City College of New York
School of Engineering

Civil Engineering Department

SUS 7800B - **Sustainable Infrastructure**

Term Project

THE UPGRADE OF NEWTOWN CREEK WASTEWATER TREATMENT PLANT

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Abstract

In big cities like New York, a tremendous amount of fresh water is being used for household needs, schools, businesses, street and sidewalk washing, etc. Therefore, the proper level of purification of the wastewater prior to releasing it to the water bodies is a major priority.

In the order to protect public health and local waterways, wastewater treatment plants are constructed in most cities of the developed world. Water pollution control plants remove most pollutants from wastewater before it is released to local waterways. At the plants, physical and biological processes closely duplicate how wetlands, rivers, streams and lakes naturally purify water. In my term paper I want to investigate the water purification process, including recent and future upgrades, taking place at the Newtown Creek Wastewater Treatment Plant.

Also, knowing the concentrations of discharged pollutants prior to and after the upgrade, using Mass-Based Limitation Equation, I will analyze how the upgrade affected loads of total suspended solids and biochemical oxygen demand in local waterways; I will calculate the approximate amount of pollutants which were avoided due to a modernization of the plant.

Furthermore, I will calculate an approximate amount of GHG emissions linked to biogas flaring, which will be reduced, once flaring of the excess biogas is discontinued.

1 Case Background

Newtown Creek Wastewater Treatment Plant located in Greenpoint, Brooklyn; it is the largest of New York City's 14 wastewater treatment plants. The plant is operating since 1967. The drainage area of Newtown Creek is approximately 15,000 acres (25 square miles); the plant treats the sewers of more than 1 million residents from northeast section of Brooklyn, eastern midtown sections of Manhattan and western section of Queens (Figure 1). 70% of the sewers in the city are part of the same combined sewer system; therefore, Newtown Creek receives sanitary and industrial wastewater, street runoff, and stormwater via a net of sewers[1].

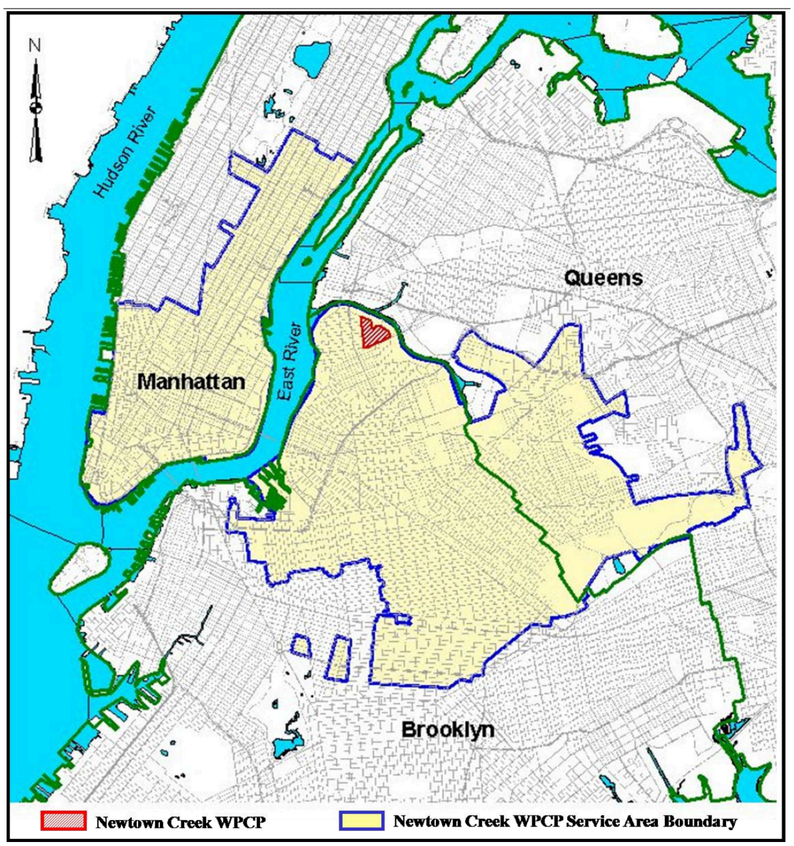

Figure 1 – Newtown Creek Watershed and WPCP Service Areas (Credit: EPA)

Due to population growth and increased area of impervious surfaces an increase of storm runoff started to occur more often in the late 1980s. During heavy rains or snow the combined sewers fill to capacity and are unable to carry the combined sanitary and storm sewage to the plants, at which point combined sewer overflow (CSO) occurs: the mix of excess storm water and untreated sewage flows directly into the city's waterways (Figure 2) [2].

