WATER QUALITY TESTING

AT MULTIPLE SITES ACROSS THE NEW YORK HARBOR ESTUARY TO ASSESS THE FEASIBILITY OF + POOL WATER FILTRATION

JUNE 1 – OCTOBER 2, 2015

November 20, 2015

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EXECUTIVE SUMMARY

Between July 1st and October 2nd 2015, Friends of + POOL tested the water quality in the East River at four sites around New York in order to asses the feasibility of + POOL's proprietary filtration system. The sites tested were Hallet's Cove in Astoria, Queens, Transmitter Park in Greenpoint, Brooklyn, Domino Sugar Factory in Williamsburg, Brooklyn and Governor's Island. The testing was a continuation of water quality testing done at Brooklyn Bridge Park in Brooklyn in 2011 and Pier 40 Hudson River Park in Manhattan in 2014.

Over 300 samples were analyzed and 1,407 tests conducted, resulting in over 3,000 water quality measurements. The 2015 + POOL testing program is believed to be the most intensive and detailed water quality testing program conducted over such a large stretch of river in the NYC area.

Despite observing unique water quality characteristics, the data and analysis at all four sites showed that each site would be feasible for + POOL filtration. Values for the parameters examined for each site remained fairly stable during the testing period, although daily fluctuations based on factors such as weather did occur. Following extreme weather events, such as rainstorms, increases in the values for turbidity, total suspended solids, color (true and apparent), conductivity, derived salinity, and Enterococcus were often observed - frequently returning to a stable condition within two days after the occurrence of such an event.

Amongst the four sites, Governor's Island showed the highest average level of enterococcus at 504.86 cfu/100ml, the primary parameter in relation to swimmability as defined by EPA swimming standards. The high average was due to an as-of-yet unexplained spike in measured bacteria from August 20th to September 3rd. The average at Governor's excluding the anomaly was 66.25 cfu/100ml. Hallet's Cove was the second highest at 97 cfu/100ml, followed by Transmitter Cove at 34.72 cfu/100ml and Domino Sugar Factory the lowest at 26.72 cfu/100ml.

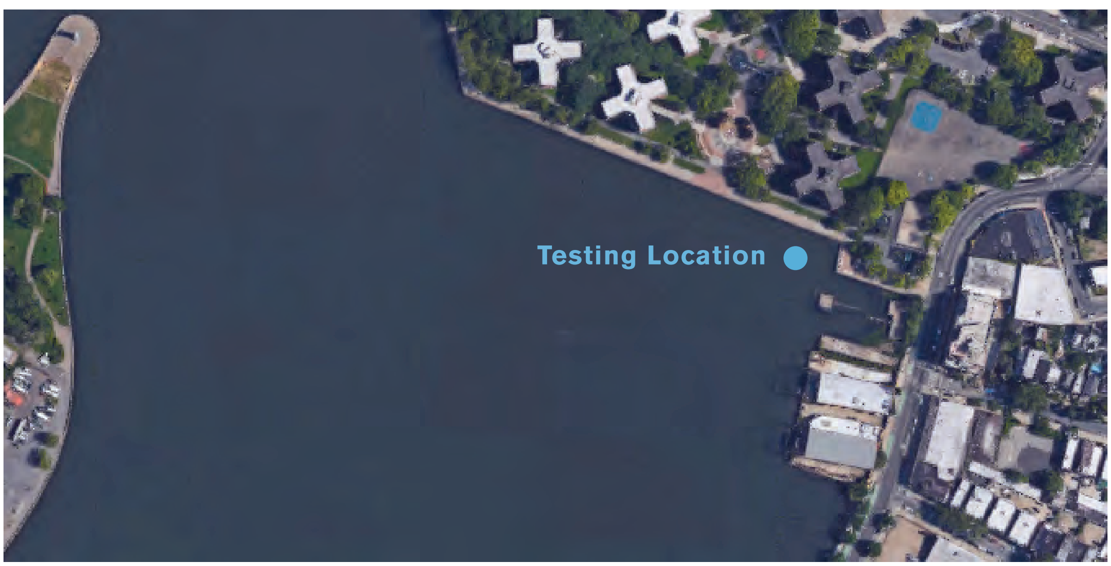
In conclusion, the results of the testing showed that all four sites are feasible from a + POOL filtration standpoint and water quality is not a determining factor in selecting the most appropriate site for the first + POOL.

TESTING SITES

Hallet's Cove

Hallet's Cove is located along the East River at the border of Astoria and Ravenswood. This site is within one block away from the Socrates Sculpture Garden and next to Goodwill Park with impressive views of Roosevelt Island and the Upper East Side. The location for this site (30-01 Vernon Blvd) is not very easy to access although it is about 40 minutes away from Times Square. Connections are available by the N and Q trains as well as the Q103 bus. Astoria Park Pool is approximately 15 minutes away.

Hallets Cove (avg. depth 13ft) is in a fairly well sheltered location and well out of reach of the navigable channel (~ 1600 ft). The average current at this location is 2.8 knots and the location supports space requirements for the +Pool (510,000 square feet in available area). The closest CSO is Tier 3.

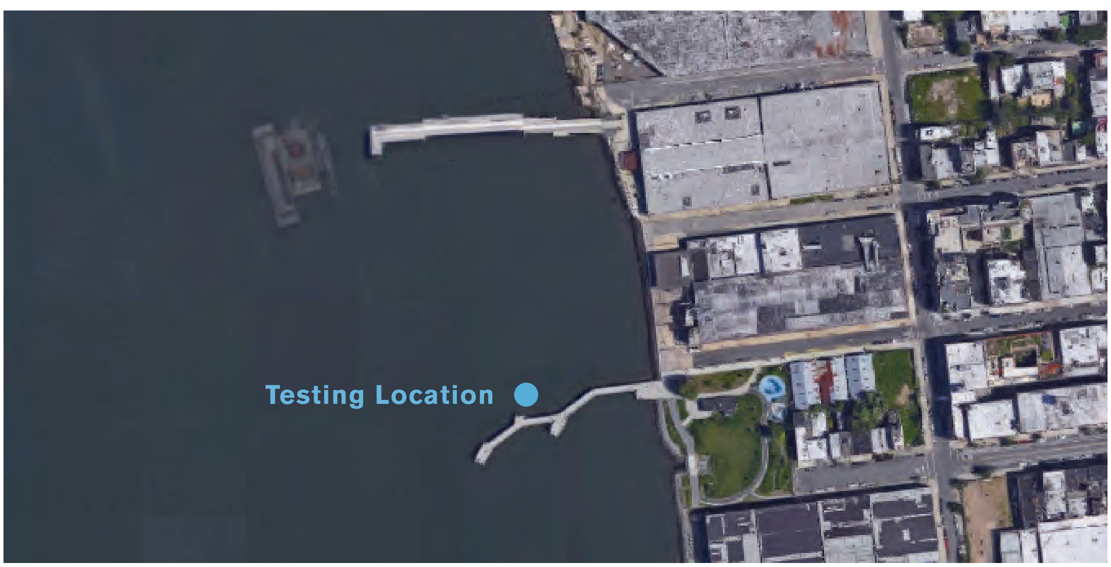


Testing Sites

Transmitter Park

WNYC Transmitter Park was opened in 2012 in the Greenpoint-Williamsburg area as a 1.5 acre waterfront park. Previously the location was home to two WNYC radio transmission towers that moved to the Meadowlands in 1990 when they switched over to broadcasting an AM frequency. In 2010, the City began what would be a $12 million dollar redevelopment project at the site that opened in September 2012. The area supports a green space with natural areas to enjoy all sorts of activities and active recreation -- even fishing. The park boasts views of the Empire State building and the United Nations as well as much of the East side of Manhattan and NYC skyline. Transmitter Park is accessible via the G, E, R, and F trains, and the East River Ferry. This site is about 30 minutes away from Times Square and is within one mile of McCarren Park Pool.

Transmitter Park (agv. depth 34 ft) is located in an exposed stretch of the East River and is within 650 feet of the navigable channel - including an active East River Ferry terminal. The average current is 1.9 knots due to the width of the river at this location which has an available area of 150,000 square feet. The closest CSO is Tier 4.

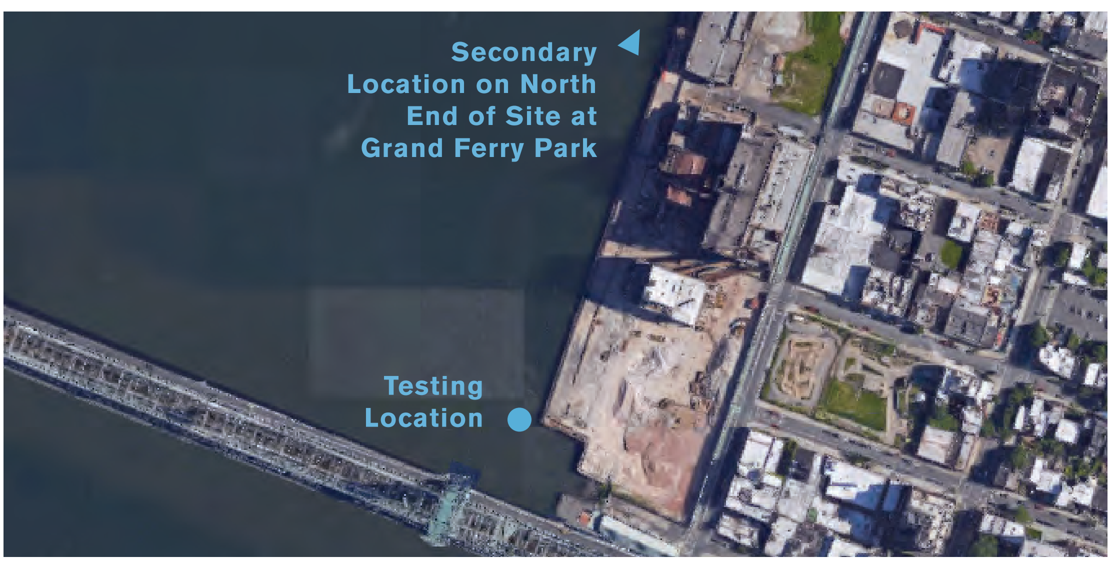


Testing Sites

Domino Sugar Factory

The Domino Sugar Refinery, located in Williamsburg, Brooklyn was originally built in 1882 with the oldest building still standing. At one point (1870), the refinery processed over half of all the sugar used in the United States and in 2004 after operating for 148 years the factory was shut down. In 2007 three of the refinery buildings were given landmark status with the rest of the site being actively converted for residential use by the Two Trees Management company with plans to reconnect the South Williamsburg area to the waterfront with parkland and a public esplanade. This site is easily accessible via. the L, E, R, and F trains as well as the East River Ferry. The site is about 30 minutes from Times Square and is within 20 minutes of the McCarren Park Pool and 8 minutes from the Metropolitan Recreation Center.

