MANHASSET BAY PROTECTION COMMITTEE

EEA Inc.

Stannards Brook Water Quality Assessment Report
Seasonal Rain Event Study

FINAL REPORT: June 2008

List of Acronyms

CSO – Combined Sewer Overflow
DO - Dissolved Oxygen
EEA – Energy and Environmental Analysts, Inc.
GIS – Geographic Information System
GPS – Global Positioning System
MBPC – Manhasset Bay Protection Committee
Mg/L – milligrams per liter
NCDHL – Nassau County Department of Health Laboratory
NCSWMP – Nassau County Storm Water Management Program
NEMO – Nonpoint Education for Municipal Officials
NH_3 – Ammonia
NO_2 - Nitrite
NO_3 – Nitrate
NYSCRR – New York State Codes, Rules, and Regulations
NYSDEC – New York State Department of Environmental Conservation
NYSDOS – New York State Department of Sanitation
PWWD – Port Washington Water District
SBPP - Stannards Brook Park Preserve
TKN - Total Kjeldahl Nitrogen
TN - Total Nitrogen
TP - Total Phosphate
TSS- Total Suspended Solids
USEPA – United States Environmental Protection Agency
YSI – Yellow Springs Instrument

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1.0 Introduction

1.1 Purpose of Study

In 1999 the Manhasset Bay Water Quality Improvement Plan was completed. Recommendations were made to improve stormwater monitoring and restoration projects along Stannards Brook in order to decrease nutrient and pollutant loads to Manhasset Bay. The purpose of this study was to detect wet weather evidence of nonpoint source pollution and determine discharges to Stannards Brook that have the greatest need for retrofits.

1.2 Physical Description of Project Area

Stannards Brook is nestled within the Stannards Brook Park Preserve (SBPP) in Port Washington, New York (Figures 1A and 1B). Originating at the eastern edge of the Port Washington Water District (PWWD) parcel, it flows a distance of approximately 325 meters through the SBPP. The SBPP is a Nassau County facility. The Brook exits the preserve at the intersection of Charles and Carlton Streets via a grated discharge in the retaining wall (Figure 2) and eventually feeds into Manhasset Bay, north of the Port Washington Yacht Club (Figure 1B).

Stannards Brook is a stream which is fed by nonpoint sources of stormwater run off and surrounding natural springs. Drainage of stormwater from the surrounding residential area is routed into Stannards Brook via storm water culverts and outfalls at several locations along the Brook’s length. The Stannards Brook Watershed spans approximately 14 acres within the city of Port Washington (Figure 1C).

1.3 New York State Water Quality Standards

The New York State Department of Environmental Conservation (NYSDEC) Division of Water has published best usage classifications for the New York State bodies of water and discharge water quality standards for those classifications [NYSDEC 1994]. Stannards Brook is an unmarked stream on the United States Geological Survey Sea Cliff quad map (Division of Water map R-25SW). Since it is a stream with a discontinuous flow, it takes the NYSDEC fresh surface water assignment of Class D. Class D waters have been deemed suitable for fishing and fish survival. Of the thirteen parameters sampled for this investigation, five were given a NYSDEC concentration standard shown in Table 1 below.

Table 1: NYSDEC Acceptable Parameter Values for Class D Fresh Surface Water

Parameter	Standard (units)
Dissolved Oxygen	> 3 (mg/L)
pH	6 < pH < 9.5
Total Coliform	< 2400 (count/ 100 mL)
Fecal Coliform	< 200 (count/ 100 mL)
Ammonia (NH3)	<0.31 (mg/L)

NYSDEC has assigned three spatially specific classifications for Manhasset Bay. Stannards Brook terminates in the southeastern portion of Manhasset Bay, north of the Port Washington Yacht Club and therefore falls into Class SB waters. Class SB waters are saline surface waters that are best used for primary and secondary contact recreation (i.e.: swimming and boating). These waters must be a suitable habitat for fish to live and reproduce. The NYSDEC Class SB standards for the four applicable parameters are shown in Table 2.

Table 2: NYSDEC Acceptable Parameter Values for Class SB Saline Surface Waters

Parameter	Standard (units)
Dissolved Oxygen	> 5 (mg/L)
pH	± 0.1 of normal pH
Total Coliform	< 2400 (count/ 100 mL)
Fecal Coliform	< 200 (count/ 100 mL)

At the time of this writing, enterococci counts do not have an NYSDEC acceptable level. However, the value of 33 counts/ 100 mL will be adopted for this study. This standard was used as the action level in the Nassau County Storm Water Management Program Dry Weather Flow, 2004 Final Draft (NCSWMP). Refer to Section 2.1.3 for a discussion of microbial indicators (coliform and enterococci) and their significance.

1.4 Summary of Previous Studies Conducted Near the Project Site

1.4.1 Nassau County Stormwater Management Program, Final Draft, Dry Weather Flow Study, 2004

This dry weather flow study had three major priorities: 1) Screen for illicit discharges and priority areas in Nassau County 2) Create a baseline to document performance of best management practices and 3) to collect data for annual assessments.

Stannards Brook was sampling point 32 for this study and was grouped into a low priority area for illicit discharge detection. Stannards Brook was sampled 2 times throughout the year (summer and fall). The summer and fall results of that study show that Stannards Brook had fecal coliform counts in excess of 2,400 counts/ 100 mL and enterococci levels of greater than 33 counts/ 100 mL, i.e. levels exceeding acceptable standards.

1.4.2 Nassau County Stormwater Management Program, Final Draft, 2005 Annual Report

This report was the second yearly evaluation of the Nassau County Stormwater Management Program in relation to the six minimum control measures which are: 1) Public Education and Outreach 2) Public Participation 3) Illicit discharge detection and elimination 4) Construction site storm water run off control 5) Post construction storm water management and 6) Pollution Prevention.

Stannards Brook is a major watershed that drains into Manhasset Bay. However no sampling was done specifically on the Brook for this particular study. Sampling on the nearby Leed's Pond was conducted between June 2 and September 2, 2004. The average fecal coliform bacteria counts for Leed's Pond were 98 counts/ 100 mL and enterococci levels were above 35 counts/ 100 mL for at least 6 days during that sampling period.