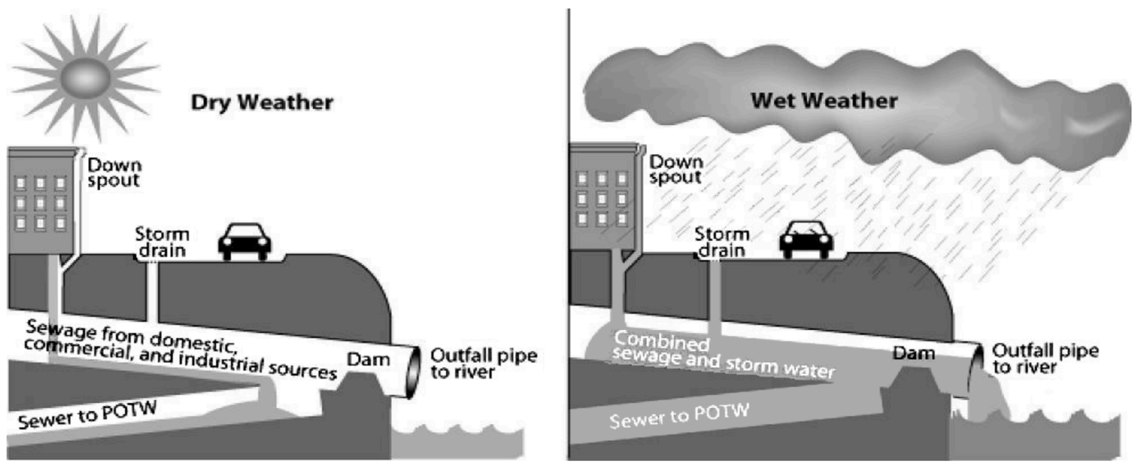

Figure 2 – Combined sewer overflow (Credit: EPA)

In the 1990s, the Newtown Creek WWTP already required a serious upgrade, including the involvement of newly developed technologies in the order to deal with increasing amount of sewage coming into the water bodies due to CSO. Along with that, the city needed higher quality of water purification and more sustainable approach regarding GHG emissions from sludge. Therefore, the upgrade project was under discussion.

The original Newtown Creek plant (Figure 3) was working according to the following plan: firstly, sewage was sent to raw influent screening and grit tanks, then the substance traveled to batteries of modified aeration tanks, then a sedimentation process was taking place in the sedimentation tanks, eventually, chlorine disinfection completed the purification process. Notice that the original treatment plant occupied 32 acres[3, 4].

Figure 3 – Original Newtown Creek Plant (Credit: NYC EPA)

The original aeration capacity of Newtown Creek Wastewater Treatment Plant was 310 million gallons per day (MGD) and provided 60% removal of biochemical oxygen demand (BOD5) and 70% removal of suspended solids (TSS). However, this level of purification was not sufficient according to The Clean Water Act, and it was another reason among many to upgrade the existing system.

2 The Upgrade

2.1 Challenges for Upgrade

The Clean Water Act led to a necessity to improve the quality of water leaving the plant. As a solution to solve the problem of CSO and in the order to improve the level of purification, the following procedures were proposed.

Construction of additional wastewater treatment units was necessary to provide secondary treatment of sewage and to improve the plant's ability to handle combined sanitary and storm flows in wet weather. According update projections, the annual average dry weather flow would remain at 310 MGD, but the plant was now required to provide 85% removal of biochemical oxygen demand and 85% removal of suspended solids[1].

In the order to implement the facility update, architects and engineers had to deal with many challenges, including the fact the facility operates 24 hours/7 days a week making it impossible to turn off any part of the system as well as space limitations.

These challenges led to the system upgrade being planned based on the scenario when addition and removal of structures is organized at the fixed and limited space in between the existing fixtures. New buildings and operational equipment had to be constructed and ready to be used before the corresponding outdated piece could be taken out of service and demolished, making space for the next building in the sequence.

In the order to obtain an extra area for new construction, the City of New

York DEP acquired three adjoining properties and demapped two streets; thereby, the site area could be expanded from 36 acres to approximately 53 acres. An increase of the site footprint could provide space for a third secondary treatment battery and other new facilities[4].