The location for the Domino Sugar factory (avg. depth 35 ft) is located in a narrow area of the East River, just North of the Williamsburg Bridge. This site boasts impressive views of Manhattan, capturing several bridges, the Freedom Tower, the Empire State Building, Governors Island, the Statue of liberty, among many others. This site is within 290 feet of the navigable channel and experiences an intense current that averages 2.9 knots. Due to the narrowness of this location and the presence of the Williamsburg bridge, vessel traffic is heavily concentrated near the proposed site for the +Pool, which has an area of approximately 232,000 feet. The closest CSO is Tier 4.

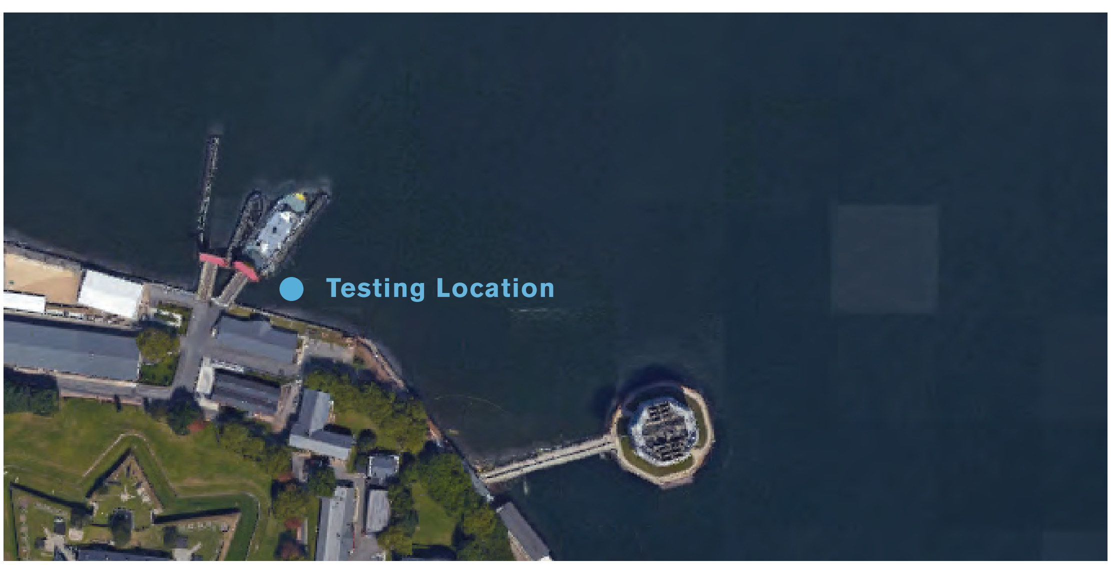


Testing Sites

Governor's Island

Governor's Island is a 172-acre island in the upper portion of New York Bay and is located roughly 800 yards from the southern most point of Manhattan. The Island is legally considered to be part of the borough of Manhattan and has a long history that includes three historical military installations and fortifications ranging from the American Revolutionary War where Continental troops fired upon British ships to being a US army outpost (1783-1966) and a United States Coast Guard base (1966-1996). Part of the Island (~22 acres) was declared to be a national monument in 2001 and this portion is administered by the National Parks Service. In 2003, the City of New York acquired 150 acres of the island for $1 which is overseen by The Trust for Governor's Island. The Island is open to the public throughout the summer and early fall and is accessible by the Governors Island Ferry service from Manhattan (weekdays and weekends) and Brooklyn (weekends only). This site is approximately 50 minutes from Times Square, including a 15 minute ferry trip. The Island boasts incredible views of lower Manhattan and iconic New York landmarks.

Governor's Island (avg. depth 7 ft) is located in the upper portion of the New York Harbor at the entrance of the East River. The site is situated in an exposed and heavily trafficked area - including the Governors Island Ferry terminal and is often subjected to multiple currents (2.4 knot avg.). There are no CSOs nearby.



METHODOLOGY

Summary

Water samples were collected, tested, and analyzed at each site Monday-Friday beginning July 1st and ending October 2, 2015. For the month of July, two samples were taken from both the northern and southern ends of Domino to determine if results would be affected by nearby construction. It was ultimately determined that any construction related effects were negligible. Testing at Hallet's Cove was suspended after July due to a lack of resources to be able to continue sampling throughout the summer.

Sampling at many of the sites presented a challenge due to the limited availability of access to waterfront locations in the New York City area. None of the sites allowed for direct access or entry to the river and all samples were taken from a height of between 5-15 feet (tide dependent) from seawalls and elevated walkways. To resolve these issues and to obtain the most representative samples possible, surface grab samples were conducted using a two gallon bucket attached to a 50' rope. Samples taken at sites such as Hallet's Point, the Domino Sugar Factory, and Governors Island were often subjected to enhanced site dynamics that included increased current, eddies, swells, shoreline rise, and the accumulation of detritus which were a result of samples being taken in close proximity to seawalls - although the effects of such were not so extreme as to drastically affect the results derived from the samples taken (ie. they were still representative of each location).

Ultimately, the objective of sampling was to collect a specific amount of water small enough in volume to be transported conveniently to the water quality lab while remaining large enough for analytical purposes (about 500ml for general analysis and 10ml for bacterial testing) and still accurately representing the water in the area that is being sampled. Water quality sampling protocols were adapted from Standard Methods for the Examination of Water and Wastewater in an effort to obtain samples that met the requirements for the feasibility study and so that the samples were handled in such a way so that they did not deteriorate or become contaminated before analysis. To ensure this, the technicians followed a strict sampling protocol that included:

Methodology

- Cleaning all sampling equipment prior to use and ensuring that all containers (500ml collection containers and 15ml sterile centrifuge tubes) were clean and free of contaminants before collection a sample from any location.
- Filling each container completely so as to limit mixing and aeration of the sample as much as possible. Sample containers did not contain any preservatives, such as sodium thiosulphate.
- Each sample was recorded with a location (fixed sampling points), date, and time. Additionally, each sample was given a unique identifier which was used to track each sample throughout the testing process.

Manual grab samples were used as the method of collection at each site. Grab samples were collected daily at the same approximate time for each location and analyzed within hours to document the extent, frequency, and duration of any variations in water quality at a particular location. For this study, samples were not preserved other than being kept cool and protected from solar radiation (shielding and the use of opaque collection bottles) in an attempt to retard any chemical or biological changes before analysis could be conducted.

Since some parameters such as pH can be affected by changes in temperature, the basic properties of water samples were recorded on site - these included pH and water temperature as well as environmental information such as current direction, observed weather conditions, the amount of precipitation, and tidal height.

Methodology

Schedule

Water quality testing took place daily Monday–Friday between July 1–October 2, 2015.

In the month of July, testing took place at Hallet's Cove, Transmitter Park, Domino Sugar Factory and Governor's Island.

In the months of August, September and beginning of October, testing took place at Transmitter Park, Domino Sugar Factory and Governor's Island.

On testing days, water samples were collected from each site moving north to south throughout the morning hours. Samples were then taken to the River Project test labs to be analyzed within 24 hours of their collection.

Methodology

Equipment List

- Lamotte 220we portable turbidimeter / nephelometer
- Graduated cylinder
- Glass-fiber filter disk
- 500ml Thermo Scientific Nalgene Polysulfone (PSF) filter holder
- Deionized water
- 5psi hand vacuum pump
- Aluminum weighing dish
- Toaster oven
- Electronic bench scale
- Hach DR890 portable colorimeter
- Graduated syringe
- 1 micron (μm) Millex syringe filter
- Fisher Scientific accumet Excel bench pH and Conductivity meter
- Portable handheld pH probe
- Enterolert® Quanti-tray® 2000
- Enterolert® reagent
- UV lamp
- 41C incubation oven
- Quanti-Tray sealer

Methodology

1. Turbidity

Turbidity is a measure of the cloudiness of water and is a good indicator of water quality because it allows us to determine how much material is suspended in the water. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, algae, plankton and other microscopic organisms. While turbidity has no direct effect on human health, it can make filtration of water more difficult as well as acting as a possible medium for microbial growth (increased turbidity is often correlated with increases in bacteria, viruses, parasites, and other disease causing organisms). High levels of turbidity can increase the temperature of the water since many suspended particles in the water column will absorb heat from the sun. This in turn can reduce the amount of available oxygen in the water as well as the sun's ability to penetrate the surface of the river which can have negative consequences for fish and other creatures. Additionally, high levels of turbidity can also affect the color, smell, and texture (gritty) of the water making it feel gross to swim in.

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the sample. For the 2015 site feasibility study a turbidity meter (Lamotte 220we portable turbidimeter / nephelometer) was used to measure the amount of particles in the water (recorded in Nephelometric Turbidity Units) which has the ability to provide good indications based on the intensity of light scattered in one particular direction, predominantly at right angles to the incident light. The unit (with a range of 0-4000 NTU) also utilizes multiple photoelectric cells designed to minimize stray light and color interferences. The correlation of turbidity with the weight or particle number concentration of suspended matter is difficult because the size, shape, and refractive index of the particles affect the light-scattering properties of the suspension - as a result, our researchers also conducted analysis for Total Suspended Solids (described later) and submitted samples to another lab (Micromeritics Analytical Services) for Particle Size Distribution Analysis.

Turbidity analysis was conducted at Pier 40 as soon as the samples arrived at the field station. It is ideal for turbidity to be analyzed as soon as possible after a sample

Methodology

is taken to prevent any changes due to biological (ie. algae growth), chemical activity, or physical activity (ie. particle dissolution, since water has the potential to act as a solvent).

Testing Procedures

To conduct this test, the sample collection container from a particular site was agitated to break up any aggregates and ensure homogeneity within the container. Then a small portion (about 10ml) of sample is poured off into a sample tube which is then wiped to remove any condensation or moisture - condensation may occur on the outside surface of a sample cell when a cold sample is being measured in a warm, humid environment and this interferes with turbidity measurement. After inserting a 0 NTU standard and zeroing the unit to ensure that the turbidity meter will read the sample accurately, the sample is then placed into the unit and read at least three times. These values are recorded on a lab sheet and then averaged to produce a final turbidity value for the sample. This process is then repeated for each sample collected after the sample tube is rinsed at least three times with deionized water.

To ensure a level of quality control, generated values are compared to values from other tests conducted. If there is any indication that a value is above or below an expected norm, the test is repeated using another aliquot from the same sample collection container. Duplicate tests are also run randomly to ensure that values are accurate. The turbidimeter / nephelometer is also “zeroed” after each sample is tested.

Methodology

2. Total Suspended Solids (TSS)

Total Suspended Solids is a measure of the amount of solids that remain suspended in a solution. This test complements turbidity analysis since the correlation of turbidity with the weight or particle number concentration of suspended matter is complicated due to particle size, shape, and ability to refract the light used in that particular test (different solids absorb more light or are too large and are not read accurately by the nephelometer). TSS is a way to capture the amount of particles that remain suspended in a solution (not dissolved) and is represented by the weight of those particles (in milligrams) in one liter of water: mg/L. High values for TSS can increase the difficulty of filtration, since there is more suspended material in the water which may clog membranes and filtration materials as well as act as a substrate for bacterial growth - similar to high values of turbidity.