1.4.3 Stannards Brook Park Preserve Master Plan Study

The Stannards Brook Park Preserve (SBPP) Master Plan Study was completed in April of 2005. Its focus was on existing physical conditions of the park as well as recommendations to improve the recreational quality of the SBPP. It was noted that a high influx of debris (leaf litter and downed tree branches) and sediment deposits are a consistent problem for the stream and evidence exists for flooding at one house on Washington Street. While water quality studies were not performed as a component of this plan, protecting the preserve from "storm water ill effects" was the top priority project for Stannards Brook.

2.0 Methodology

In order to retrieve the data needed to characterize nonpoint source contributions to Stannards Brook, EEA conducted a field campaign to collect storm water run off at three locations along the stream during one wet weather event in each season. These locations constituted water quality sampling stations used for this study and throughout this text are referred to as Station 1 – at the head of the stream, Station 2 – midstream, and Station 3 – at the discharge. Using criteria set by similar studies, the New York State Department of Sanitation (NYSDOS), Manhasset Bay Protection Committee (MBPC), and Energy and Environmental Analysts, Inc. (EEA) classified a wet weather sampling event as one proceeding a dry period of 4 to 5 days and predicted to accumulate at least 0.5 inches (1.27 cm) of rain during a continuous six hour period. The field sampling protocol was designed to collect two sets of samples from each station; one at first flush (time period immediately following the beginning of the wet weather event) and one post flush (1 to 3 hours later).

First flush samples are an important component to understanding what nutrients and bacteria are being delivered to Stannards Brook from the surrounding area. These samples are likely to contain the highest concentrations of nutrients and bacteria because they are representative of dry weather build up along the stream banks and park area. Post flush samples aid the understanding of the residence time of these nutrients and bacteria in Stannards Brook.

2.1 Field Sampling Program

Three water sampling events were conducted for this study, one in the summer (July 6, 2005), one in the fall (December 9, 2005), and one in the spring (April 4, 2008). As shown in Figure 1A, three stations were chosen along the length of the stream and visited for each sampling event (above outfalls, below outfalls, and at the discharge).

The 2005 year samples were collected by filling three pre-labeled bottles for nutrient analysis by EcoTest Laboratories and one pre-labeled jar for bacterial count analysis by

Nassau County Department of Health Laboratory (NCDHL). NCDHL and Ecotest are listed as New York State Department of Health certified laboratories. The 2008 year samples were collected by filling five pre-labeled bottles by EcoTest Laboratories for both nutrient and bacterial analyses. Upon collection, containers were stored on ice and delivered to the respective laboratories for analysis immediately following the sampling event under proper Chain-of-Custody documentation. A Chain-of-Custody form is filled out in the field during sampling and signed on arrival to the laboratory. It serves as a record of the sampling inventory, requested laboratory tests, and identifies the sample deliverer and laboratory recipient.

Water quality parameters were measured at each station during first and post flush samplings. Temperature, salinity, and dissolved oxygen were measured during the summer and fall events using a Yellow Springs Instruments (YSI) model 556 or 85. The pH readings were obtained using a YSI model 556 during the summer 2005 sampling event, and a ISFET pH meter model IQ120 during the spring 2008 sampling event.

Depth measurements were recorded for each station at time of collection using a standard meter stick. Flow velocities were measured at each station by recording travel time of a ping pong ball over a given distance.

2.1.1 Station Locations

Three sampling stations were chosen along the length of Stannards Brook (Figure 1A) and visited for each sampling event. These stations were approximately evenly spaced along the brook’s length; Station 1 was located at the head of the stream just below the PWWD outfall, Station 2 was located approximately mid stream below a series of stormwater outfalls, and station 3 was just prior to the grated discharge at the end of the SBPP grounds. Station locations were recorded during the fall sampling event using a Trimble GeoXT GPS and GPS coordinates are given in the table below.

Station	Latitude (North)	Longitude (West)
Station 1	40o 49’ 44”	73o 41’ 41”
Station 2	40o 49’ 43”	73o 41’ 48”
Station 3	40o 49’ 41”	73o 41’ 54”

2.1.2 Wet Weather Determination

Wet weather sampling was determined by a procedure which involved constant monitoring of satellite imagery and weather prediction internet websites such as the Weather Channel and the NOAA National Weather Service sites for Port Washington and Baxter Estates areas. It was important to have a rain event predicted to accumulate at least 0.5 inches of rain during a consecutive 6 hour period as well as have that rain event occur after a 4 to 5 day dry spell. It was also essential to be able to deliver water quality samples to the laboratories for analysis during their business hours and within 6 hours of field collection.

The summer sampling event occurred on July 6, 2005. As reported by the Weather channel website and the NOAA National Weather Service website, a total of 0.21 inches (0.67 cm) fell in the Port Washington area during the four day period prior to sampling. On the day of sampling, an observed total of 0.82 inches (2.11 cm) of rain fell in Port Washington. Sampling began at 11:02 AM and continued until 12:58 PM.

The fall sampling event took place on December 9, 2005. This storm was a mix of rain, sleet, and snow. The four previous days totaled 0.09 inches (0.22 cm) of rain in Port Washington. On the day of sampling, a total on 0.62 inches (1.54 cm) was observed. Sampling began at 1:07 PM and continued until 2:39 PM.

The spring sampling event occurred on April 4, 2008. According to the NOAA National Weather Service website, a total of 0.62 inches fell in the Port Washington area on the sampling date. Sampling began at 3:30 AM and continued until 6:00 AM. NOAA recorded no precipitation in Port Washington for the four days prior to sampling.