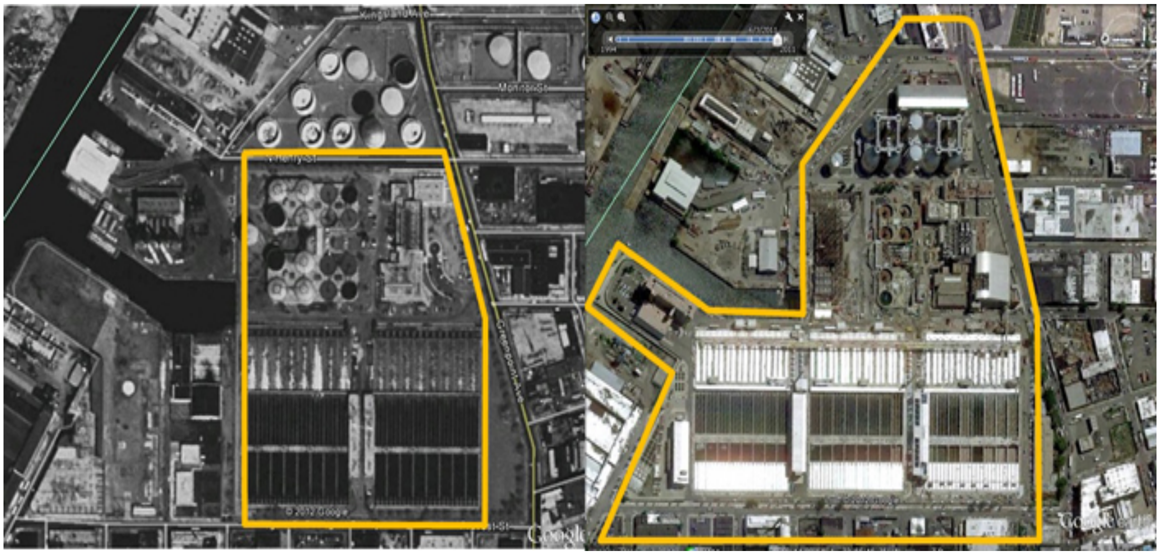

Figure 4 – Original (left) and upgraded (right) Newtown Creek Plant (Credit: AAEES)

2.2 Highlights of The Upgrade

The long-term upgrade project began in 1998 and originally was scheduled for completion in 2008.

As the lead architect and master planner for the renovation project, Ennead Architects LLP (earlier Polshek Partnership) was chosen by the city; “Greeley and Hansen”, “Hazen and Sawyer”, and “Malcolm Pirnie” developed environmental engineering parts of the upgrade.

The overall $5 billion upgrade, was aiming to increase the plant's treatment capacity from 620 to 700 MGD of combined wastewater and stormwater flow during heavy storms.

According to Skanska construction group the scope of the main operations of the project are:

- Building a new North Battery of eight aeration/sedimentation tanks with a new corresponding grit gallery.
- Demolishing and reconstructing four aeration/sedimentation/grit tanks in the Central Battery.
- Modifying the remaining four aeration/sedimentation/grit tanks in the Central Battery and eight aeration/sedimentation/grit tanks in the South Battery.
- Construction of a North Control Building.
- Modifying pre-existing elements to integrate old and new plant components.
- Procurement and installation of nine process air blowers.
- Upgrading the odor control system with aluminum tank covers[5].

The plan of the upgrade was organized as a three-phase plan (Figure 5).

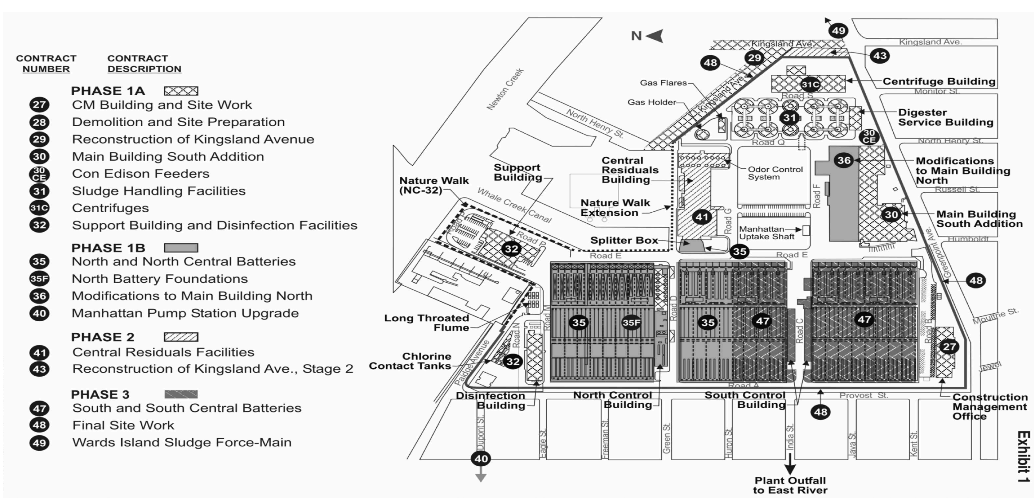

Figure 5 – The Master Plan for the Newtown Creek WWTP Plant Upgrade (Credit: NYC DEP)