Testing Procedures

To conduct an analysis for Total Suspended Solids, a well-mixed 100ml sample (aliquot) from the sample collection container from a particular site (again agitation is designed to break up any aggregates and ensure uniformity within the container) is measured in a graduated cylinder. A pre-prepared* glass-fiber filter disk is inserted into a 500ml Thermo Scientific Nalgene Polysulfone (PSF) filter holder and receiver (fitted with a graduated funnel) and then seated in place with deionized water. The 100ml of sample water is then added to the graduated funnel (volume is checked once again) and then pulled through the filter under a 5psi vacuum applied by a hand vacuum pump. Any lingering particles are washed into the filter with deionized water which is removed through the application of vacuum suction. The filter is then carefully removed from the filter apparatus and placed in an aluminum weighing dish to be dried for one hour at 103-105 °C. Once the filter is dry, it is weighed on a stabilizing balance. This weight is recorded and compared to the weight of the dry pre-prepared filter (before the addition of aliquot) - the difference between the two is the weight of total suspended solid residue in grams. This weight is then added to a mathematical formula which converts the weight to miligrams and volume of water (100ml) to Liters - resulting in mg/L. This process is then repeated for each sample.

Methodology

TSS (mg/L) = [(Final weightg - Initial Weightg) x 1000]/(sample volume in liters)

*Glass-fiber filter disks have been washed with three successive 20ml portions of deionized water which is removed from the filter by use of the vacuum apparatus. Once all traces of water are removed from the disk, it is dried for at least one hour at 103-105 degrees Celsius in an aluminum weighing dish and then cooled in a dessicator overnight to ensure that all moisture is removed. The pre-prepared filter disk is weighed before the application of aliquot and this value is recorded to compare with the weight of the filter after a sample has been passed through it.

Methodology

3. Color Apparent

directly related to turbidity since water clarity is determined by the amount of available light penetration into the water, the amount of suspended and dissolved particles and solids in the water, and the color of dissolved organic materials. The presence of salts can also affect the clarity of water as higher levels of salt ions can increase the aggregation of suspended particles, increasing their weights and settling ability. Coloration in water can be the result of natural processes (algae growth and productivity, mineral weathering, natural metallic ions, etc.) or human actions (pollution, industrial waste discharge, etc.) and is highly depended upon the amount of suspended or dissolved material. Water color is an important water quality parameter (and a descriptor of clarity) as it can be used as an indicator for any changes in a water body - caused by natural processes or human actions such as pollution. Color Apparent is a term used to describe a water source (or sample) as it appears - this includes all suspended and dissolved particles.

Testing Procedures

To conduct this test, the sample collection container from a particular site was agitated to break up any aggregates and ensure homogeneity within the container. Then a 25ml aliquot of sample is poured off into a sample tube which is then wiped to remove any condensation or moisture - condensation may occur on the outside surface of a sample cell when a cold sample is being measured in a warm, humid environment and this interferes with turbidity measurement. After inserting a standard, consisting of filtered deionized water which contained no color (0 Pt/Co), to ensure that the colorimeter will read the sample accurately, the sample is then placed into the unit and read at least three times. These values are recorded on a lab sheet and then averaged to produce a final color apparent value for the sample. This process is then repeated for each sample collected after the sample tube is rinsed at least three times with deionized water. The colorimeter is also “zeroed” after each sample is tested.

Methodology

4. Color True

Color True is a term to describe water color once suspended materials have been removed, with only dissolved particulate matter remaining. In the 2015 site feasibility study, a Hach DR890 portable colorimeter was used to generate water color values using the Platinum-Cobalt (Pt/Co) color scale (also referred to as a Apha-Hazen scale) for both color apparent and color true.

Testing Procedures

To conduct this test, the sample collection container from a particular site was agitated to break up any aggregates and ensure uniformity within the container. Then a 25ml aliquot of sample is poured off into a graduated syringe which is used to filter the aliquot through a 1 micron (μm) Millex syringe filter into a sample tube. The sample tube is then capped and is wiped to remove any condensation or moisture. After inserting a standard of 0.45 Pt/Co water, to ensure that the colorimeter will read the sample accurately, the sample is then placed into the unit and read at least three times. These values are recorded on a lab sheet and then averaged to produce a final color apparent value for the sample. This process is then repeated for each sample collected after the sample tube and syringe are rinsed at least three times with deionized water. The colorimeter is also “zeroed” after each sample is tested.

Methodology

5. pH

In chemistry, pH (power of Hydrogen) is a numeric scale of the molar concentration of Hydrogen ions in a solution. It is expressed as a numeric scale from 0-14 (with 7 being considered neutral) and is used to specify how acidic or alkaline (basic) is a solution. Any value less than 7 is considered acidic (battery acid has a concentration of about 0-1) and any value greater than 7 is considered to be basic (household bleach has a concentration of about 13). pH is an important water quality parameter as changes in pH can indicate things such as sewage overflows or additional runoff entering a waterway, that there may be increased bacterial activity, or that there may be an algal bloom. All of these things can affect water quality in negative ways. The average pH for natural river waters ranges between 6.0 and 8.5 with pH values below 4.5 or higher than 9.5 being lethal to aquatic organisms. Additionally, pH is a determinant of how the water might feel to someone swimming in it - if the pH is too high (ie. the water is too alkaline or basic) then the water might feel gross, slimy, and slippery (almost like the feeling of bleach). High pH can also increase calcium buildup on surfaces and cause the water to become cloudy. For humans, contact with substances that have a pH over 11 or under a pH of 4 can cause skin, eye, and mucous membrane irritation. However, these values are highly unlikely to be encountered in freshwater systems, although acidic conditions (anything below a pH of 7) increase the levels of heavy metals as it tends to cause them to leach from structures and pipes. Additionally, acidic conditions may cause increased wear on infrastructure, surfaces, machinery, and filtration substrates through corrosion and erosion of materials as well as making swimmers feel dry and itchy after swimming.

Testing Procedures

For the 2015 site feasibility study, a Fisher Scientific accumet Excel bench pH and Conductivity meter was used to measure pH at the Pier 40 water quality lab. pH was also measured with a portable handheld device in the field since it is a highly temperature dependent parameter. These two values were recorded along with the temperature of the water at the time of pH reading. To take these readings, a small portion of sample water was poured into a 15ml beaker into which a pH probe was inserted. After achieving a stable reading, the value was recorded directly from the

Methodology

main unit (lab) or from the handheld device (in the field). After rinsing the probe with deionized water, this process was repeated for all samples. The portable handheld pH probe was calibrated with standardization solutions of known pH at the beginning of every week to ensure accurate readings. The lab unit was calibrated at the beginning of every month along with the incorporated conductivity probe.

Methodology

6. Specific Conductivity and Derived Salinity

Conductivity and salinity are two water quality variables that are closely linked together. Salinity is an expression of the measure of dissolved salts in water and can be quite complicated and time consuming to measure - often through complete chemical analysis. Salinity by itself is often expressed as a unitless value, however values that are based on conductivity are often followed by the units PSU (Practical Salinity Unit) or PPT (Parts Per Thousandth). Conductivity on the other hand is a measure of the waters ability to conduct an electric current and this measure can be used to derive the concentration of salts (dissolved ions) in water depending on temperature and ion presence, concentration, mobility, and valence.

The salinity of water can alert us to changes in river conditions as well as events such as increased urban runoff and sewer discharge as the concentration of dissolved mineral salts typically increases with these types of events which tend to decrease general water quality. In the 2015 site feasibility study, specific conductivity was measured directly using the Fisher Scientific accumet Excel bench pH and Conductivity meter in mS/cm. Salinity was then derived based on the values for converted specific conductivity (uS/cm).

Testing Procedures

For the 2015 site feasibility study, a Fisher Scientific accumet Excel bench pH and Conductivity meter was used to measure conductivity at the Pier 40 water quality lab. To take these readings, a small portion of sample water was poured into a 15ml beaker into which a standardized conductivity probe was inserted. After achieving a stable reading, the value was recorded directly from the unit interface along with the temperature which is an integrated function of the probe. After rinsing the probe with deionized water, this process was repeated for all samples. The specific conductivity, which was read in mS/cm is then converted to uS/cm by multiplying the value by 1000 and then converting that value to conductivity (K) by the mathematical formula:

Conductivity = Specific Conductivity x (1+0.0191 x (Temperature (C) - 25)

Methodology

The value for conductivity was then used, along with recorded temperature values, to calculate derived salinity for each sample through mathematical formulation:

Salinity = $a_0+a_1R_t^{1/2}+a_2R_t+a_3R_t^{3/2}+a_4R_t^{2}+a_5R_t^{5/2}+S$

where $S = [t - 1/51 + 0.0162\ (t-15)](b_0+b_1R_t^{1/2}+b_2R_t+b_3R_t^{3/2}+b_4R_t^{2}+b_5R_t^{5/2})$ and a_0= 0.0080 a_1= -0.1692 a_2= 25.3851 a_3= 14.0941 a_4= -7.0261 b_0= 0.0005 b_1= -0.0056 b_2= -0.0066 b_3= -0.0375 b_4= 0.0636 t = temperature of sample in Celsius S = practical salinity R = conductivity ratio

Methodology

7. Enterococcus

Enterococci are a class of indicator bacteria (a type of fecal streptococci) that the Environmental Protection Agency (EPA) uses to determine both swimming pool and beach water quality. Enterococci are indicative of fecal contamination from warm blooded animals in water (the enterococci bacteria itself is generally benign). Testing for enterococci can help predict the presence of bacteria and pathogens that may lead to illness (vomiting, diarrhea, infections, and respiratory illnesses) if a person were to be exposed by swimming in the water, since it often shares the same environmental conditions as other bacteria. In order to meet the water quality for marine water bathing area standards, the geometric mean of enterococci colony forming units (CFU) must be below 35 per 100 milliliters of water (35 CFU/100ml) and less than 4 CFU per 100 milliliters of water for pool standards (4 CFU/100ml). Note that the ratio of indicator bacteria to the level of pathogens in the environment is not fixed and may depend on a number of factors such as exposure to sunlight and high or low water temperatures.

For the 2015 site feasibility study, The River Project was contracted to conduct Enterococcus / Bacterial analysis since they had an established bacteria lab, where the presence of enterococci was measured using the Idexx laboratory Enterolert method which allowed us to calculate the most probable number of bacteria present in a sample. The methodology employed by The River Project was prescribed under the +POOL 2015 Site Feasibility Study: Water Quality Monitoring Plan and Laboratory Procedures which outlined a method based on the IDEXX Laboratories Enterococcus Enterolert® Quanti-tray® 2000 Method Standard Operating Procedure. The IDEXX Enterolert® method detects enterococci in drinking water using a 100 mL format with results in 24 hours. The method utilizes the IDEXX Enterolert® Quanti-tray® system.

