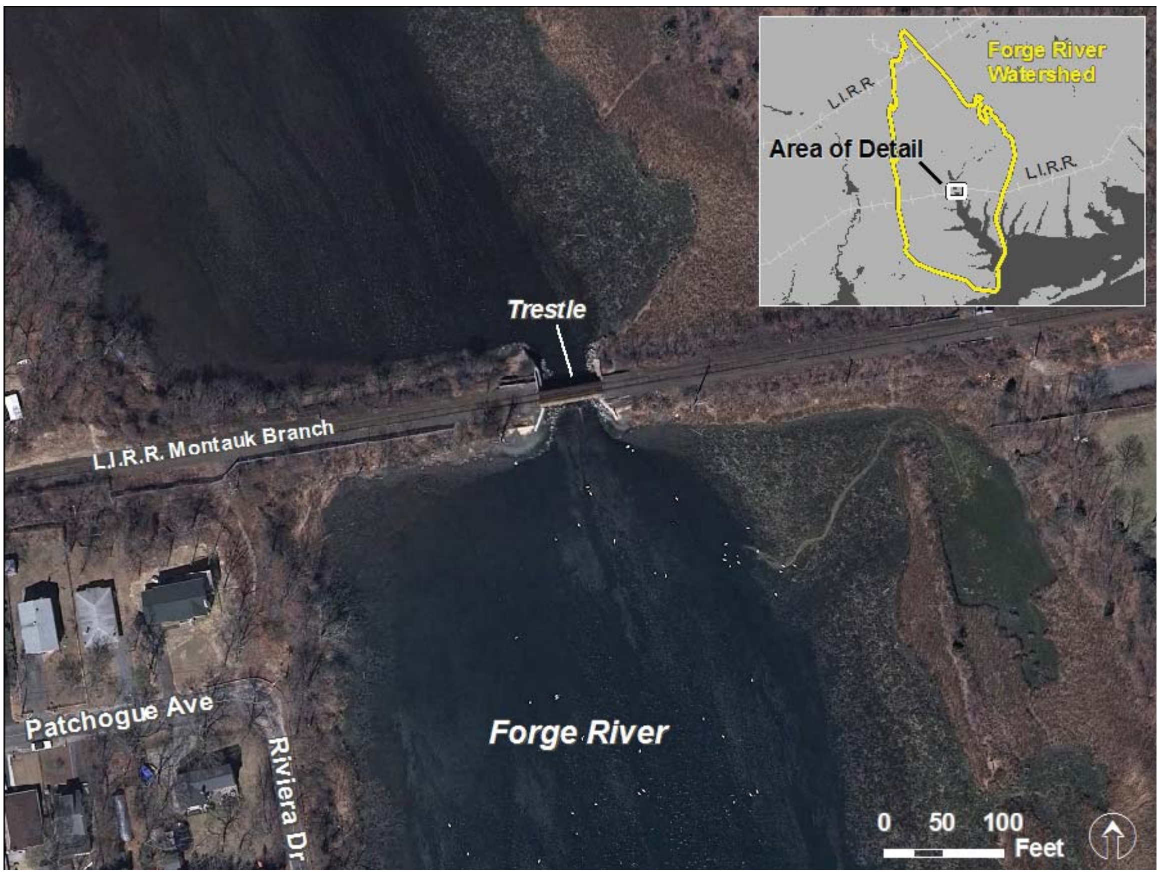
5 Geographic Setting

The Forge River is a partially mixed estuary that discharges to Moriches Bay. The upland area of the Forge River, *i.e.*, the watershed area, is situated in the southeastern portion of the Town of Brookhaven and encompasses the hamlets of Mastic and Moriches and the Poospatuck Reservation. Portions of the hamlets of Manorville, Shirley and Center Moriches and the Village of Mastic Beach also comprise the watershed. Figure 5-1 provides a location map for the Forge River watershed communities and adjacent areas.