2.3 Digester Eggs

Eight giant digester eggs (145-feet high, 80-feet wide, capacity 3 million gallons of each egg) process sludge, thick organic material removed from treated wastewater at the temperature 95°F (Figure 6). Together, these 8 digester eggs process 1.5 million gallons of sludge each day in the Newtown Creek WWTP. For about 21 days sludge is treated by bacteria during anaerobic digestion. This process turns sludge into water, CO_2, methane and biosolids.

Figure 6 – Digester Eggs (Credit: Polshek Partnership Architects)

As part of the pilot phase, 2 tons of organic “bioslurry” was added daily to the sludge to increase biogas production. Waste Management is processing organic food waste from the nearby schools and farmers’ markets at the Varick facility and plans to increase its volume to 50 tons per day during the 3-year demonstrating project starting at the end of 2015; the goal is to raise capacity up to

250 tons per day by the end of the project. If the pilot proves successful, there is the potential to process up to 500 tons of organic food waste per day.

According to one of the project's leaders – Anthony Fiore (Department of Energy, DEP), "the scale of today's pilot project is tiny – the daily addition of bioslurry amounted to less than 500 gallons, while each of the plant's eight digesters holds 3 million gallons – so measurement of its overall impact on methane production was impossible. The purpose of the pilot project was to test logistics, and to that extent, it was a success".

About 500 million cubic feet of biogas is produced through anaerobic digestion per year[6]. Newtown Creek WWTP collects biogas and currently uses about 40% of it for heating the digesters and buildings of the facility; however, the remaining 60% of the biogas is flared, which contributes to GHG emissions (calculated in the part 3.2 of the term project).

3 METHODS

3.1 Water Contamination

3.1.1 Importance of TSS and cBOD5

National Pollutant Discharge Elimination System (NPDES) permits establish discharge limits and conditions for discharges from municipal wastewater treatment facilities to waters of the U.S. The Environmental Protection Agency (EPA) establishes secondary treatment standards for publicly owned treatment works (POTWs). Such standards are minimum, technology-based requirements for discharges from municipal wastewater treatment plants. These standards are reflected in terms of five-day biochemical oxygen demand (BOD5) and total suspended solids (TSS) removal.

Total suspended solids give a measure of the turbidity of the water. Suspended solids cause the water to be milky or muddy looking due to the light scattering from very small particles in the water. Total suspended solids are solids that either float on the surface or are suspended in the water. TSS is the measure of all suspended solids in a liquid. TSS is the most common measure of the amount of solids in wastewater effluent.

Biochemical Oxygen Demand after 5 days (BOD5) represents the quantity of oxygen, which is consumed in the course of aerobic processes of decomposition of organic materials, caused by microorganisms. The BOD therefore provides information on the biologically convertible proportion of the organic content of a sample of water. This leads to the consideration of these materials in terms of their susceptibility to oxidation by the use of oxygen. BOD is stated in mg/l of oxygen. In the Table 3.1 below displayed established standards for secondary treatment of municipal wastewater[8].

Table 3.1 - Effluent limitations for secondary treatment standards[8]

Parameter	Average monthly limitation	Average weekly limitation
BOD_5	30 mg/L (or 25 mg/L $CBOD_5$)	45 mg/L (or 40 mg/L $CBOD_5$)
TSS	30 mg/L	45 mg/L
BOD_5 and TSS removal (concentration)	not less than 85%	N/A
pH	Within the range of 6.0–9.0 standard units at all times (or expressed as instantaneous minimum and maximum limitations)*	

* unless the POTW demonstrates that: (1) inorganic chemicals are not added to the waste stream as part of the treatment process; and (2) contributions from industrial sources do not cause the pH of the effluent to be less than 6.0 or greater than 9.0

3.1.2 Calculating the decrease of Total Suspended Solids (TSS) and Five-day Biochemical Oxygen Demand (BOD5)

Due to the fact that TSS and cBOD5 are very important for wastewater treatment, as they are measuring plant efficiency, therefore, to estimate how the upgrade of Newtown Creek WWTP influenced the impact of the facility on the aquatic life, it is necessary to determine changes of the cBOD5 and TSS discharges.