2.1.3 Sampled Parameters

Water quality parameters were chosen for this study based on their ability to characterize the current health of the Stannards Brook stream system and compare it with previous studies. For the purposes of this report, sampled parameters are grouped into three categories: bacteria, nutrients, and physical parameters. Parameters analyzed for this study were:

- Bacteria – Total Coliform, Fecal Coliform, and Enterococci
- Nutrients – Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Total Phosphate (TP), and Total Suspended Solids (TSS)
- Physical – Dissolved Oxygen (DO), Temperature, Salinity, pH, water depth, and flow rate

Coliform bacteria are a form of pathogens which are known to cause severe illness in humans when ingested. Pathogens can be traced to sources such as improperly treated or untreated sewage from combined sewage overflows (CSO), water fowl, animal waste, septic systems, and storm water runoff. To date, no practical method exists to accurately measure the presence of pathogens. Therefore, coliform and enterococci bacteria are used as an indicator organism because if they are detected in large quantities in a water sample, then they signal the potential presence of other more harmful pathogens such as viruses. Coliform is universally present even in pristine spring water. At high levels they indicate excessive decaying organic material in the water. Fecal coliform is a component of total coliform and indicates that there are mammal or bird feces in the water. Enterococci bacteria also indicate that there are feces from warm blooded animals (i.e. humans, dogs, etc.) in the water. The United States Environmental Protection Agency (USEPA) has determined that enterococci have a greater correlation with swimming-associated gastrointestinal illness in both marine and fresh waters compared to other bacterial indicator organisms.

Nutrients, which include total suspended solids, were also analyzed for this study. In proper quantities, nutrients sustain a thriving ecosystem. However, it is now known that the number one cause of impairment of lakes and coastal waters in the United States is nutrient enrichment. Excessive amounts of nutrients can lead to the growth of harmful algal blooms that use up the limited amounts of dissolved oxygen in a water body and ultimately cause eutrophic conditions creating an environment that can not support aquatic life. Nutrients primarily come from fertilizers, sewage treatment plants, animal manure, atmospheric deposition, and internal nutrient recycling from sediments. Total suspended solids are those particles that can be filtered out with a 0.7 micron filter and include silt and organic matter. An influx of TSS can reduce the useable habitat in an ecosystem as well as clogging fish gills, reducing visibility, and disrupting photosynthesis in submerged aquatic vegetation. [NYS - Nassau County 2004, USEPA 1986, Oasis Design website].

Dissolved oxygen is necessary to maintain a healthy aquatic ecosystem. Most marine biota utilizes oxygen that is dissolved in the water column. Many of these organisms are sensitive to dissolved oxygen concentrations and suffer when levels fall below ~ 5mg/L. As reported by Howell and Simpson (1994), "Although individuals may show sensitivity to low oxygen in the laboratory, mobile species may move out of hypoxic areas, and both sessile and mobile populations may develop behavioral or metabolic adaptations when chronically exposed to hypoxia". The USEPA (2000) has determined values of dissolved oxygen that will cause acute and chronic effects on aquatic life in the region of the Virginian Province (Cape Cod, MA to Cape Hatteras, NC). Chronic effects are those that negatively impact growth, while acute affects cause death. The recommended criteria define limits of dissolved oxygen based on continuous and cyclic (diel, tidal, episodic) exposure to hypoxic conditions. Hypoxia is defined by many regulatory agencies as DO <3 mg/L, the level below which many finfish and benthic species experience stress [Anderson and Taylor, 2001]. The proposed NYSDEC standards for acute exposure are never less than 3.0 mg/L and for chronic it is a duration exposure curve ranging between 1 day at 3.0 mg/L and up to 60 days at 4.6 mg/L.

2.2 Laboratory Analyses

Samples were collected Environmental Scientists at EEA, Inc. for bacterial count analysis and nutrient analysis. Upon collection, samples were stored on ice and delivered to the respective laboratories for analysis immediately following the sampling event under proper Chain-of-Custody documentation. In 2005, bacterial count analysis was conducted by Nassau County Department of Health Laboratory (NCDHL) and nutrient analysis by EcoTest Laboratories. In 2008, EcoTest Laboratories performed analyses for both the bacteria and nutrients. Both labs are New York State Department of Health certified laboratories.

2.2.1 Bacteria

Nassau County Department of Health Laboratory and EcoTest Laboratories analyzed total coliform, fecal coliform, and enterococci counts. Total and fecal coliform counts were analyzed using a multiple tube fermentation method. Enterococci counts were analyzed via membrane filtration. Results of these bacterial counts are listed per sampling station and flush time in Tables 3-5 for each of the seasonal sampling events.

2.2.2 Nutrients

Nutrient concentrations in milligrams per liter (mg/L) for Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Total Phosphate (TP), and Total Suspended Solids (TSS) were analyzed by applicable EPA analytical methods at EcoTest Laboratories. Ammonia, nitrate, and nitrite are all inorganic forms of nitrogen dissolved in aqueous solution. These compounds are accessible for plant uptake and in excessive amounts promote algal blooms. Total Kjeldahl Nitrogen (TKN) is the summation of ammonia and organic nitrogen. Organic nitrogen comes primarily from protein in either dead or live cells. Total nitrogen (Total N) is comprised of inorganic and organic nitrogen species and is the summation of TKN, nitrate, and nitrite. Results of nutrient concentration analysis are listed per sampling station and flush time in Tables 3-5 for each of the seasonal sampling events.

2.3 Data Results

Data analysis results for the water quality samples follow. Results are divided into three categories: bacterial counts, nutrient concentrations, and physical parameters.

2.3.1 Summer 2005 Sampling Bacterial Counts

Summer bacterial counts are listed in Table 3 and depicted graphically in Figure 3. Bacterial counts were always found to exceed NYSDEC or NCSWMP standards for all samples taken and at times by large amounts.

Total coliform counts ranged between 3,000 and 30,000 counts per 100 mL and averaged roughly 17300 counts per 100/mL. The highest total coliform reading was seen at Station 1 (head of stream) for both first flush and post flush samples. The lowest total coliform reading was seen during the post flush sampling at Station 2 (midstream). At station 1, total coliform counts remained identical during the first flush and post flush samplings. A first to post flush decrease of 5,000 counts/100 mL was seen at Station 2. The most notable change occurred at the discharge station (Station 3). Here, the post flush counts (28,000) increased by nearly 6 times above the first flush counts (5,000).