The Enterolert® reagent, based on IDEXX's Defined Substrate Technology®, is used for the detection of enterococci in water by using a 4-methylumbelliferyl-ß-D-glucoside as the defined substrate nutrient-indicator. This compound, when hydrolyzed by enterococcus ß- glucosidase, releases 4-methylumbelliferone which exhibits fluorescence under a UV365nm lamp. After a 24 hour incubation period (at 41°C), if enterococcus is present, the reagent will fluorescence when exposed to a long-

Methodology

wave (365-366 nm) UV lamp. Note that this is the only EPA approved method for enterococcus detection in both fresh and salt waters.

Testing Procedures

Bacterial samples were collected in the field using 15ml sterile centrifuge tubes. MPN/100mL. Once at the Pier 40 field station, samples were deposited in a specified refrigerator for testing by The River Project.

The following is the method outlined for use by The River Project:

Turn on Quanti-Tray Sealer 10-15 minutes before starting analysis. The single standard test volume is 10 mL diluted with 90 mL sterile water to a 100 mL total volume. To accomplish this, extract 10ml from the sample centrifuge tubes using a sterile pipette and dilute as follows in a 100ml sterile container: 1 to 10 dilution Pipet 10 mL of sample into a 90 ml sterile dilution blank for a total volume of 100mL (these samples must have been used within 20 minutes after dilution). Add Enterolert® reagent and shake sample 25 times in 7 seconds to inoculate sample and dissolve reagent. Confirm that reagent has been completely dissolved, then carefully pour entire contents of diluted blank into sterile Quanti-tray® 2000. Remove all air bubbles from Quanti-tray® 2000 wells by tapping gently to release trapped air. Place Quanti-tray® 2000 onto rubber insert (well side down) with large cutout facing away from the sealer. Insert Quanti-tray® 2000 into sealer until it is drawn in. Remove from back of sealer, label with sample identification, date, and time. Place Quanti-tray® 2000 into incubator and incubate for 24 hours at 41 ± 0.5°C.

Interpretation: Do not read samples before 24 hours. Samples can be incubated up to 28 hours. After 28 hours, lack of fluorescence is a VALID NEGATIVE TEST and can be reported as such. Fluorescence after 28 hours is an INVALID result and should not be reported. Note: Use an Enterolert negative (sterility) control with each sample read. This control tray should be stored in the dark between uses. Detect fluorescence using UV Lamp. Any fluorescence is positive for enterococcus. Mark each + well with a black marker and check each tray for confirmation of fluorescence, if possible.

Methodology

Recording: Count the number of positive large wells and small wells and record on the worksheet next to the correct dilution. Calculate the MPN (for each dilution) using the IDEXX MPN tables or the Quanti-Tray 2000 computer program. Multiply the result by the dilution factor (10). Report results as enterococcus MPN/100 mL.
manner.

RESULTS

Overall Weather

According to the National Weather Service's monthly climatological report (National Climatic Data Center) the climate summary for New York City (Central Park data) during the summer testing period was as follows:

- Temperature (degree Fahrenheit)
    - High: 96 (7/29/15)
    - Low: 53 (10/2/15)

- Precipitation (inches)
    - Total: 8.61 inches with the greatest amount in a 24 hour period being 1.95 inches on 7/30/2015.

- Observed weather conditions (number of days)
    - Heavy Rain: 4
    - Light Rain: 11
    - Rain: 15

Results

Hallet's Cove

* Testing at Hallet's Cove was suspended after July due to a lack of resources to continue sampling throughout the summer. The following data is for July only.

Due to its location and specific site dynamics, the Hallets Cove site presented with some of the least positive values in terms of water quality when compared to the other sites being examined in this study. As a result of many factors including, but not limited to: site dynamics, shallow depth, overall poor/diminished water quality, limited access via. public transportation, and the development of other projects in the area, among others, the Hallets Cove location has been removed from consideration as a site for the installation of +Pool.

	Turbidity (NTU)	Total Suspended Solids (mg/L)	Color True (mg/L Pt Co)	Color Apparent (mg/L Pt Co)	pH	Specific Conductivity (mS/cm)	Salinity (PPT)	Enterococcus (cfu/100ml)
High	64.9	204.6	550	204.6	7.74	40.83	44.55	97
Low	2.59	2.4	44.7	2.4	7.4	36.76	14.75	<10
Average	7.93	15.32*	84.4*	15.32*	7.57	38.76	25.77	-

Results

Transmitter Park

During the course of the Summer water quality testing period, Transmitter Park had consistently healthy water in regards to the basic parameters being measured. Comparatively, the site had some of the lowest averages for many of the parameters tested, including the lowest recorded averages of Total Suspended Solids and Color Apparent. However, the site contained the highest average recorded value for Color True during the Summer testing period. High values and fluctuation recorded correlate to rain events and may be due to the close proximity of the site to one of at least 5 (Tier 3) Combined Sewer Outfalls (CSOs) in the area (located between Freeman and Milton Street). The effects of the CSOs would be affected by both tidal flows (greater effects would be seen with the site is downstream of the CSOs during a discharge) as well as outfall volume.

	Turbidity (NTU)	Total Suspended Solids (mg/L)	Color True (mg/L Pt Co)	Color Apparent (mg/L Pt Co)	pH	Specific Conductivity (mS/cm)	Salinity (PPT)	Enterococcus (cfu/100ml)
High	5.76	30.52	66	152	7.79	43.08	27.71	428
Low	1.29	0.72	6	26.6	7.26	34.51	23.08	<10
Average	3.74	5.05	28.02	75.5	7.66	40.57	26.18	34.72

Results

Domino Sugar Factory

Domino Sugar Factory had some of the highest average recorded values across all eight parameters, with the highest recorded average values observed for Turbidity, Total Suspended Solids, Specific Conductivity, and Salinity. These values can most strongly be attributed to heavy waterfront construction and close proximity to CSOs. However, the lowest recorded averages of both Color Apparent and Color True during the Summer testing period were observed at the site.

There are three tier 3 CSOs located near this location between Grand St. and South 8th St. - with one being located on S. 5th street near the southernmost point of the proposed site. The nearly constant current appears to moves wastes and sediments away from the site at a high rate in a way similar to Transmitter Park. At the beginning of the 2015 water quality testing, two locations were tested to see if construction had any ill effects on general water quality; differences between the two test locations were negligible.

	Turbidity (NTU)	Total Suspended Solids (mg/L)	Color True (mg/L Pt Co)	Color Apparent (mg/L Pt Co)	pH	Specific Conductivity (mS/cm)	Salinity (PPT)	Enterococcus (cfu/100ml)
High	9.68	32.25	75.3	133.6	7.79	13.21	27.81	298
Low	1.2	0.95	1.6	42	7.31	35.04	23.41	<10
Average	4.3	5.87	27.62	51.44	7.68	40.86	26.3	26.71

Results

Governor's Island

During the summer testing period, Governor's Island experienced some of the highest variability of the three sites, with the largest disparity between highs and lows and the highest recorded average of both Color Apparent and Enterococcus. In fact, the site had average levels of Enterococcus that were almost 15 times higher than recorded averages of either of the two sites, which is due to a largely unexplained and extreme spike in bacterial levels recorded between August 20th and September 3rd. Despite not having any CSO's on the island, the high levels of indicator bacteria may be correlated with wastewater discharge from CSOs on the Manhattan and Brooklyn sides of the island, which is ultimately downstream from most discharge points. However, the island resides in an open area which is exposed to currents resulting in dilution, heavy mixing of wastes, and incorporation of oxygen (not measured in this study), potentially reducing their effects. Of the three sites, Governor's Island had the lowest recorded averages of Specific Conductivity and Salinity during the summer testing period.

	Turbidity (NTU)	Total Suspended Solids (mg/L)	Color True (mg/L Pt Co)	Color Apparent (mg/L Pt Co)	pH	Specific Conductivity (mS/cm)	Salinity (PPT)	Enterococcus (cfu/100ml)
High	10.04	23.04	76	78.68	8.09	44.4	27.76	6867
Low	1.07	1.02	0	16.3	7.37	20.56	16.56	<10
Average	3.65	5.49	27.71	78.68	7.72	38.85	25.42	504.86

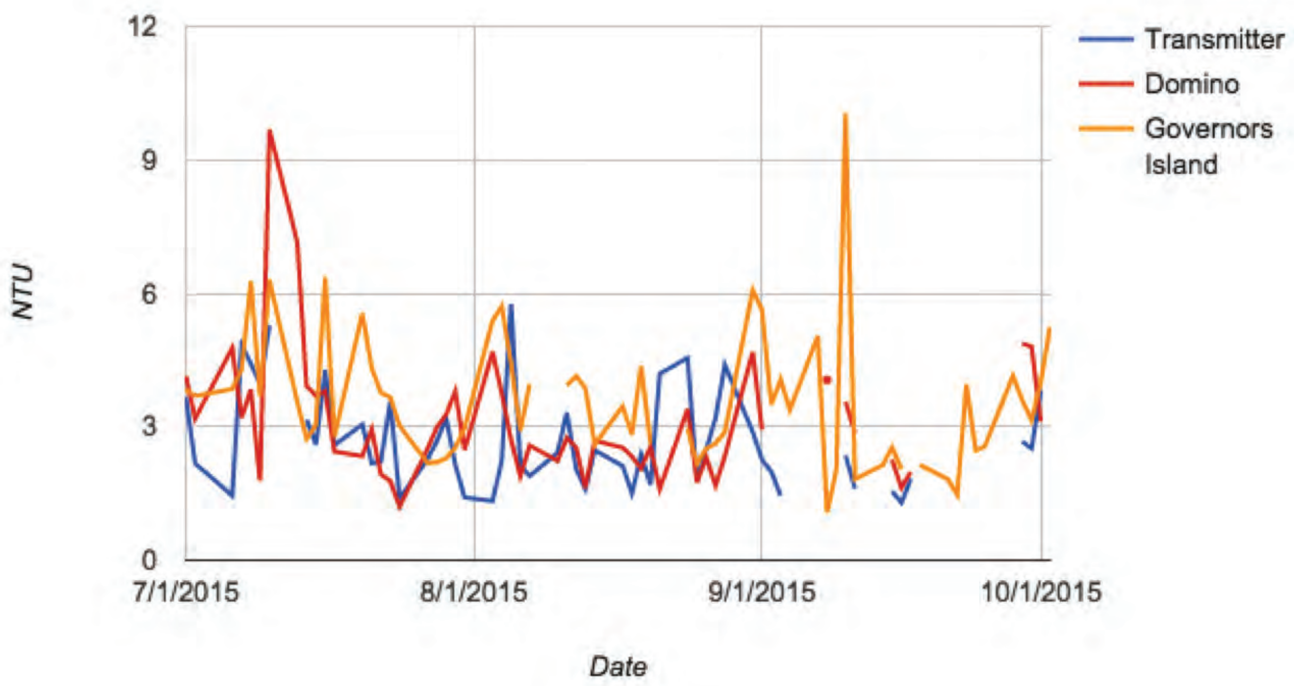
COMPARATIVE RESULTS

Recorded Averages

	Turbidity (NTU)	Total Suspended Solids (mg/L)	Color True (mg/L Pt Co)	Color Apparent (mg/L Pt Co)	pH	Specific Conductivity (mS/cm)	Salinity (PPT)	Enterococcus (cfu/100ml)
Transmitter	3.74	5.05	28.02	75.5	7.66	40.57	26.18	34.72
Domino	4.3	5.87	27.62	51.44	7.68	40.86	26.3	26.71
Gov. Island	3.65	5.49	27.71	78.68	7.72	38.85	25.42	504.86