Figure 5-1. Location Map of the Forge River Watershed

The Forge River watershed contains two major highways, an important arterial, a network of local roads, and other noteworthy transportation infrastructure. Interstate Highway 495 traverses the northern tip of the watershed while State Highway 27 (Sunrise Highway) runs east to west through the center of the watershed. Montauk Highway, located south of State Highway 27, is an important east-west corridor for local commerce; it passes through the population center of the Village of Mastic. Other transportation features in the watershed include the Long Island Rail Road Montauk and Ronkonkoma Branches and the Brookhaven Airport. The Montauk Branch runs east to west across Shirley, Mastic, and Moriches and crosses the upper reaches of the Forge River via a trestle. The trestle, shown in Figure 5-2, is an important landmark of the Forge River. A portion of the Brookhaven Airport falls within the western boundary of the watershed.

Figure 3.2 Long Island Rail Road Trestle Across the Upper Forge River



Most of population within the watershed is located south of State Highway 27 and to the west side of the Forge River within Mastic, Mastic Beach, Shirley, and the Poospatuck Reservation. Residential neighborhoods are located on the east side of the Forge River, though they are significantly less extensive than those on the west side. Except for a medium-density residential area adjacent to the Brookhaven Airport, population density within the upper reaches of the watershed is relatively low and vacant land area is significant.

5.1 Data Sources and Maps

To characterize the watershed, *i.e.*, the upland areas of Forge River, this plan utilizes a variety of geographic, environmental, and socioeconomic data. Sources of the data are primarily government and academic institutions. Table 5-1 summarizes the data types and providers of the data utilized for this study. Where data was developed and updated or enhanced as part of this study, the source is listed as 'Consultant.' References to published reports are contained in the body of the report and listed in 'Works Cited,' Section 14. The Works Cited section includes numerous reports by the School of Marine and Atmospheric Sciences (SoMAS) of Stony Brook University which, in most cases, were prepared for the Town of Brookhaven.

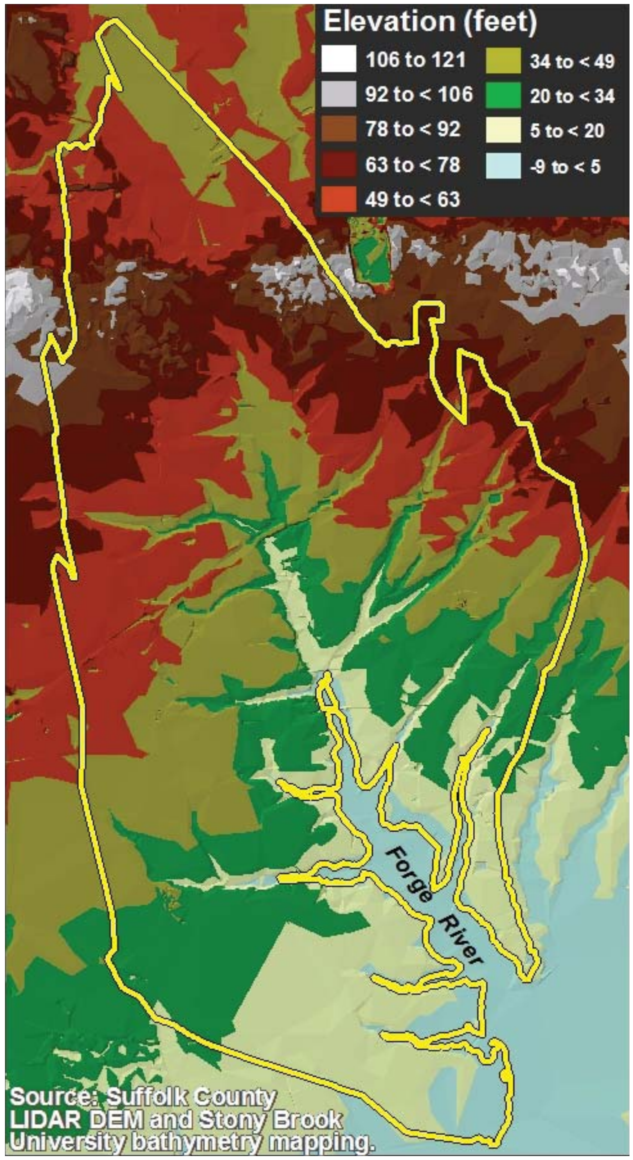
Table 5-1. Data Category and Class

Data Type	Source
Stormwater Infrastructure	Town of Brookhaven
Topography	Town of Brookhaven and Suffolk County
Hydrology	NYS DEC and consultant
Flood Zones	FEMA
Precipitation	NOAA
Land Use	Town of Brookhaven and Consultant
Land Cover	Consultant
Population	LIPA
Housing	US Bureau of the Census
Economics	US Bureau of the Census
Zoning	Town of Brookhaven
SPDES Permits	NYS DEC
Nitrogen Load/Balance	SoMAS and consultant
Benthic Habitat	NYS DOS
Bathymetry	Town of Brookhaven