Fecal coliform counts were always less than total coliform counts and in some cases by an order of magnitude. This can be expected since fecal counts are a component of the total coliform counts. Fecal coliform counts ranged between 500 and 17,000 counts/ 100 mL with an average of 5600 counts/100 mL. The lowest counts were seen midstream at Station 2 during the post flush sampling and the highest counts were seen also during the post flush sampling at the discharge (Station 3). First flush and post flush fecal coliform counts varied for each station. A decrease of 2500 counts/100 mL from first to post flush was seen at Station 2. Station 1 measured a 5,000 count/100 mL increase between first and post flushes. As with total coliform counts at Station 3, fecal coliform counts rose significantly from first (2,300) to post (17,000) flush measurements, a 7 fold increase.

Enterococci counts averaged 34,500 counts per 100 mL ranging between 26,000 and 40,000. The highest and lowest counts were measured at Station 1 at the head of the stream with the lowest reading during the first flush sample and the highest during the post flush sample. A 1.5 fold first to post flush increase in Enterococci counts was seen at Station 1. A slight increase was also seen at Station 2 (1.12 times higher). Station 3 reported a 1000 count/ 100 mL decrease from first to post flush.

2.3.2 Summer 2005 Sampling Nutrient Concentrations

Summer sampling nutrient concentrations are listed in Table 3 and shown graphically in Figures 4, 5, and 6. Nutrients were analyzed here in three categories: 1) Nitrogen species [Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), and organic nitrogen], 2) Total Phosphate (TP) and 3) Total Suspended Solids (TSS).

Referring to Figure 4, it can be seen that the bulk of the total nitrogen inputs during the summer sampling are from nitrate. Concentrations were fairly constant for all stations. Nitrogen concentrations ranged between 2.8 and 3.7 mg/L. The most nitrogen rich station was at the discharge during first flush sampling. Variation exists spatially between first and post flush samples. At Station 1 a slight increase was observed while Stations 2 and 3 displayed a decrease between first and post flush samples.

As shown in Figure 5, total phosphate concentrations remained fairly consistent throughout the summer samplings. TP values ranged between 0.05 and 0.09 mg/L with an average of 0.07 mg/L. The lowest TP concentration was seen in the first flush sample at Station 3 (discharge). The highest concentrations were seen in the post flush samples for both Stations 2 and 3. All TP concentrations increased from first to post flush measurements. The most significant rise occurred at station 3 where a 0.04 mg/L increase was recorded.

Total suspended solids concentrations also remained fairly consistent throughout the summer sampling event (Figure 6). Values ranged from 3 to 6 mg/L with an average of 5 mg/L. The lowest TSS concentration was measured at station 1 during the post flush sampling. The highest concentrations were measured at the Station 2 post flush sample and at Station 3 during the first flush sample. Small changes in concentration from first to post flush samples were varied per station. A decrease was seen for stations 1 and 3 while an increase was seen at Station 2.

2.3.3 Summer 2005 Sampling Physical Parameters

Table 3 details the physical parameters measured in the field during the summer sampling event. Depths were varied for each station and sample session. In general, depths ranged between 9.5 and 28.6 cm and averaged 16.7 cm. An increase in depth from first to post flush measurements was found at stations 1 and 2 (3 cm and 6 cm respectively) while a decrease of 3 cm was seen at station 3.

Flow rates throughout Stannards Brook during the summer sampling event were low with an average of 3.7 cm/sec and a range from 2.3 cm/sec at Station 1 (first flush) to 5.2 cm/sec at Station 2 (first flush). A slight increase in flow rate from first to post flush measurements was noted for station 1 while a decrease in flow was seen at Stations 2 and 3. The most significant drop in first to post flush flow rate occurred at Station 2 with a change of 2.6 cm/sec.

The pH values recorded during the summer sampling event ranged from slightly acidic (6.71) to slightly basic (7.74) with an average pH of 7.45. No significant trend in pH values was detected for first to post flush readings. A minor increase of 0.12 was seen at Station 2 while a lesser decrease (0.03) was measured at Station 3.

Temperatures measured during the summer event averaged 17.5 degrees Celsius throughout the sampling with ranges between 15.3 and 18.82 degrees C. Temperatures at Station 1 were consistently lower by approximately 3 degrees C than those measured at Stations 2 and 3. A slight rise in temperature (roughly 0.4 degrees) was noted for all stations between first and post flush measurements.

Dissolved oxygen levels remained consistent throughout the summer sampling event. Concentrations ranged between 7.1 and 8.4 mg/L with an average of 7.8 mg/L. A minor increase in first to post flush DO levels was detected at station 1. While minor decreases were seen at Stations 2 and 3.

Salinity readings were all consistent through the summer sampling event. The range of salinity values varied only by 0.06 ppt and averaged 0.25 ppt.

2.3.4 Summer 2005 Comparison to NYSDEC Water Quality Standards

Tables 1 and 2 in Section 1.3 of this report list the NYSDEC standards for the applicable parameters (total and fecal coliform counts, pH, and dissolved oxygen) evaluated for this study. As stated in section 1.3 of this report, no NYSDEC standard for enterococci counts exist for class D or class SB waters and therefore the NCSWMP value of 33 counts/100 mL were used as a standard. Total and fecal coliform counts considerably exceed the NYSDEC standard in all cases of summer sampling. A similar exceedance is seen for the enterococci levels when compared to the NCSWMP standard. The physical parameters of pH and dissolved oxygen were all within the acceptable NYSDEC range.

Total coliform levels at the head of the stream (Station 1) during first and post flush samples measured 12.5 times above the acceptable limit. At Station 2, located midstream, total coliform counts exceeded the NYSDEC standard by 3 times during the first flush and a lesser amount of 1.25 times during the post flush sample. At Station 3, located at the discharge, initial first flush total coliform counts exceeded the NYSDEC standard by 2 fold and by nearly 12 times during the post flush sampling. The greatest exceedances of total coliform counts were noted above the outfalls (both flush samples) and at the discharge during the post flush sample.