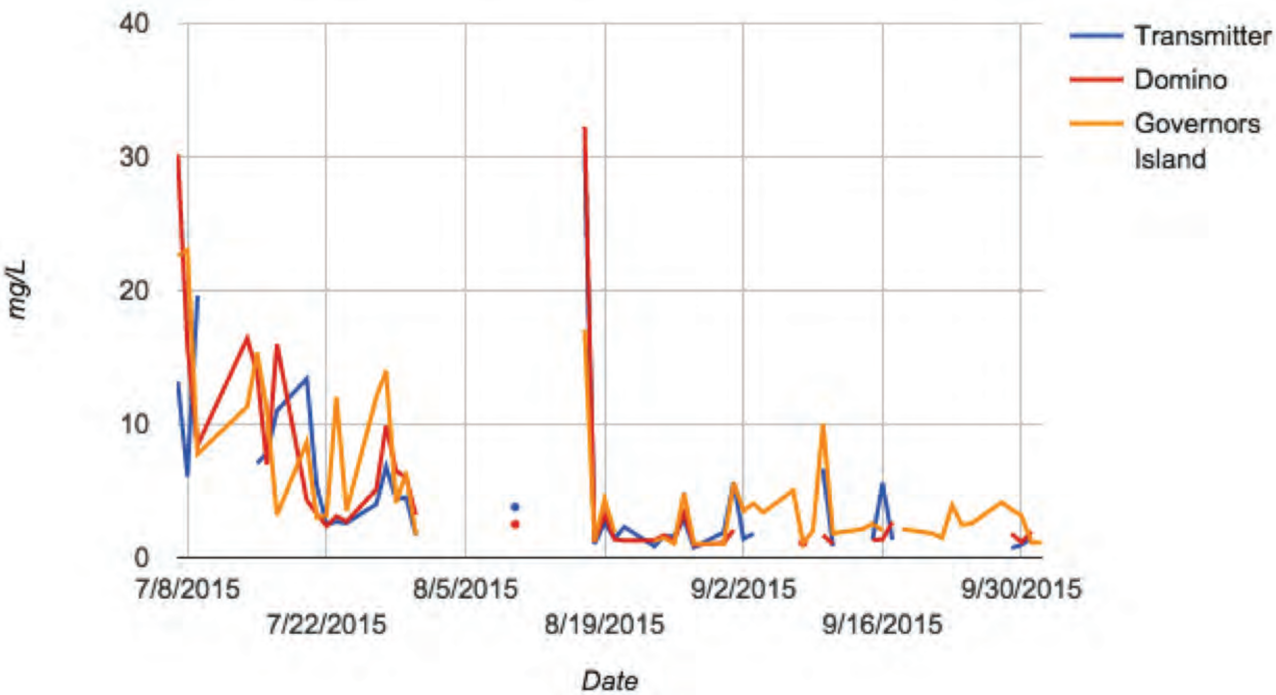
Comparative Results

Turbidity



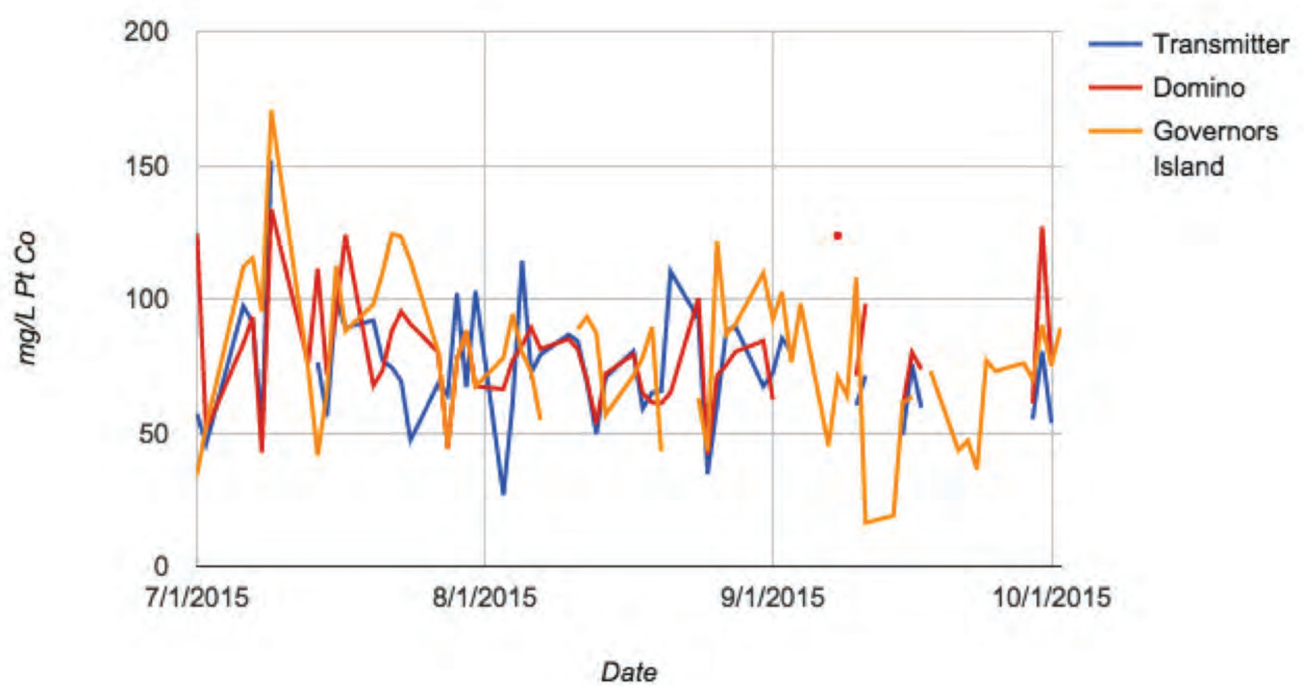
Comparative Results

Total Suspended Solids (TSS)