5.2 Topography

Figure 5-2 depicts a relief model of the watershed topography and river bathymetry. This relief model is an integration of a recent (2006) LIDAR-based (LIght Detection And Ranging) digital elevation model of topography that was provided by the Suffolk County GIS Department and a bathymetry model produced by Stony Brook University (Flood, 2007). The LIDAR-based topography model is a high-resolution grid of 5-foot-by-5-foot ground elevation cells while the bathymetry model comprises 10-cm (0.1m) contours.

Figure 5-2. Terrain Relief Model of the Watershed

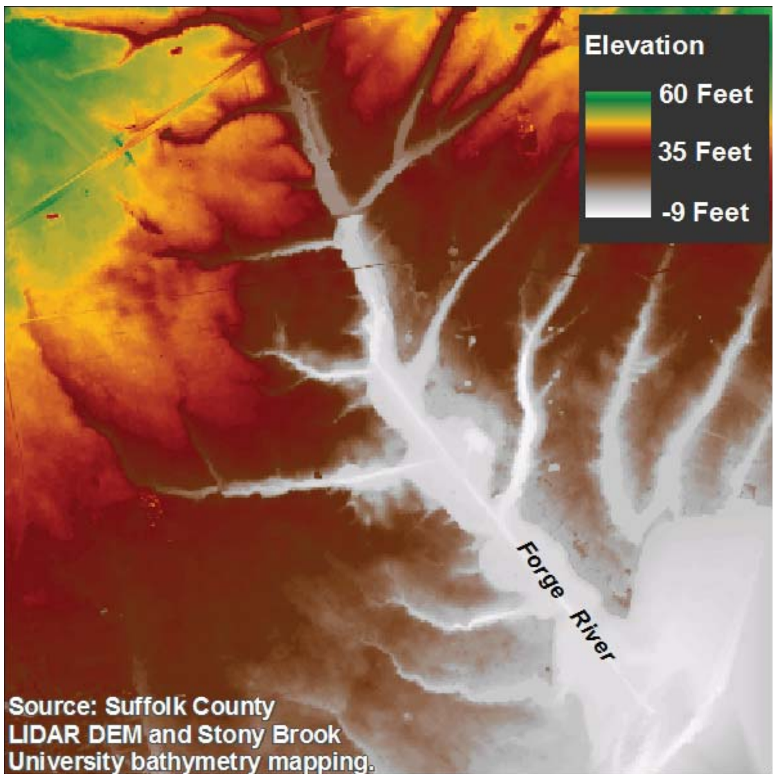


(Source: Town of Brookhaven and Suffolk County).

The integrated topography and bathymetry model provides excellent detail, and it was utilized for the delineation of the storm-sewer-shed boundaries described in Section 4. The combination model provides sufficient detail such that sills, dredged channels and the banks of the estuary are clearly revealed. Because of its accuracy and high-resolution, the relief model can be utilized for the development of the TMDL model. A section of the combined elevation-bathymetry model for the Forge River area is provided in Figure 5-3.

A review of the digital elevation model (Figure 5-2) reveals that most of the lower half of the watershed comprises gentle to moderately sloping terrain except near the creeks. Along the edges of the creeks and the streams, the terrain changes abruptly and forms elongated cuts in the landscape. In the upland areas of the middle reaches of the watershed, elevations reach approximately 100 feet and then fall to 45 feet at the northernmost tip of the watershed. The observation that the terrain rises and falls is counterintuitive to the generally accepted concept of watershed delineation, *i.e.*, where boundaries are typically drawn along break, or ridge, lines where rainfall is shed in opposing directions on either side of the break lines. However, these areas are encompassed by the Forge River groundwater contributing area. The bathymetry of the Forge River, along with a discussion of dredging operations over time, is discussed in Section 10.1.