Fecal coliform counts at Station 1 registered at 12.5 and 33 fold above the acceptable limit for first and post flush samples respectively. At Station 2, an exceedance of 12.5 was seen in the first flush sample while a lesser exceedance of 2 times was noted for the post flush sample. Station 3, at the discharge, showed an exceedance of 9.5 times for the first flush sample. The post flush sample at Station 3 had the greatest exceedance of 70 times the acceptable NYSDEC limit.

Enterococci counts were in exceedance of the NCSWMP standard for all summer samples. At minimum, these values were nearly 3 orders of magnitude (1000 times) above the 33 count/ 100 mL standard. Station 1 had both the least (first flush – 780 times above) and greatest (post flush – 1200 times above) exceedances recorded for the summer sampling.

2.3.5 Fall 2005 Sampling Bacterial Counts

Fall bacterial counts are listed in Table 4 and depicted graphically in Figure 7. Bacterial counts were always found to exceed NYSDEC or NCSWMP standards for all samples taken and at times by large amounts.

Total coliform counts ranged between 24,000 and above the laboratory detection limit of 160,000 counts per 100 mL. Excluding the Station 2 post flush counts (>160, 000 counts/ 100 mL), fall total coliform counts averaged 52,800 counts per 100/mL. The highest total coliform reading was seen at Station 2 (midstream) for the post flush sample. This is an unknown quantity, but at least 160,000 counts/100 mL. The lowest total coliform reading was also seen at Station 2 during the first flush sample. At Station 1, total coliform counts dropped by a factor of 3 between the first flush and post flush samplings. The most significant change occurred at Station 2, where a first to post flush increase of at least 6 times occurred. At the discharge station (Station 3) an increase by 3 fold was seen, this is the inverse of station 1 first to post flush total coliform counts.

Fecal coliform counts comprised a substantial component of the total coliform counts. Fecal coliform counts ranged between 5,000 and 160,000 counts/100 mL with an average of nearly 43,700 counts/100 mL. The lowest counts were seen midstream at Station 2 during the first flush sampling and the highest counts were also seen at Station 2 during the post flush sampling. First flush to post flush fecal coliform counts all rose significantly for each station. An increase of 2.3 times occurred at Station 1. The most substantial increase occurred at station two with a 32 fold rise from first to post flush samples. A lesser increase occurred at Station 3 with a change of 6,000 counts per 100/mL from first to post flush samples.

During the fall sampling event all of the enterococci counts were above the laboratory detection limit of 6,000 counts/100 mL.

2.3.6 Fall 2005 Sampling Nutrient Concentrations

Fall sampling nutrient concentrations are listed in Table 4 and shown graphically in Figures 8, 9, and 10. Nutrients were analyzed here in three categories: 1) Nitrogen species [Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), and organic nitrogen], 2) Total Phosphate (TP) and 3) Total Suspended Solids (TSS).

Referring to Figure 8, it can be seen that the primary source of total nitrogen inputs during the fall sampling are from organic nitrogen. Concentrations varied by as much as 2 mg/L. Nitrogen concentrations ranged between 2.2 and 4.2 mg/L. The most nitrogen rich station was at Station 1 (head of the stream) during the first flush sampling. Variation exists spatially between first and post flush samples. At Station 1 a decrease was observed while Stations 2 and 3 displayed an increase between first and post flush samples.

As shown in Figure 9, total phosphate concentrations remained within a small range (0.20 to 0.39 mg/L), however a trend of spatially decreasing TP values can be seen. The highest TP concentrations occur at station1 and the lowest occur at station 3. TP concentrations stayed constant from first to post flush measurements for Station 1. A slight first to post flush decrease occurred for Stations 2 and 3.

Total suspended solids concentrations are shown in Figure 10. Values ranged from 45 to 110 mg/L with an average of 70 mg/L. The lowest TSS concentration was measured at Station 3 during the post flush sampling. The highest concentrations were measured at the Station 1 during both flush samples. Changes in concentration from first to post flush samples were varied per station. While concentrations at Station 1 remained the same, a 10 mg/L increase was seen at Station 2 and a decrease of 11 mg/L was seen at Station 3.

2.3.7 Fall 2005 Sampling Physical Parameters

Table 4 details the physical parameters measured in the field during the fall sampling event. Depths were varied for each station and ranged between 8.9 and 15.2 cm with an average of 12.4 cm. Depth changes from first to post flush measurements varied for each station. An increase in depth was seen at Station 1 (1.9 cm) while a 3.8 cm decrease was seen at Station 2, and station 3 showed no change in first to post flush depths.

Flow rates throughout Stannards Brook during the fall sampling event were high with an average of over 48 cm/sec. Flow rates ranged from 37.5 cm/sec to 75 cm/sec. A decrease in flow rate from first to post flush measurements was noted for stations 1 and 3 while station 2 flow rates remained steady.

The YSI model 85 used for physical parameter sampling in the fall was not equipped for pH measurements.

Temperatures measured during the fall event averaged just above 3.5 degrees Celsius throughout the sampling with ranges from 2.7 to 4.2 degrees C. Temperatures at all stations showed a slight rise between first and post flush measurements.

Dissolved oxygen levels remained consistent throughout the fall sampling event. Concentrations ranged between 13.66 and 14.9 mg/L with an average of 14 mg/L. A minor increase in first to post flush DO levels was detected at station 1. While minor decreases were seen at Stations 2 and 3.

Salinity readings were all consistent through the fall sampling event. The range of salinity values were between 1.3 and 1.8 ppt with an average of 1.5 ppt. A decrease in salinity was seen for all stations when comparing first to post flush samples.

2.3.8 Fall 2005 Comparison to NYSDEC Water Quality Standards

Tables 1 and 2 list the NYSDEC standards for the applicable parameters (total and fecal coliform counts, pH, and dissolved oxygen) evaluated for this study. As stated in section 1.3 of this report, no NYSDEC standard for enterococci counts exist for class D or class SB waters and therefore the NCSWMP value of 33 counts/100 mL will be used as a standard. Total and fecal coliform counts considerably exceed the NYSDEC standard in all cases of fall sampling. A similar exceedance is seen for the enterococci levels when compared to the NCSWMP standard. Dissolved oxygen concentrations were all well within the acceptable NYSDEC range.