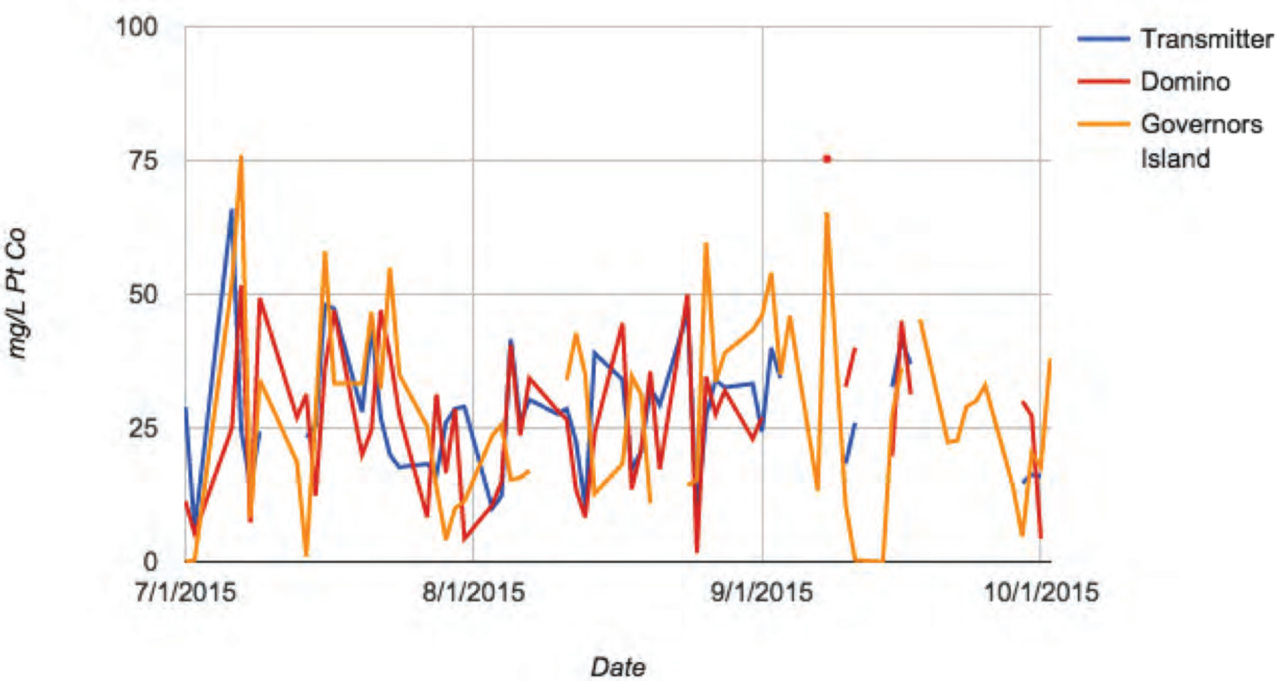
Comparative Results

Color Apparent



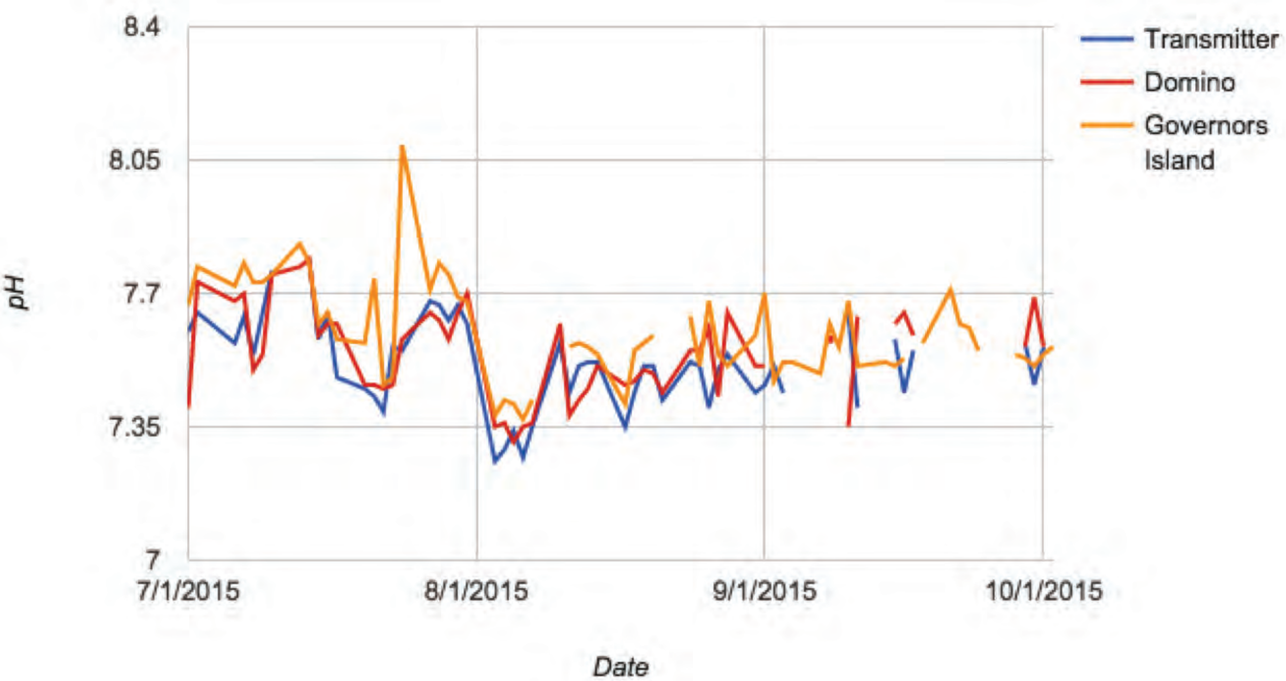
Comparative Results

Color True



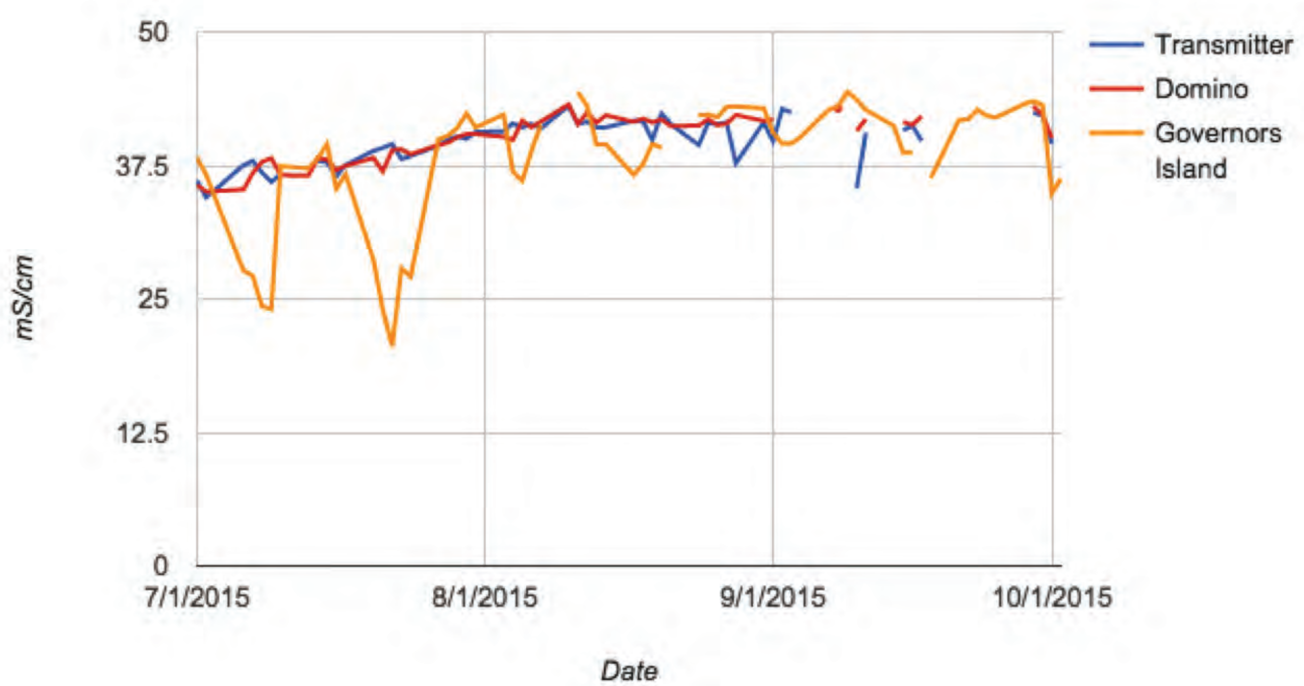
Comparative Results

pH



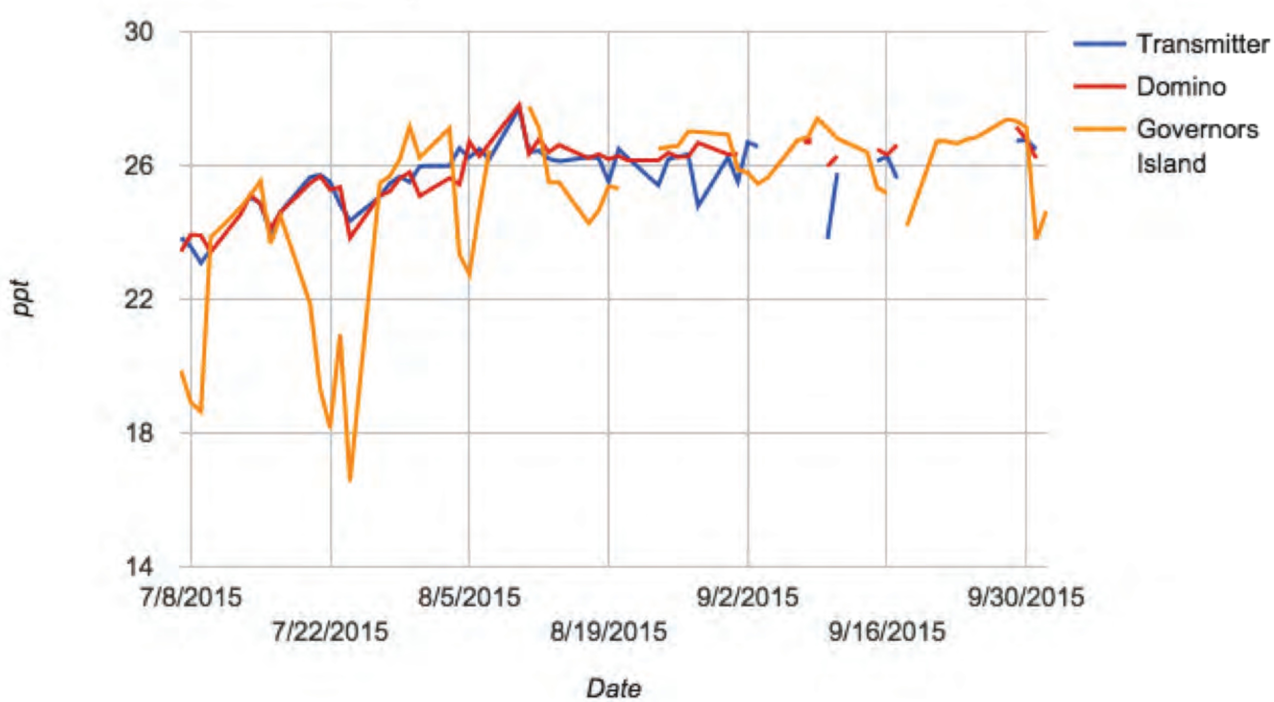
Comparative Results

Conductivity



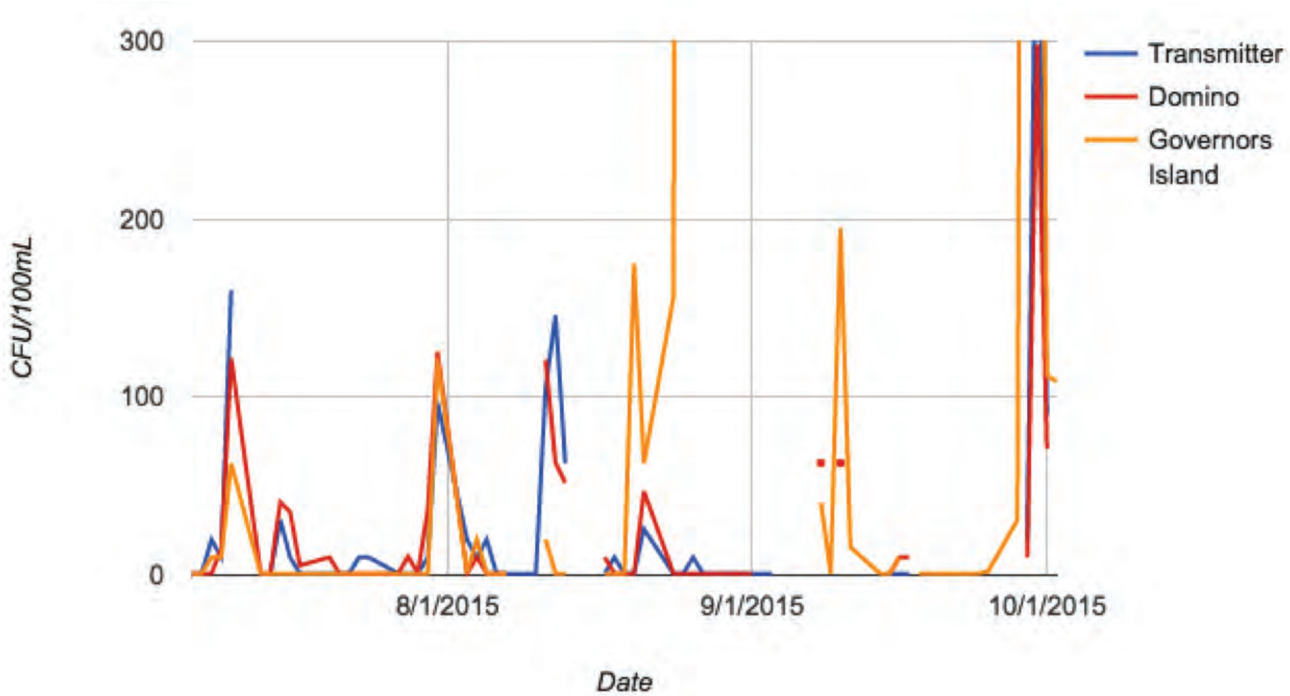
Comparative Results

Derived Salinity



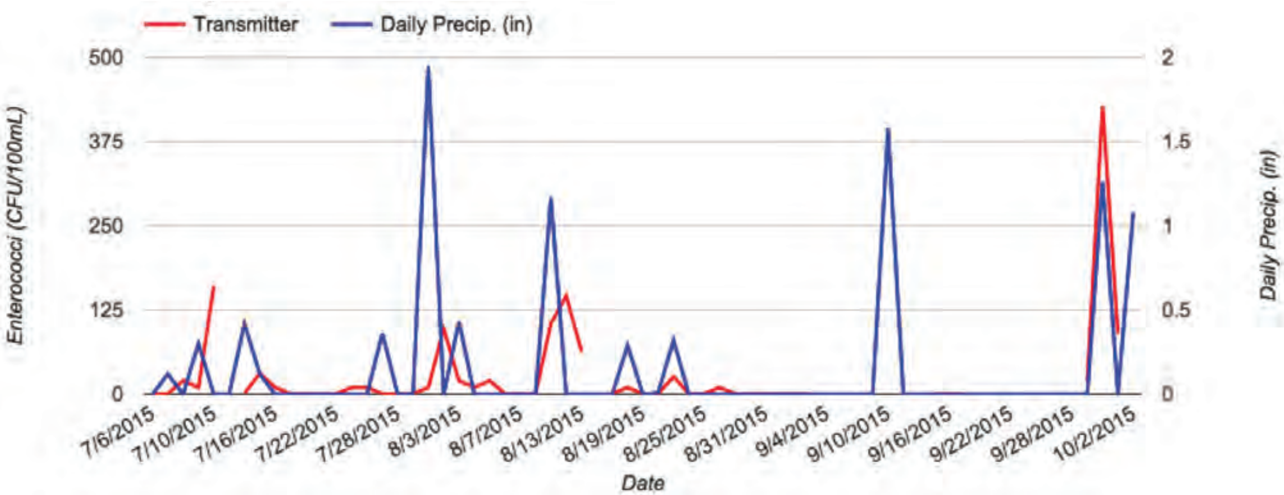
Comparative Results

Enterococcus



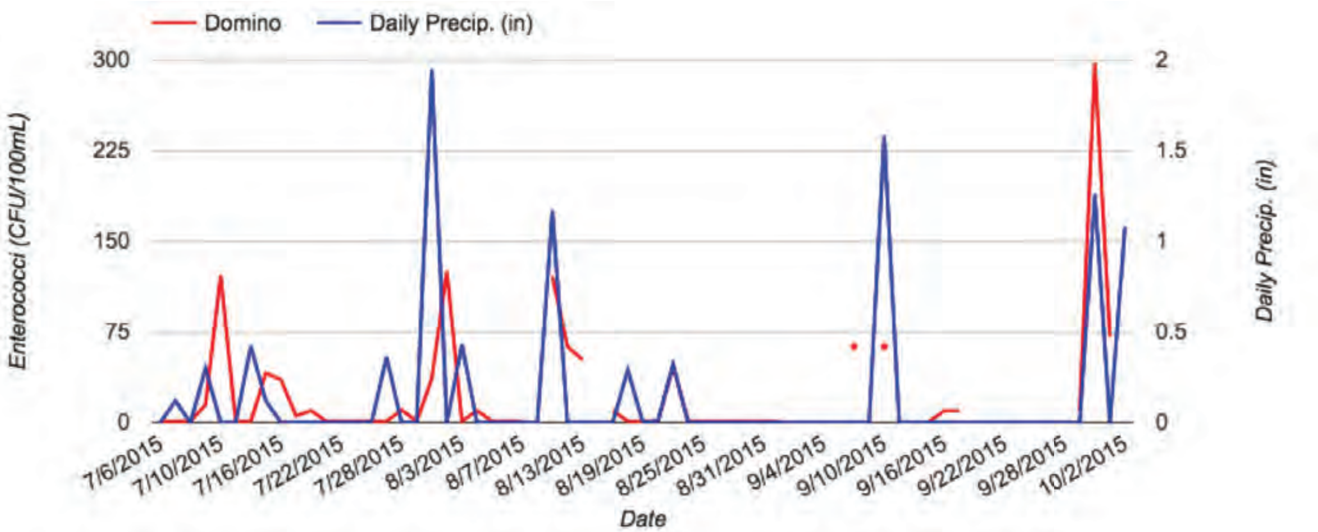
Comparative Results

Precipation vs. Enterococci in Transmitter Park



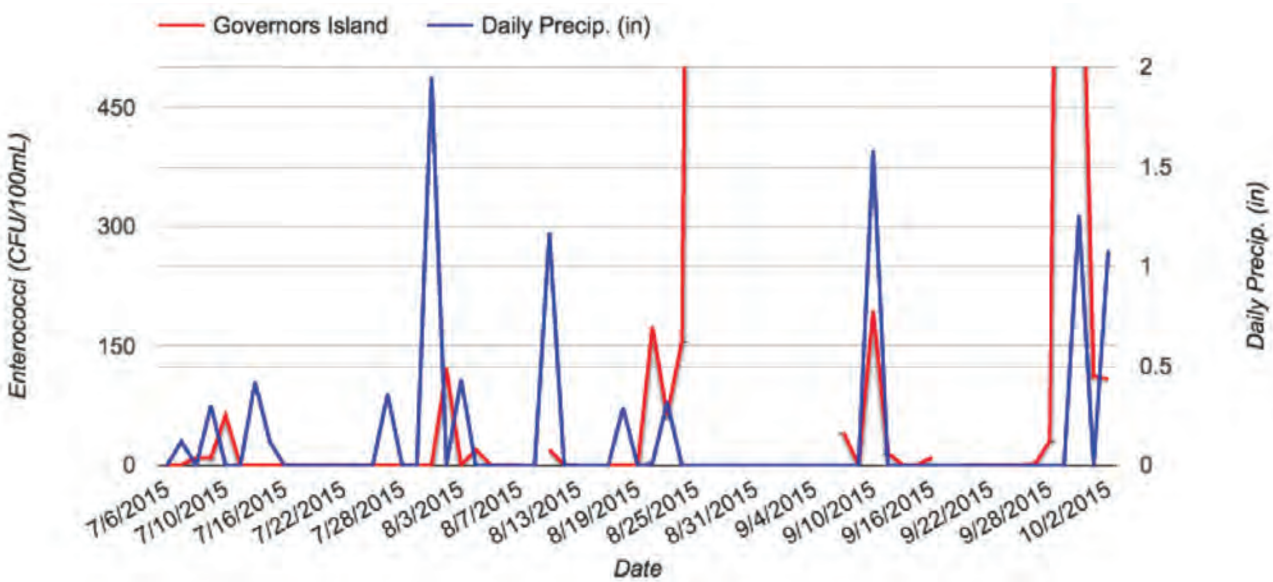
Comparative Results

Precipation vs. Enterococci in Domino Sugar Factory



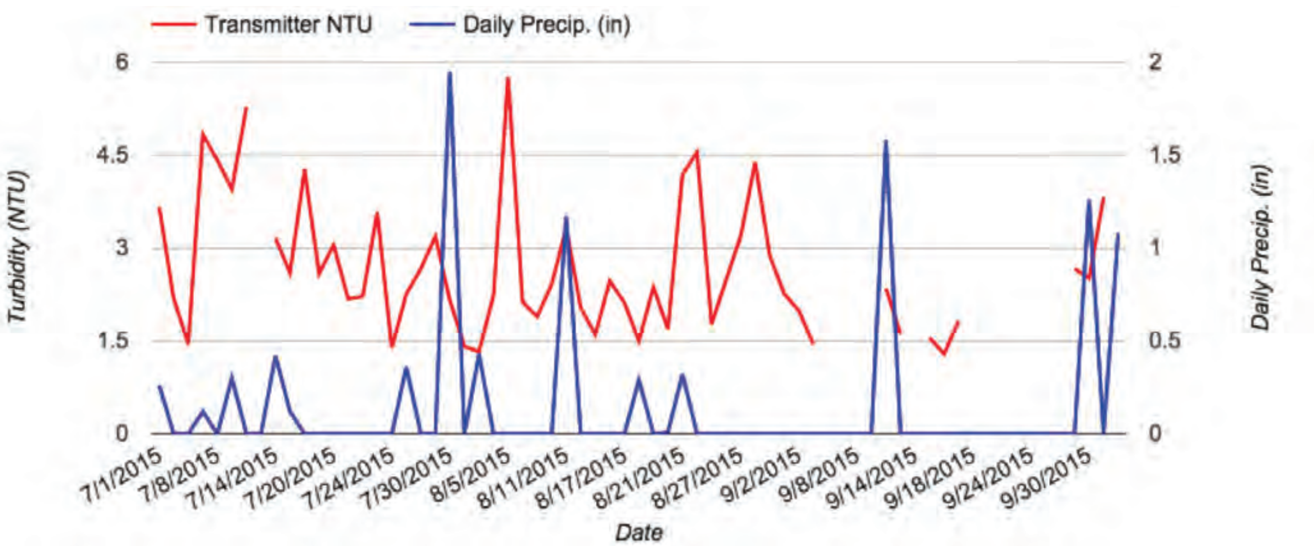
Comparative Results

Precipation vs. Enterococci in Governor's Island



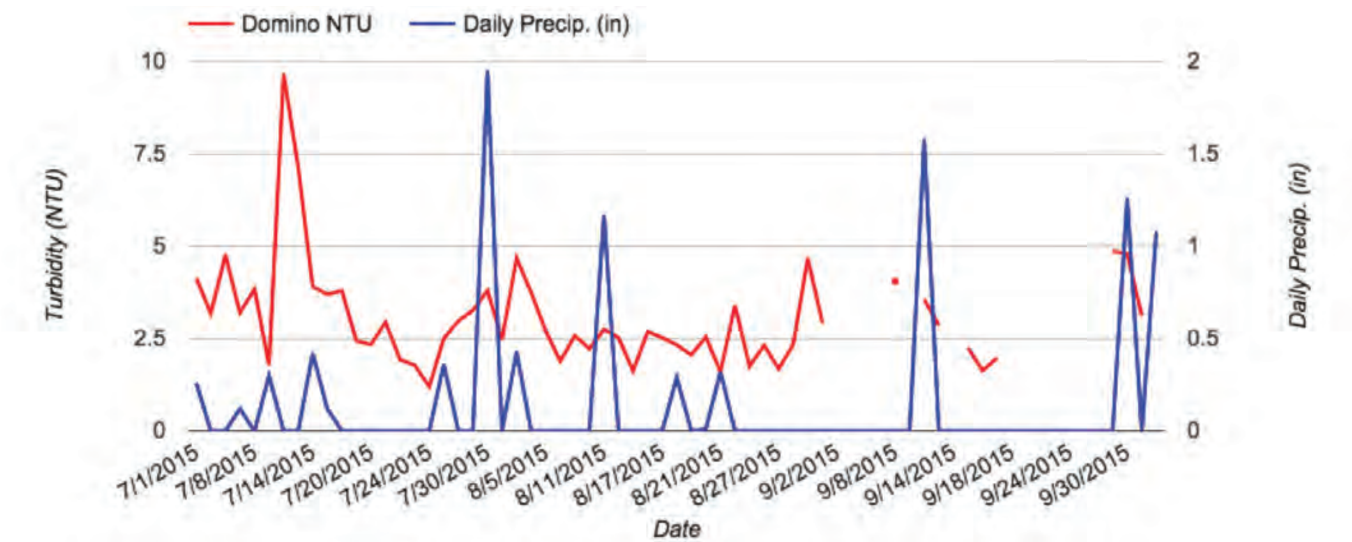
Comparative Results

Turbidity vs. Rainfall in Transmitter Park



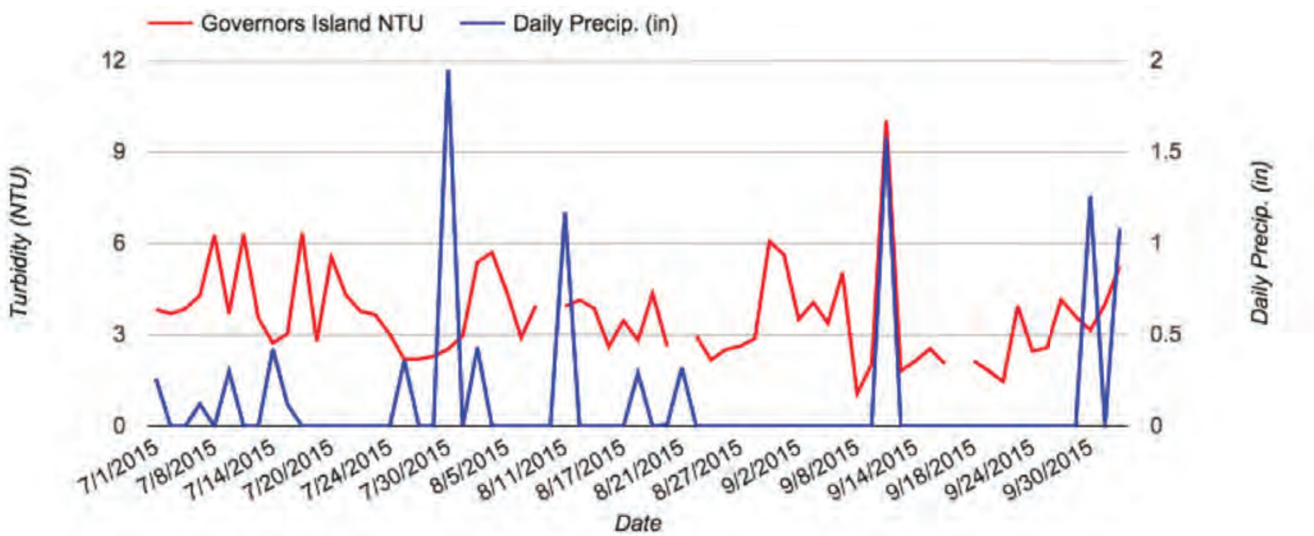
Comparative Results