Figure 5-3. Detailed View of the Integrated Digital Elevation and Bathymetry Models



(Source: Suffolk County LIDAR DEM and Stony Brook University bathymetry mapping.)

5.3 Hydrology

There a number of watershed functions which govern the hydrologic environment. Initially, the watershed collects water from precipitation, a portion of which becomes runoff. In areas directly adjacent to the Forge River, runoff is directed to the river via the outfalls of the stormwater collection systems or via direct runoff (*i.e.*, overland flow) from impervious surfaces. The other areas of the watershed temporarily store the remainder of the precipitation in various amounts and durations in storage basins and the soil. In the latter instance, precipitation is transmitted to the water table via infiltration through soil and other pervious surfaces. In the developed portions of the watershed, stormwater recharge basins release rainfall accumulated from their collection areas into groundwater via recharge. Stormwater that is recharged to the water table is eventually released to the Forge River as groundwater discharge from its banks and from the ponds, streams and creeks that are tributary to the Forge River.

According to report prepared for the Town of Brookhaven by the School of Marine and Atmospheric Sciences entitled *Some Aspects of the Forge River Ecology* (Brownawell, Gobler, & Swanson, May 2009), the East and West Mill Ponds are the major sources of surface discharge to the Forge River, contributing 80 percent of surface water runoff. In 2007, the School of Marine and Atmospheric Sciences measured the flow from the East and West Mill Ponds at approximately 0.96 million cubic feet per day. In addition, they also found that groundwater flow was 1.6 times that of stream flow. This finding is less than half that reported in Redfield's 1952 study (Redfield, 1952), where groundwater flow was estimated at 3.6 times stream flow. Although the ratio of groundwater to stream flow varies with time of year and climatic conditions, it is clear that groundwater flow is the major source of flow from the upland areas to the Forge River.

Figure 5-4 depicts the surface water features of the watershed that comprise the Forge River, its tributary creeks and streams, ponds, ditches and the shorelines. The shoreline of the Forge River and its creeks is extensive, tracing a perimeter of approximately 15 miles. The perimeter of the ponds within the watershed is also considerable and encompasses a linear periphery of about 4.6 miles, though mostly comprising the banks of the East and West Mill Ponds. The streams of the watershed account for less than two miles of total linear distance and thus do not extend far beyond their interface with the various creeks and ponds of the watershed. This is due mostly to the well-drained soils that are found throughout the watershed and, in part, to the configuration of the stormwater system. In the developed areas of the outer (*i.e.*, eastern and western) and upper reaches of the watershed, stormwater systems typically recharge runoff to groundwater through basins and leaching pools, thereby reducing runoff and overland flow.

Table 5-2 summarizes the areas of the Forge River, its tributary creeks and the freshwater ponds. The surface waters of the watershed encompass approximately 574.3 acres. The Forge River proper (*i.e.*, less its tributary creeks) accounts for the majority (69.0 percent) of the surface waters, or 396.1 acres. Old Neck, Home, Poospatuck, Lons, and Wills Creeks are 40.9, 29.4, 25.5, 15.2, and 7.7 acres in area, respectively. West Mill Pond (25.9 acres) and

East Mill Pond (10.2 acres) account for 36.2 acres of surface fresh water. The various natural and man-made ponds – located mostly within the eastern half of the watershed – total 23.4 acres in area.

Table 5-2. Areas of Water Bodies in the Watershed

Water Body	Area (Acres)	Percent of Total Area
Forge River	396.1	69.0 percent
Old Neck Creek	40.9	7.1 percent
Home Creek	29.4	5.1 percent
West Mill Pond	25.9	4.5 percent
Poospatuck Creek	25.5	4.4 percent
Small Ponds & Basins	23.4	4.1 percent
Lons Creek	15.2	2.6 percent
East Mill Pond	10.2	1.8 percent
Wills Creek	7.7	1.3 percent
Total	**574.3**	**100.0 percent**