Total coliform levels above the outfalls at Station 1 during first and post flush samples measured 37.5 and 12.5 times above the acceptable limit. At Station 2, total coliform counts exceeded the NYSDEC standard by 10 times during the first flush and by at least 67 times during the post flush sample. At Station 3, initial first flush total coliform counts exceeded the NYSDEC standard by 12.5 fold and by 37.5 times during the post flush sampling. The greatest exceedances of total coliform counts were noted at station 2 during the post flush sample.

Fecal coliform counts at Station 1 registered 5.4 and 12.5 fold above the acceptable limit for first and post flush samples respectively. At Station 2, an exceedance of 2 was seen in the first flush sample and the greatest exceedance of the fall sampling set (66 times greater) was recorded for the post flush sample. Station 3 exceeded the NYSDEC fecal coliform count standard by 10 times for the first flush sample and 12.5 times for the post flush sample.

Enterococci counts were in exceedance of the NCSWMP standard for all fall samples. Since all counts were above the 6,000 count/100 mL laboratory limit, it can be said that all stations exceeded the NCSWMP standard by at least 180 times.

2.3.9 Spring 2008 Sampling Bacterial Counts

Spring bacterial counts are listed in Table 5 and depicted graphically in Figure 11. Bacterial counts were found to exceed NYDEC or NCSWMP standards for all samples taken, at times by an order of magnitude.

Total coliform counts ranged between 11000 and 460000 counts per 100mL and averaged 24000 counts per 100mL. The highest total coliform reading was observed at Station 2 (midstream) during the post flush sampling. The lowest total coliform reading was observed during the frist flush sampling at Station 2. At Station 1, total coliform dropped by a factor of 100 between the first flush and post flush samplings. The most significant change occurred at Station 2, with a first to post flush increase of at least 6 times occurred. At the discharge station (station 3) the first and post flush total coliform sampled were at the same level (24000). The pattern between Stations 1 and 2 suggests major movement of total coliform downstream between first and post flush samplings.

Fecal coliform counts comprised a minor component of the total coliform counts. Fecal coliform ranged from 460 to 11000 counts per 100mL with an average of around 5000 counts/ 100 mL. The highest fecal coliform readings were seen during the first flush sampling at Station 1 and during the post flush sampling at Station 2. The lowest fecal coliform reading was seen at Station 3 during both the first and post flush samplings. Between the first flush and post flush fecal coliform decreased at Station 1, increased at Station 2, and remained the same at Station 3. The fecal coliform shows the same pattern as the total coliform suggesting major movement of bacteria during the storm event.

Enterococci counts ranged from 460 to 11000 counts per 100mL with the average around 5000 counts/ 100mL. The highest enterococci counts were at Stations 1 and 2 during the first flush sampling. The lowest enterococci count observed was at Station 3 during the post flush sampling. All stations decreased in enterococci counts between first flush and post flush sampling.

2.3.10 Spring 2008 Sampling Nutrient Concentrations

Spring sampling nutrient concentrations are listed in Table 5 and shown graphically in Figures 12-14. Nutrients were analyzed in three categories: 1) Nitrogen species [Ammonia (NH3), Nitrate (NO3), Nitrite (NO2), and organic nitrogen], 2) Total Phosphate (TP), and 3) Total Suspended Solids (TSS).

Referring to Figure 12, it can be seen that the primary source of total nitrogen inputs during the spring sampling are from nitrate. Concentrations of nitrate ranged from 0.7 mg/L to 1.6 mg/L. There was a distinct pattern seen at all stations that nitrate decreased between first and post flush.

As shown in Figure 13, total phosphate concentrations decreased at all stations between the first flush and post flush sampling. Concentrations of total phosphate ranged from 0.065 to 0.16 mg/L. The station with highest total phosphate concentrations at each sampling time was Station 1 (head of stream). The station with the lowest total phosphate concentrations at each sampling time was Station 2 (midstream).

Total suspended solids concentrations are shown in Figure 14. Values ranged from less than 5 mg/L to 35 mg/L. The highest concentration of TSS was seen in the post flush at Station 2. During the first flush TSS decrease steadily between Station 1, 2 and 3. However, during the post flush Station 3 had slightly higher concentration than station 1; the most significant rise occurred at Station 2 with a 5-fold spike up to 35 mg/L.

2.3.11 Spring 2008 Sampling Physical Parameters

Table 5 details the physical parameters masured in the field during the spring sampling event. Water depths varied between each station and sample session; values ranged from

20cm to 29cm. Increases in water depth from first to post flush measurements were found at Stations 2 and 3.

Flow rates throughout Stannards Brook during the spring sampling event were high with an average of 71 cm/sec and a range of 51 to 102 cm/sec. Flow rates were measured during the post flush only due to equipment and site condition limitations. The most significant flow rate occurred midstream at Station 2.

The pH values remained fairly consistent throughout the spring sampling event, ranging from 6.4 to 6.6 with an average value of 6.5. All pH values are considered slightly acidic.

Temperatures measured during the spring sampling event averaged 7.8 degrees Celsius. Temperature readings at each station increased from first flush to post flush by 0.1-0.3 degrees Celsius.

Dissolved oxygen remained consistent throughout the spring sampling event. Concentrations ranged between 10.66 and 11.71 mg/L with an average of 11.31 mg/L. Dissolved oxygen concentrations at each station increased from first flush to post flush, with Station 1 having the most significant change.

Salinity readings were all consistent through the spring sampling event. The salinity values for all stations, first and post flush were zero ppt.

2.3.12 Spring 2008 Comparison to NYSDEC Water Quality Standards

Tables 1 and 2 list the NYSDEC standards for the applicable parameters (total and fecal coliform, pH, dissolved oxygen) evaluated for this study. As stated in section 1.3 of this report, no NYSDEC standard for enterococci exists for class D or class SB water and therefore the NCSWMP value of 33 counts/100 mL were used as a standard. Total and fecal coliform counts considerably exceed the NYSDEC standard in all cases of spring sampling. A similar exceedence is seen for the enterococci levels when compared to the NCSWMP standard. The physical parameters of pH and dissolved oxygen were within the acceptable NYSDEC range for all samples.