Suspended sediment discharge records are derived from analytical results of sediment samples and water discharge from the pre-upgrade period at the WWTP and from the period of time after the upgrade of secondary treatment was complete. Suspended solids discharge records are derived from analytical results of released purified water samples. Most are computed as daily time-series records. EPA recommends that permit writers apply the 30-day and 7-day average secondary treatment standards directly as average monthly (calendar month) and average weekly (calendar week) discharge limitations.

Loads of TSS and cBOD5 were calculated based on the concentrations of cBOD5 and TSS in the samples of purified water in Newtown Creek, obtained from "Newtown Creek Wastewater Treatment Plant Wet Weather Operating Plan" (Table 3.2, 3.3) [1].

Table 3.2 – Pre-Renovation Interim Effluent Discharges from Newtown Creek WWTP (as of 2001)[1]

Parameter	Limit	Monitoring Frequency
Dry Weather Flow	310 MGD	(30 day mean)
Total Flow		Monitor (12 month rolling average)
$cBOD_5$ (1)	45 mg/l	(30 day mean)
	60% removal	(30 day mean) (2)
	68 mg/l	(7 day mean)
TSS (1)	35 mg/l	(30 day Mean)
	70% removal	(30 day mean) (2)
	53 mg/l	(7 day mean)
	60 mg/l	(Daily Maximum) (3)

(1) Sample type 24-Hour Composite
(2) Total Daily Flow greater than 310 MGD excluded from percent removal calculations.
(3) Not applicable within one calendar day of the day in which the instantaneous flow > 620 MGD.

Table 3.3 – Post-Upgrade Interim Effluent Discharges from Newtown Creek WWTP (as of 2011)[1]

Parameter	Limit	Monitoring Frequency
Dry Weather Flow	310 MGD	(30 day mean)
Total Flow		Monitor (12 month rolling average)
$cBOD_5$ (1)	25 mg/l	(30 day mean)
	85% removal	(30 day mean) (2)
	40 mg/l	(7 day mean)
TSS (1)	30 mg/l	(30 day Mean)
	85% removal	(30 day mean) (2)
	45 mg/l	(7 day mean)
	50 mg/l	(Daily Maximum) (3)

(1) Sample type 24-Hour Composite
(2) Total Daily Flow greater than 310 MGD excluded from percent removal calculations.

From the Tables 3.2 and 3.3 above, we can see that the concentrations of discharges after the upgrade had decreased: 30 day mean concentration of cBOD5 decreased from 45 mg/L to 25 mg/L, 7 day mean concentration of cBOD5 decreased from 68 mg/L to 40 mg/L, 30 day mean concentration of TSS decreased from 35 mg/L to 30 mg/L, 7 day mean concentration of TSS decreased from 53 mg/L to 45 mg/L. Therefore, based on these parameters, I will calculate the amount of cBOD5 and TSS, which could have been released to the Newtown Creek and East River respectively, but was avoided due to the improvement of the process.

All the calculations are based on the following formula:

Mass based limitation calculation equation

Mass-based Limitation Lbs/day	=	**Design Flow** in million gallons per day (MGD)	X	**Concentration-based Limitation** in milligrams per liter (mg/L)	X	**Conversion Factor** **8.34** with units of (lbs)(L) / (mg)(millions of gallons)

Below in the Table 3.4 of calculated daily loads of cBOD5 and TSS prior renovation and after the upgrade was complete.

Table 3.4 – Load of cBOD and TSS

	Design Flow MGD	30-day Mean Concentration (mg/L)	Conversion Factor	Mass-based Limitation Lb/day	Mass-based Limitation tons/day
Pre-Renovation					
cBOD5	310	45	8.34	**116343**	**58.1715**
TSS	310	35	8.34	**90489**	**45.2445**
Post-Upgrade					
cBOD5	310	25	8.34	**64635**	**32.3175**
TSS	310	30	8.34	**77562**	**38.781**

Knowing the daily loads of pollutants I calculated monthly and annual loads (Table 3.5).