Figure 5-4. Water Features of the Watershed

5.4 Flood Zones

Figure 5-5 on the following page depicts the flood zones within the Forge River watershed. Approximately 600 acres of the lower-lying areas of the watershed lie within the 100-year flood hazard area. This places approximately 750 properties – the overwhelming majority of which are residential uses – within the 100-year flood hazard zones, including the VE zones that are susceptible to wave action or storm surges. These include the following zones as designated by the Federal Emergency Management Administration (FEMA):

- High-Risk Areas
  - Zone A: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these zones.
  - Zone AE: The base floodplain where base flood elevations are provided. AE Zones are now used on new format Flood Insurance Rate Maps (FIRMs) instead of A1-A30 Zones.
- High-Risk Coastal Areas
  - Zone VE: Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves.

5.5 Precipitation

Annual average precipitation in the area is 45.07 inches/year (Source: National Oceanic and Atmospheric Administration data at Central Park in New York City, 65 miles west of the Forge River, 1869-2009). As discussed in Section 11.9.8, data from the National Atmospheric Deposition Program (NADP) was used to determine the total nitrogen contribution from precipitation. This data was taken from 2004-2008 at Site NY-96 located in Cedar Beach, Southold, New York, which is approximately 30 miles northeast of the Forge River. The average annual precipitation at this site is 47.3 inches for Years 2004 through 2008.

5.6 Infrastructure

5.6.1 Drainage

The drainage infrastructure in the Forge River watershed consists of typical stormwater collection and conveyance structures such as catch basins, leaching basins, manholes, pipes, outfalls and recharge basins. According to GIS data obtained from the Town, there are approximately 24 outfalls that discharge to the Forge River and the creeks upstream (Figure 5-6). These collect stormwater from the neighborhoods and roads immediately adjacent to the Forge River and discharge directly to the estuary with no treatment. The majority of storm drainage in the watershed discharges to the ground via leaching basins and recharge basins. Most of the subwatersheds contain storm-sewer-sheds, or areas that are piped to and/or have overland flow to a small recharge basin. The stormwater collected in the recharge basins receives some treatment through deposition of suspended particles and microbial activity during detention and infiltration prior to reaching groundwater.

5.6.2 Sanitary

Suffolk County is only approximately 30 percent sewered. These areas consist of a mix of municipally- or privately-owned sewage treatment plants. The remainder of the County is dependent on on-site systems for wastewater treatment. Prior to the mid-1970s, – when much of the development in the Forge River watershed occurred – cesspools were installed for on-site wastewater treatment. These structures comprise simple leaching basins into which untreated wastewater flows. Beginning in the mid-1970's, on-site wastewater treatment system design was improved with the installation of septic systems. Septic systems have a holding tank for solids and an associated leaching system. Septic systems are designed to have a two-day detention time, thus providing greater treatment (when properly maintained) than cesspools. Effluent from on-site wastewater treatment systems infiltrates into the ground and ultimately reaches groundwater, which, in turn, flows, to the Forge River.

5.7 Geographic Setting Summary

The Forge River is a partially-mixed estuary that discharges to Moriches Bay. The Forge River contributing area has moderately sloping terrain with greater relief in the upland part of the basin. Hydrology is dominated by groundwater due to highly permeable soils and shallow depth to groundwater in the lower portions of the watershed. Surface water enters the Forge River from the East and West Mill Ponds and through creeks that have small drainage areas, some of which include stormwater collection systems. On-site wastewater treatment systems are common in the watershed due to its early development for seasonal beach communities and the lack of a large centralized wastewater treatment facility. Many of the on-site wastewater treatment systems in the watershed are still cesspools. Most of the on-site wastewater treatment systems are likely to be quite old and/or infrequently serviced.