Total coliform level at the head of stream (Station 1) during first flush was 100 times the acceptable limit which decreased during post flush to 10 times the NYSDEC standard. At Station 2 total coliform counts exceeded the limit by 4.5 fold during first flush and nearly 200 fold during post flush. At Station 3, both the first and post flush exceeded NYSDEC standard by 10 times the maximum amount.

A fecal coliform count at Station 1 was 55 times the acceptable limit during first flush and 12 times during post flush. At Station 2 the first flush sample was 23 times the limit and the post flush sample escalated to 55 times the acceptable limit. Station 3 first and post flush counts both registered 22 times the NYSDEC maximum limit.

Enterococci counts were in exceedence of the NCSWMP standard for all spring samples.

2.3.13 Seasonal Comparison of Bacterial Counts

Comparisons between summer, fall and spring bacterial counts are shown graphically in Figures 15-17. Data for the summer, fall and spring bacterial counts are found in Tables 3, 4 and 5 respectively.

Figure 15 is a seasonal and spatial comparison for total coliform samples. No obvious spatial or seasonal trend exists for this data set; generally the summer values were low throughout compared to the other seasons. The greatest total coliform counts occurred during the spring at Stations 1 and 2.

Figure 16 is a seasonal and spatial comparison for fecal coliform samples. The fall fecal coliform levels were noticeably higher than the other seasons sampled with Station 2 levels over 10 times that of the spring and summer. The spring and summer values varied between stations and flushes but remained under 17000 counts per 100 mL.

Figure 17 compares seasonal and spatial bacteria counts for the enterococci samples. There were two noticeable trends. First, that the fall and spring enterococci levels were relatively consistent between stations and flushes compared to the highly variable summer sample. And second, that the spring enterococci levels were often over 5 times that of the fall and summer levels.

2.3.14 Seasonal Comparison of Nutrient Concentrations

Seasonal and spatial comparisons for nutrients were addressed in three categories: 1) Nitrogen species [Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), and Organic Nitrogen], 2) Total Phosphate (TP) and 3) Total Suspended Solids (TSS). These comparisons are shown graphically in Figures18-23.

Figure 18 shows high summer and low fall nitrate values for Stations 1 and 2; and high fall, low summer values for Station 3. Spring nitrate values remained average compared to the dramatic shifts in the summer and fall nitrate values. As expected, Figure 19 illustrates the opposite trends of Figure 18, as nitrate is reduced to the nitrite form. Figure 19 shows high fall, low summer nitrite values for Stations 1 and 2; and high summer, low fall nitrite values for Station 3. The data in Figure 20 exibihits a similar pattern to that in Figure 19, although most levels are at a decreased concentration.

Total phosphate concentrations (Figure 22) were consistently higher in the fall compared to the summer by nearly an order of magnitude. Spring phosphate values were similar or slightly higher than the summer values at each station.

Seasonal and spatial comparisons for first and post flush concentrations of total suspended solids are show in Figure 23. Much like total phosphate concentrations, fall TSS concentrations were on the whole much higher than summer and spring concentrations.

2.3.15 Seasonal Comparison of Physical Parameters

Tables 3 (summer), 4 (fall) and 5 (spring) list the values for the physical parameters measured during this study.

All water depths were within an agreeable range of values. The flow rates for the summer sampling were considerably lower than the fall and spring rates. Water temperatures were highest during the summer sampling and lowest during the fall sampling; all temperatures were within the normal range for each season. Salinity concentrations were much higher in the fall samples which may be attributed to the usage of deicing salts on the surrounding streets as observed during the fall sampling event. While no measurable salinity was recorded during the spring sampling, low levels of salinity were noted during the summer sampling. Dissolved oxygen levels were consistently 2 to 3 mg/L higher in spring compared to summer and in fall compared to spring. pH was more basic during the summer compared to spring with an average value of 6.5 for spring and 7.5 for summer.

2.3.16 Seasonal Comparison to NYSDEC Water Quality Standards

As stated in Sections 2.3.4, 2.3.8 and 2.3.12, all samples taken for this study greatly exceeded NYSDEC standards for total and fecal coliform counts as well as NCSWMP enterococci standards. NYSDEC standards for dissolved oxygen were met in all cases and pH concentrations were well within range for the summer sampling set.

3.0 Summary of Results

The most obvious water quality problem observed in Stannards Brook is the high influx of bacteria or pathogens during rain events. Bacterial counts for all sampling sessions were consistently well above the NYSDEC and NCSWMP standards for all water samples collected. Summer samples averaged 6 times above the NYSDEC total coliform counts standard and 23 times above the fecal coliform counts standard. Summer enterococci counts averaged 1000 times above the NCSWMP standard. Fall samples averaged 30 and 18 times above the NYSDEC total and fecal coliform counts respectively. Exact enterococci counts were inconclusive during the fall; however, an average exceedance of at least 180 times the NCSWMP standard was detected. Spring samples averaged 50 times and 25 times above the NYSDEC total and fecal coliform counts respectively. Spring enterococci counts averaged above 150 times above the NCSWMP standard.

Bacterial and nutrient input levels on a per station basis are similar within each sampling event. With the limited data set collected for this study it is difficult to pin point an exact station that is the primary contributor along Stannards Brook.

Seasonally, bacterial counts are similar. Nitrogen inputs are of similar total concentrations however they are comprised of differing species. Inorganic nitrogen dominates the summer samples because during that time plants are growing and biological uptake of nitrogen is greatest. The fall season nitrogen composition changes to a concentration rich in organic nitrogen. This can be attributed to a fresh leaf litter in the early stages of decay. In addition, at that time of year, flora is in a biologically dormant state, basically shutting down photosynthetic processes and therefore not up-taking the readily available nutrients. This is also seen when looking at the total phosphate concentrations. Phosphate is a limiting nutrient necessary for biological growth. Starting in the spring phosphate is utilized by plants during the growing season. In the summer, almost all phosphate is incorporated into plant material. Fall phosphate concentrations are much higher overall again attributing to a biologically dormant state. Total suspended solids are also correlated to seasonal change in that more sediment is trapped by the vegetative buffer during the growing season reducing in lower TSS values in summer compared to fall.