Table 3.5 – Monthly and annual load of cBOD and TSS

		Daily Load (tons)	Monthly Load (tons)	Annual Load (tons)
Pre-Renovation	cBOD5	58.1715	1745.145	**20941.74**
	TSS	45.2445	1357.335	**16288.02**
Post-Upgrade	cBOD5	32.3175	969.525	**11634.3**
	TSS	38.781	1163.43	**13961.16**

Now we can estimate approximate reduced load for the upgraded facility (Table 3.6).

Table 3.6 – Approximate reduced load of cBOD and TSS

	Monthly Load Decrease (tons)	Annual Load Decrease (tons)
cBOD5	775.62	9 307.44
TSS	193.905	2 326.86

Taking into account the fact that the first stage of the upgrade was completed in June of 2008, I want to estimate the approximate amount of pollutants, which could've been released to the water body, but because of the upgrade were prevented. As of today, in December of 2015, it's been full 7 years and 5 months since the water treatment plant was upgraded, so based on these factors I'll calculate prevented BOD5 and TSS loads.

Table 3.7 – Prevented cBOD5 and TSS loads

	Decreased Load since June 2008 (tons)
cBOD5	69 030.18
TSS	17 257.545

From the Table 3.7 above, we can see that 69030.18 tons of cBOD5 and 17257.545 tons of TSS were prevented from being discharged to the Newtown

Creek. It is a significant achievement towards reducing water pollution and degradation of aquatic life.

3.2 GHG Emissions Analysis

Daily, about 1.5 million cubic feet of biogas is produced as byproduct at Newtown Creek Plant in the process of anaerobic digestion, which is about 500 million cubic feet of biogas per year[6].

The biogas released from wastewater treatment contains about 95% of methane, which can be captured and used for electricity and heat generation[9]. It is possible for the plant to use the biogas for both heat and power; however, Newtown Creek uses only about 40% of biogas to provide heat for plant buildings and the digester eggs. The remaining 60% of biogas is flared into the atmosphere, emitting GHG emissions to the atmosphere (Table 3.8).

Table 3.8 – Amount of biogas used and flared

	ft^3	CO_2 (ft^3)	CH_4 (ft^3)
Total Biogas Produced (ft^3)	**1 500 000**	**75 000 (5% of mixture)**	**1 425 000 (95% of mixture)**
Biogas Used at WWTP (40% from produced)	**-**	**-**	**570 000**
Biogas Flared (60% from produced)	**-**	**-**	**855 000**

In my term project I want to estimate the amount of GHG emissions from the unused biogas.

The amount of GHG from the flared methane can be estimated, taking into account the formula of chemical reaction:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Knowing that burning of methane produces 2.7 times more of the carbon dioxide, I can calculate that flaring 1 ton of CH4 yields 2.7 tons of CO2.

Also, I'm making an assumption regarding the conditions: assuming Normal Temperature and Pressure - is defined as 20^{o}C (293.15 K, 68^{o}F) and 1 atm (101.325 kN/m^{2}, 101.325 kPa, 14.7 psia).

In the calculations, a density of 0.1150 pounds/ft^{3} was used for carbon dioxide and a density of 0.0417 pounds/ft^{3} was used for methane.

Conversion factor 0.0005 was used to convert units of lbs into tons. Therefore:

1 cubic feet of CO2 weights 5.75x10^{-5} tons

1 cubic feet of CH4 weights 2.085 x10^{-5} tons

Results of calculated GHG emissions from flared biogas are demonstrated in the Table 3.9 below.

Table 3.9 – GHG emissions

	CO_2 5% of Biogas	**CH_4 95% of Biogas**
Biogas Mixture	75 000 (ft^{3})	1 425 000 (ft^{3})
Biogas Used at WWTP (40% from produced)	-	570 000 (ft^{3}) 11.8845 (tons)
Biogas Flared (60% from produced)	-	855 000 (ft^{3}) 17.8268 (tons)
GHG (CO2 equivalent)	4.3125 (tons)	48.1322 (tons)
Total GHG emissions from flaring biogas:		**52.4447 tons (daily)** **19 142.3155 tons (per year)**

From the Table 3.9 we can see that with the today's rate of digested sewage, approximately 17.8268 tons of methane are flared daily, which totals almost 20 thousand tons (per year) of GHG emissions in the CO2 equivalent.

However, implementation of the system of biogas purification and connection of the gas line with the natural gas grid (Figure XX) would help to avoid emissions associated with flaring and lead to use of methane from a renewable source.