Figure 5-5. Flood Zones of the Forge River Watershed

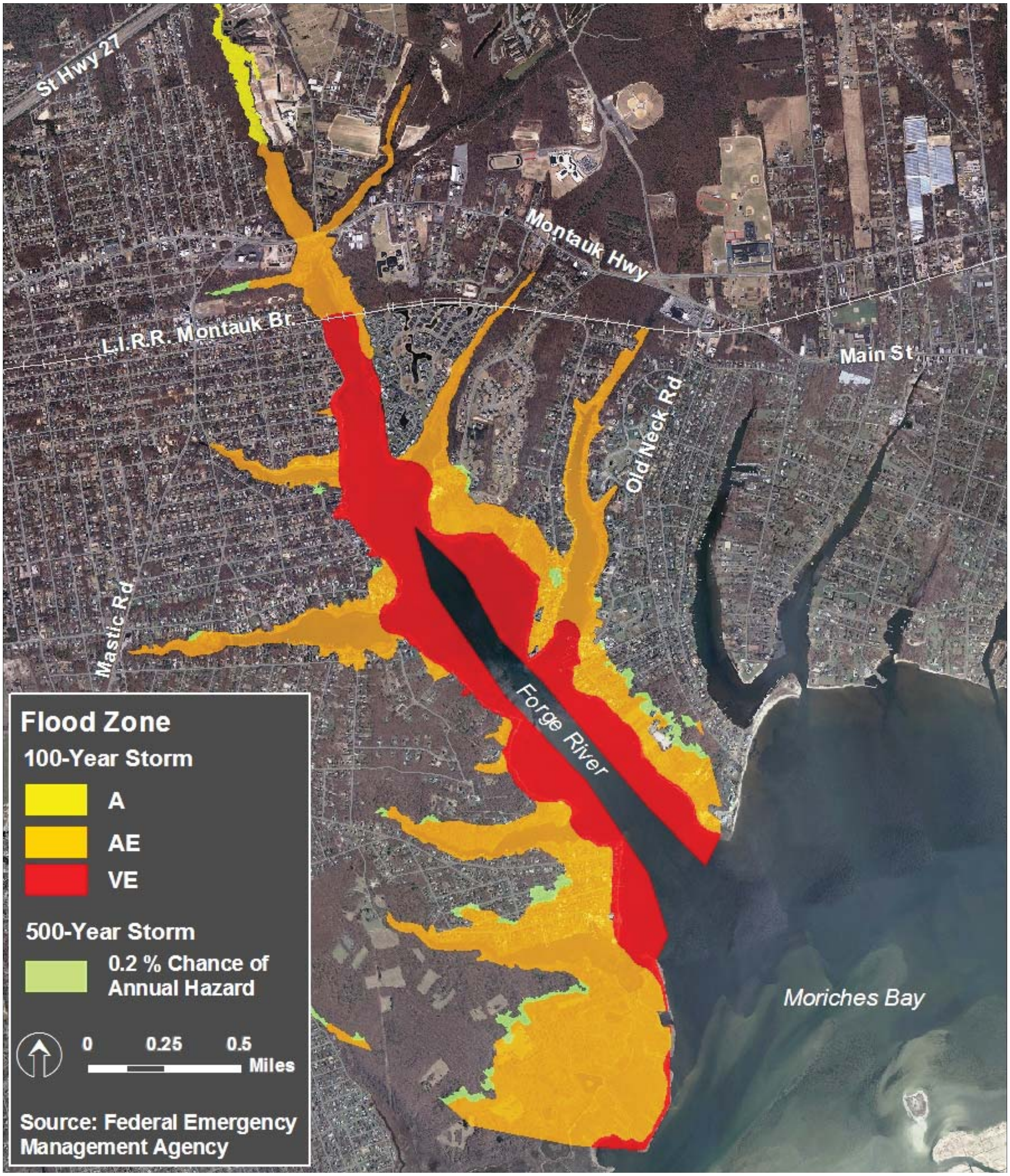
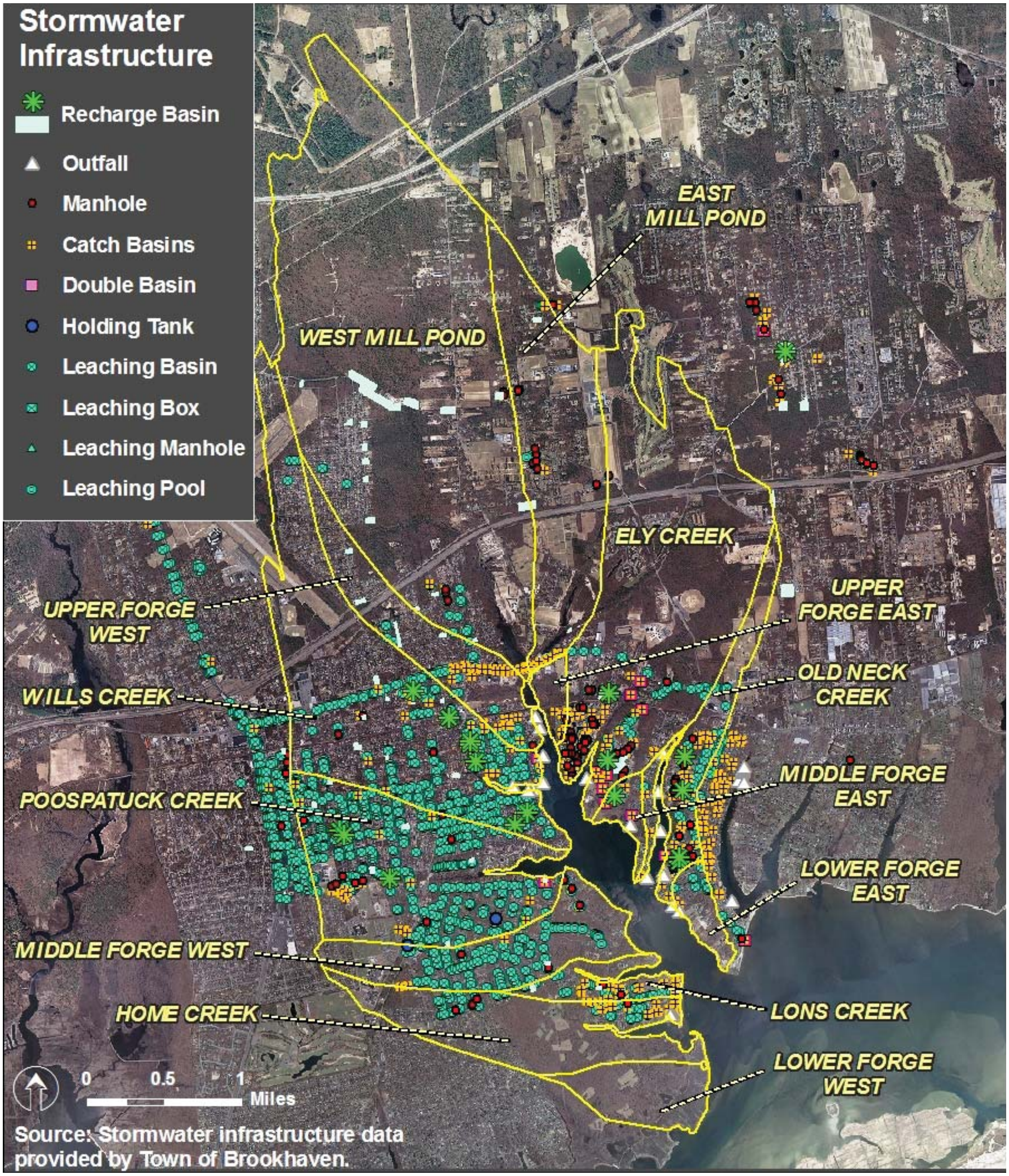