4.0 Discussion and Conclusions

As stated previously, there is no clear cut location at which nutrient inputs are the greatest. Rises and falls of bacterial counts or nutrient concentrations between first and post flush events can be attributed to residence time in Stannards Brook or as distance from the source. Residence time is a calculation based on the theory that a bacterial or nutrient concentration could be tracked from its influx location to the end of the Brook. For example, an upstream concentration of bacteria could be seen to increase at downstream locations overtime, because the bacteria is traveling with the flow of water downstream. Distance from the source means that a concentration measured in the Brook during the first flush could be seen to increase in the post flush sample simply because it was still traveling overland to the Brook. Take station 2, at midstream as an example. Initial first flush concentrations could be lower than post flush simply because of the time required to travel from the streets surrounding Stannards Brook.

The major problem elucidated by this study is the significant bacterial loading into Stannards Brook occurring during rain events. All samples taken were above the acceptable standard for bacterial concentrations.

In the Nassau County Storm Water Management Program Dry Weather Flow Study of 2004, Stannards Brook registered high levels of fecal coliform (> 2400 counts/ 100 mL) as well as high levels of enterococci bacteria (> 33 counts/ 100 mL) in both the summer and fall of 2003. These values are consistent with the bacterial counts documented in this report for the summer and fall of 2005 and the spring of 2008.

5.0 Recommendations

1. While local dry weather data is available for wet weather sampling comparison, no on-site baseline has been calculated. A comprehensive water quality sampling program could shed light on what locations are the true source contributors of pollutants to Stannards Brook. This should include four season water quality sampling for both dry weather and wet weather events in an expanded spatial setting (i.e. more sampling stations including, samples directly from pipe outfalls). In order to understand input timing, the sampling method should also allow for simultaneous water sample collections at each station versus sequential sampling as was done for this study.

2. Due to the present observable condition (corrosive, rusty appearance) of the septic pipes within the Brook, it is recommended that dye tracers are utilized to attest that the pipes are within a closed system operating to state and county standards.

3. Since 2005, signs prohibiting dog walking have been prominently posted throughout the park. However, dog walking and dog waste were observed at multiple points during the spring 2008 reconnaissance. Therefore, it is suggested to either have a presence to enforce the regulation or instate a Pooper Scooper ("Clean up after your pet") program to reduce domestic pet generated bacterial loads to Stannards Brook and ultimately in Manhasset Bay. This could be done through park user education as well as with trash receptacles that have plastic "doggy" bags and signage within the SBPP telling owners to pick up what their pets leave behind. Additionally, Nassau County Local Law 7-2007 was passed in 2008 prohibiting the feeding of waterfowl in the county. This regulation should also be readily enforced in the park to reduce fecal contributions from artificial wildlife.

4. Nassau County should coordinate with the local officials and interests groups like Town of North Hempstead and/or the New York Sea Grant Nonpoint Education for Municipal Officials (NEMO) program and invite their participation in a series of public outreach sessions. Public education and outreach topics that could be used to minimize illicit discharges into Manhasset Bay via Stannards Brook are:
   1. The nitrogen influx effects of lawn fertilizers on Manhasset Bay
   2. The effects of at home car washing and vehicle fluid changing
   3. The effects of bacterial loads in surface waters as a result of domestic pet waste and feeding of waterfowl

5. In addition, stenciling "Manhasset Bay Drainage" on curb inlets that discharge directly into the Bay can increase public awareness as to the effects of nonpoint pollution on Stannards Brook and Manhasset Bay.

6. To control the effects of non-point source pollution caused by runoff from abutting dead end streets at the north side of the Brook, the use of leaching catch basins along the upper reaches of the streets would be a worthwhile endeavor. These basins could serve to trap sediment (and pollutants bound to them) before reaching the Brook. In addition, these structures would serve as energy dissipation devices when stormwater runoff enters the structures, and then overflow when the leaching basin capacities have been exceeded. Vegetative strips created at the street end could be used as an alternative or supplement in order to trap sediment and pre-treat the water quality flow into the Brook.

7. Concern for invasive species within the Stannards Brook Park Preserve, and a desire to restore the natural areas of the park were stated in the Stannards Brook Park Preserve Master Plan. An ecological inventory and assessment should be conducted to identify the invasive species in the Preserve and the extent of the affected area. Nassau County should coordinate with the Nature Conservancy and

the Long Island Weed Management Area task force to develop a long-range weed control plan for the Park. This would include prioritizing the list of invasive species identified on-site, addressing the "early detection" and eradication needs first, and controlling the off-site spread of invasive species.

8. While Stannards Brook may have historically trickled through a shallow drainage channel; the channel morphology is now characteristic of a flash-type urban stream that has outgrown its natural banks. Failed timber cribbing along the banks, deep channel scour, undercut banks and coarse sediment deposits all reflect the impacts of increased urbanization in the watershed. Some stormwater control best management practices to consider include: selective tree thinning and removal, widening the drainage channel by removing sediment deposits, cutting back the upper banks to allow for minor overflow, and stabilizing the channel banks with proven bioengineering techniques such as living crib wall and vegetated erosion control mats.

9. In order to fully address the water quality improvement needs for Stannards Brook, the watershed defined and mapped by Nassau County (Figure 1C) needs to be applied and the land uses within identified along with potential nonpoint source pollution generators. Within the watershed current conditions, capacities, and GPS locations of stormwater conveyance systems and disposal features such as catch basins, leach pools, vertical drains, etc. should be identified. These items should be added to the digital map created by Nassau County to enhance our understanding of the Stannard Brook as an important city tributary and assist in future decision making processes.

10. In conjunction with a watershed reconnaissance and increased water quality sampling, additional analysis should be conducted to determine what improved treatment measures could feasibly be implemented. This might include site investigations at recurrent problem areas and vacant parcels to determine whether potential exists to implement additional stormwater collection, treatment, filtration, and/or controls. Treatment mechanisms could include planning measures, bioengineering solutions, and or structural component installations.

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