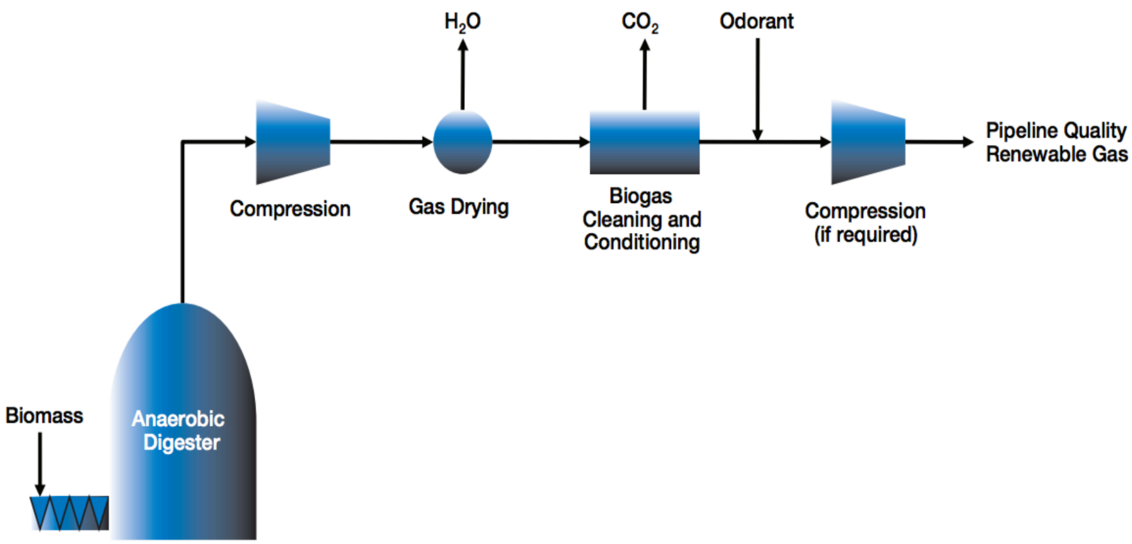

Figure 7 – Biogas preparation for pipeline quality renewable gas (Credit: National Grid)

Additionally, I want to approximate the decrease of GHG emissions, associated with connecting Newtown Creek WWTP to natural gas distribution system.

According to DEP, 54,500 tons/year of GHG emissions can be prevented through use of organic food waste at WWTP and diverting over 153,000 tons/year of organic waste from landfills when the input of bioslurry reaches 450 tons per day.

As DEP estimated, emissions of 32,400 tons/year of GHG can be reduced from the use of biogas through offsetting emissions from traditional means of harvesting natural gas.

Additionally, taking into consideration the fact that bioslurry is delivered via barges instead of by trucks, 2.1 million miles of truck trips will be avoided, which translates into a GHG reduction of 2,290 tons/year.

Taken together, the project has the potential to reduce greenhouse gas emissions by:

$$54\ 500 + 32\ 400 + 2\ 290 + 19\ 142.3155 = 108\ 332.3155 \text{ (tons/year)}.$$

From the calculations we can see, that total amount of GHG emissions prevented through implementation of a co-project with National Grid and Waste Management will exceed 100 thousands tons/year in CO2 equivalent.

4 Sustainable Outcomes of the Upgrade

4.1 Increased Treatment Capacity

Newtown Creek Wastewater Treatment Plant currently treats 18% of the city's wastewater with a capacity of 310 million gallons per day during dry weather. After the upgrade the capacity during dry weather flow didn't change, however, capacity of combined wastewater and stormwater flow during heavy rain and snow has increased from 620 to 700 million gallons per day. By 2045 the upgraded plant will serve a projected population of 1.33 million residents within the relevant drainage area.

4.2 Organic Waste

For decades, garbage from NYC was buried at the Fresh Kills landfill in Staten Island. However, when the landfill closed in 2001, the city turned to exporting garbage to other states. Transporting solid waste to other states significantly increases GHG emissions from trucks and fuel production.

However, following the example of other cities, where waste-to-energy plants have been constructed, New York finally made a big step towards reducing amount of waste sent to landfills. After the construction of digester eggs and improved secondary treatment was completed in 2008, Waste Management of NYC has begun delivering pre-processed organic food waste to the Newtown Creek Wastewater Treatment Plant where it is added to wastewater sludge. This practice helps prevent disposing organic waste in the landfills and increases the production of biogas. Currently organic food waste is collected mostly from schools, but with the established system of organics collection and the spread of organics collection via NYC Department of Sanitation, the amount of processed organics will be greatly increased and is panned to increase by 500 tons per day.