Figure 5-6. Stormwater Infrastructure in the Forge River Watershed



There are an estimated 8,100 existing onsite systems within the watershed with estimated flows ranging from 20 gallons per day (a small fruit stand) to over 42,000 gallons per day (public school). Historically, the urbanization of the watershed began in a manner similar to other coastal areas on Long Island, *i.e.*, as a seasonal beach community. As population spread eastward, many of these beach communities began supporting year-round residents. While other infrastructure was upgraded to accommodate the growing population (*i.e.*, water, electricity, etc.), wastewater continued to be treated by existing on-site systems. Those systems required only limited repair and maintenance to maintain working order. Many of the on-site systems in the watershed are still cesspools and most of the on-site systems are quite old. As there are no requirements for maintenance or upgrades to on-site systems, most homeowners service them only when a problem arises. Pump-outs will alleviate most on-site system problems until the surrounding soils can no longer infiltrate the effluent. Typically, only then are these systems replaced.

Following Suffolk County's adoption sanitary requirements (*i.e.*, 300 or 600 gallons per day (gpd) per acre, depending on the hydrogeologic zone), private developments that exceeded the flow limits were required to construct new sewage treatment plants (STPs) or connect to existing ones. These STPs require approval from Suffolk County and the New York State Department of Environmental Conservation (NYSDEC). They are regulated by their State Pollution Discharge Elimination System (SPDES) permit and at the national level, the NPDES permit. Discharge Monitoring Reports (DMR's) are required on a monthly basis and fines are distributed to those sanitary STPs that do not comply with their permit conditions. The Forge River watershed has three housing developments and one business that operate with these SPDES discharge permits.

- Waterways at Bay Point
- The Villas at Pine Hills
- Pine Hills South
- Jurgielewicz Duck Farm

The STPs that serve the housing developments have either sub-surface or recharge basins where effluent leaches to groundwater and thus ultimately reaches the Forge River. The Jurgielewicz Duck Farm discharged directly to West Mill Pond, which empties into the Forge River.

An examination of the County's groundwater model reveals that the three housing development STPs are within the Ely Creek contributing area (Figure 5-7 and Table 5-3). The Villas at Pine Hills, Pine Hills South, and Waterways at Bay Pointe are within the 10-25-year zone, 2-5-year zone, and 0-2-year zone, respectively. The DMR's of the plants include quarterly sampling results from the groundwater monitoring wells located upstream and downstream of the STP's discharge.

Table 5-3. Ely Creek Area Groundwater Nitrogen Concentrations

Wastewater Treatment Plant Name	Monitoring Dates	Average Upstream Monitoring Well Nitrogen Concentration (mg/L)	Average Downstream Monitoring Well No. 1 Nitrogen Concentration (mg/L)	Average Downstream Monitoring Well No. 2 Nitrogen Concentration (mg/L)	Linear Distance to Ely Creek (miles)
Villas at Pine Hills	10/1/09-3/31/10	5.8 (Peak: 5.9)	13.7 (Peak: 20.8)	19.05 (Peak: 32)	1.8
Pine Hills South	10/1/07-12/31/07 7/1/09-9/30/09 1/1/10-6/30/10	3.0 (Peak: 3.5)	5.9 (Peak: 8.9)	18.325 (Peak: 58.9)	1.2
Waterways at Bay Pointe	2/1/09 – 4/30/10	4.04 (Peak: 7.1)	12.74 (Peak: 22.6)	17.46 (Peak: 36.3)	0.4

Since these readings are taken from groundwater, they include nitrogen inputs from every source (*i.e.*, not just wastewater treatment plants) including stormwater recharge. The Duck Farm's SPDES permit has different nitrogen limits that range from 5 mg/L in the summer to 10 mg/L in the winter. Data from July 2009- June 2010 were obtained through a FOIL request to the NYSDEC. Averages from this data are represented in Table 5-4. Average flow for this data range is 0.578 million gallons per day (MGD).

Table 5-4. Duck Farm Average Effluent Data*

Average Effluent Concentrations	lbs/day	mg/l	no./100 ml
Total N (as N)	195.0	42.8	
Phosphorous		9.7	
Total Ammonia as (NH_3)		28.9	
Total Fecal – 30 day Geometric Average			116.1
Total Fecal – 7 day Geometric Average			423.3
Total Fecal – Monthly Medium			183.6

* Note: the Jurgielewicz Duck Farm has ceased operations

As shown in Figure 5-7, there are two additional wastewater treatment dischargers. They are the Barnes Road Duck Farm and B.L.T Ventures Car Wash. The Barnes Road Duck Farm is comprised of four lined lagoons and has a "zero-discharge" SPDES permit. Because the SPDES permit requires no discharge, there is no effluent data collected or available. The presumption is that waste from the duck farm's lined effluent lagoons is removed and taken off-site for disposal. The discharge from B.L.T. Ventures Car Wash is not considered a 'sanitary' discharge. The constituents of its discharge presumably contribute little to no nitrogen to the Forge River. Therefore, neither of these facilities is considered a nitrogen contributor to the Forge River.

Figure 5-7. Wastewater Treatment Locations