Turbidity vs. Rainfall in Domino Sugar Factory



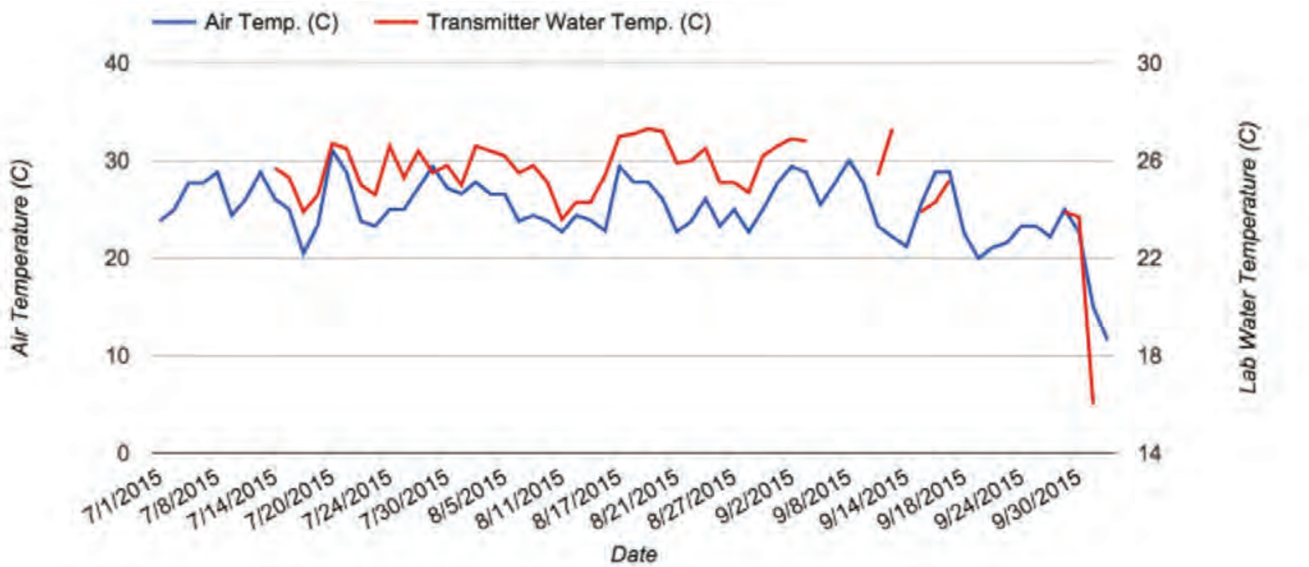
Comparative Results

Turbidity vs. Rainfall in Governor's Island



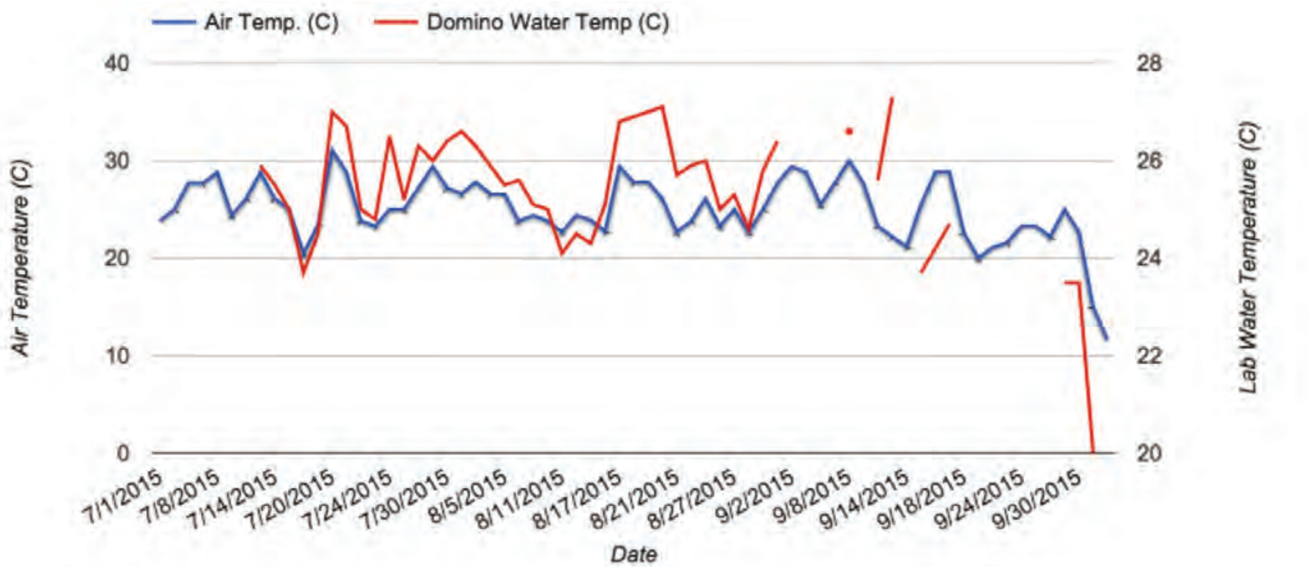
Comparative Results

Air Temperature vs. Water Temperature in Transmitter Park



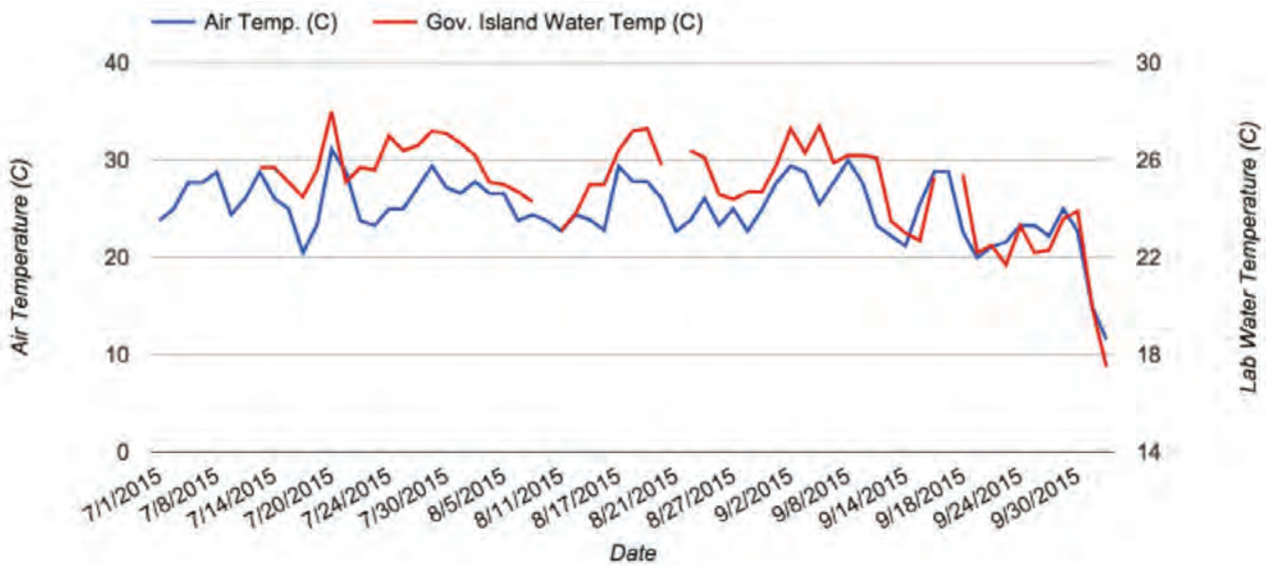
Comparative Results

Air Temperature vs. Water Temperature in Domino Sugar Factory



Comparative Results

Air Temperature vs. Water Temperature in Governor's Island



ABOUT + POOL

+ POOL is a floating, water-filtering pool for New York City that is designed to filter the very river that it floats in, making it possible for New Yorkers and its visitors to swim in clean river water. The layered filtration system incrementally removes bacteria and contaminants to ensure that there is only safe, clean, and swimmable water that meets both city and state standards. The Olympic-size pool will filter over 600,000 gallons of river water daily, making a measurable contribution towards cleaning the city's waterways.

+ POOL is designed to contribute to the health of our city's waters, while offering Kids, Sports, Lap and Lounge pools. Each can be used independently, combined to form an Olympic-length pool or opened completely into a 9,000 square foot pool for play in one of New York City's best natural resources. The pool will welcome an estimated 5,000 visitors a day and the nonprofit will work to promote water stewardship. We envision + POOL as NYC's newest public space, offering educational, recreational and cultural activities for the community.

In 2014, after conducting a series of tests in real river conditions that proved + POOL technology is possible, the designers founded Friends of + POOL, a nonprofit organization dedicated to the development, operation and maintenance of + POOL.

For more information on the project, visit www.pluspool.org.

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