After the aged sludge is sent through large centrifuges, dewatering sludge turns into a substance known as biosolids which is the consistency of “cake”. The biosolids cake is approximately 25-27% solid material.[10] Biosolids are widely used in land applications as fertilizers to return nutrients to the soil. Mixed with a bulking agent (for example – wood chips) biosolids decompose, creating compost. After alkaline treatment: biosolids are mixed with a highly alkaline material, such as lime or Portland cement; the final product resembles soil and is used as an agricultural liming agent. New York City’s biolosids are alkaline stabilized at a facility in New Jersey. Another process to biosolids is heat drying: biosolids are heated to a very high temperature to remove moisture and kill pathogens. What remains are fertilizer pellets. New York City's biosolids are made into pellets at a facility in the Bronx. These pellets are sold across the country, many of them for use in citrus groves in Florida.

4.3 Clean Energy

Emitted from sludge and organic food waste which is added to wastewater sludge, biogas is collected from the digester eggs and approximately 40% of the collected gas today is being used in the boilers that produce heat to keep the desired temperature in the digester eggs and also to heat the buildings of the facility. Currently, unused gas is flared to the atmosphere.

In the collaboration with National Grid, DEP is working on the improvement of the system for biogas purification, so the remaining 60% of the biogas could reach the pipeline quality and could be injected into the local gas distribution network. The amount of an excess gas from the plant, which will be added to the natural gas system, is estimated to be sufficient to provide heat to 5,200 homes, reduce annual GHG emissions by more than 100,000 metric tons - the equivalent of removing nearly 19,000 cars from the road – and help the City government reach its PlaNYC goal of reducing municipal GHG emissions of 30% by 2030. Towards achieving a goal of 30% GHG reduction, NYC DEP together with National Grid are planning to implement a system of biogas purification and injecting it in the national grid. National Grid is financing the design, construction, operation, and maintenance of the biogas purification system and initially DEP will provide the biogas free of charge. Once project costs have been recouped, profits will be split between DEP and National Grid's customers. Construction of the purification system began in 2014 and expected to be completed by the end of 2015[11].

According to the EPA, it is possible to produce electricity for as little as $0.038 per kWh assuming a 20-year capital repayment horizon. This compares favorably to national electricity rates that range from $0.057 to $0.228 per kWh.[26]

4.4 Air Quality

After the implementation of the secondary treatment at Newtown Creek WWTP took place, the air quality at the location and territory next to it had greatly improved due to new covered aeration tanks. And the installation of a new odor control system led to odor elimination.

According to DEP, since 2008, the levels of sulfur dioxide in the air have dropped by 69% and since 2007 the level of soot pollution has dropped by 23%.

As stated by Christopher Gilbride (Associate Commissioner of EPA), referring to the upgraded Newtown Creek WWTP: "The cleaner air enjoyed by New Yorkers today is preventing 800 deaths and 2,000 emergency room visits and hospitalizations from lung and cardiovascular diseases annually, compared to 2008". I think that the biggest part of the statistics he is talking about are related to people who developed lung diseases following the tragedy of 9/11, however, I'm sure that there are patients who developed medical conditions while living or working close to Newtown WWTP.

5 Conclusions

The update of Newtown Creek WWTP is a major event for the sustainable way of wastewater treatment not only in NYS, but also in USA, as the project is unique in the country, and was the first of its kind.

In the term paper the upgrade was explored and the main features were reviewed and parameters, such as cBOD5 load and TSS load for pre- and post-upgrade facility were determined. The amount of suspended solids prevented from entering the water bodies were approximated for the period prom upgrade completion to present day, a period of 7 years and 5 months.

After the alternative plan to biogas flaring was reviewed, GHG emissions prevented at the facility in future were calculated. The results of the calculations show that GHG emissions can be gradually reduced through the implementation of the project through the partnership between National Grid and Waste Management. The annual decrease of GHG emissions after the project is complete will be over 100 thousands tons of GHG if the technology and operation of the plant are adjusted accordingly. Involvement of the barge transport instead of trucks for bioslurry delivery also translates into the GHG emissions reduction.

Therefore, it was proven that use of biogas as a source of clean energy has huge potential not only towards reducing GHG and the possibility of slowing down global warming, but also for the economy. If all of NYS's wastewater treatment plants would implement similar techniques, New York will be a better, more environmentally friendly city with very cheap energy and cleaner water.

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