Table A-1 City of Paterson CSO Structure Activity

Outfall		Name	Existing Condition	Action Taken	Notes	Since
001		Curtis Pl.	Active			
002		Mulberry St.	Inactive	Outfall plugged	Weir inside regulator plugged to divert all flow to the PVSC Interceptor.	implementation of floatables/solids control (post-2007)
003		W. Broadway	Active			
004		Bank St.	Inactive	Regulator plugged & abandoned	100% separation proposed in the implementation of floatables/solids control.	implementation of floatables/solids control (post-2007)
005		Bridge St.	Active			
006		Montgomery St.	Active			
007		Straight St.	Active			
008		Franklin St.	Inactive	Outfall pipe consolidated with 007		implementation of floatables/solids control (post-2007)
009		Keen St.	Inactive	Outfall pipe consolidated with 010		implementation of floatables/solids control (post-2007)
010		Warren St.	Active			
011		6th Ave.	Inactive	Regulator abandoned; outfall pipe plugged	CSO area 100% separated. Junction chamber diverts all flow to the PVSC Interceptor.	pre-2007
012		5th St. & 5th Ave.	Inactive	Outfall plugged	CSO area 100% separated.	pre-2007
013		E. 11th St.	Active			
014		E. 12th St. & 4th Ave.	Active			
015		S.U.M. Park	Active			
016		Northwest St.	Active			
017		Arch St.	Active			
018		Jefferson St.	Inactive	Regulator plugged; flow diverted to 032	Masonry wall installed within regulator to block peak dry weather flows from the outfall pipe.	pre-2007
019		Stout St.	Inactive	Regulator plugged; flow diverted to 032	Masonry wall installed within regulator to block peak dry weather flows from the outfall pipe.	pre-2007
020		N. Straight St.	Inactive	Regulator plugged; flow diverted to 032	Masonry wall installed within regulator to block peak dry weather flows from the outfall pipe.	pre-2007

Outfall		Name	Existing Condition	Action Taken	Notes	Since
021		Bergen St.	Active			
022		Short St.	Active			
023		2nd Ave.	Active			
024		3rd Ave.	Active			
025		10th Ave. 33rd Ave.	Active			
026		20th St.	Active			
027		Market St.	Active			
028		S.U.M. Park 2	Active			
Internal Overflow Chambers (IOCs)	A1-1		Inactive	IOC plugged & abandoned	Plugged after no overflows recorded during wet weather.	implementation of floatables/solids control (post-2007)
	A1-2		Inactive	IOC plugged & abandoned		pre-2007
	A1-3		Active			
	A1-4		Active			
	A1-5		Active			
	A1-6		Inactive	IOC plugged & abandoned	Plugged after no overflows recorded during wet weather.	implementation of floatables/solids control (post-2007)
	A1-7		Inactive	IOC plugged & abandoned	Plugged after no overflows recorded during wet weather.	implementation of floatables/solids control (post-2007)
	A1-8		Inactive	IOC plugged & abandoned	Plugged after no overflows recorded during wet weather.	implementation of floatables/solids control (post-2007)
	A1-9		Inactive	IOC plugged & abandoned	Plugged after no overflows recorded during wet weather.	implementation of floatables/solids control (post-2007)
029		River Rd. (Loop Rd.)	Active			
Internal Overflow Chambers (IOCs)	EF-1		Active			
	EF-2		Active			
	EF-3		Active			
	EF-4		Active			
	EF-5		Active			
	EF-6		Active			
030		19th Ave.	Active			
(IOC)	V2-1		Active			
031		Rt. 20 By-pass	Active			
Internal Overflow Chambers (IOCs)	V1-1		Active			
	V1-2		Active			
	V1-3		Active			
	V1-4		Active			
	V1-5		Active			

Outfall		Name	Existing Condition	Action Taken	Notes	Since
	V1-6		Active			
	V1-7		Active			
	V1-8		Active			
	V1-9		Active			
032		Hudson St.	Active			

Sewer System Model Calibration Update

PVSC updated the calibration and validation of the system-wide InfoWorks Integrated Catchment Model (ICM) of the PVSC system based on in-system and overflow monitored in the 2015-16 period. Monitored data at the permanent metering location at the Paterson Main Line and at temporary locations, including the inflow into Regulator 006A, underflow from 006A to the PVSC interceptor, and the Paterson Interceptor were used to guide the PVSC system-wide ICM update. The City of Paterson obtained this system-wide ICM model for localized calibration updates, as well as use in the development and evaluation of alternatives in the City's Long Term Control Planning (LTCP) effort.

Hydrology parameter selection and runoff generation methodology were maintained, with the major difference being the disaggregation of large outfall-specific drainage areas into smaller subcatchments based on factors specific to the Paterson system. These factors include: (a) connectivity to internal relief points (regulators); (b) representation of potential locations for green infrastructure implementation; and (c) extent of sewer separation already performed by the City historically, and additional areas being considered for sewer separation to primarily address flooding concerns. The majority of differences between the CSO estimates documented in the 2007 Cost and Performance Report and this calibration update were the result of sewer separation efforts undertaken by the city in CSO028 and CSO029 drainage areas. Further changes came from outfall consolidation and additional sewer separation completed by the City since 2006. The PVSC system-wide model did not account for these changes; therefore, the City implemented these changes in the existing conditions ICM model and reviewed the calibration status at the permanent and temporary monitoring locations. Runoff from the separated areas at specific outfalls including CSO028 and CSO029 is reported on its own to support the water quality modeling, however, is not accounted for in the alternatives evaluation in this LTCP process.

Even with the changes noted above, generally the modeled combined sewage hydrographs showed higher peak flows and volumes during the chosen storm events. Considering that the City of Paterson system includes 23 outfalls and the flow monitoring data was available only for a short period of time at fewer locations, the City has decided to progress towards the LTCP effort with this conservative ICM model that overestimates the wet weather flow contributions from the City.

Purpose of LTCP Project

On June 30, 2004, the New Jersey Department of Environmental Protection (NJDEP) revoked the General Permit for Combined Sewer Systems (CSS) (NJPDES No. NJ0105023) to require all municipalities with CSSs to develop a Long Term Control Plan (LTCP) in accordance with the National Combined Sewer Overflow (CSO) Control Policy. This phase of the Program required owners and operators of CSSs to develop and evaluate the feasibility of pathogen control technologies to meet the requirements of the Federal Clean Water Act (CWA). Subsequently, a Combined Sewer System Cost and Performance Analysis for the City of Paterson was prepared by Schoor DePalma, Inc. in conjunction with HydroQual, Inc., and was released in March of 2007.

In accordance with the Combined Sewer Overflow Individual Permit recently issued by the NJDEP to the City of Paterson in 2015, the City is now required to prepare its portion of a Long Term Control Plan for implementation into one integrated CSO LTCP for the PVSC service area.

The Report that follows is the Evaluation of Alternatives Analysis for the City of Paterson. It is a high-level overview of the alternative technologies that are required to be evaluated as part of the Combined Sewer Overflow Individual Permit, which are as follows:

- Greenscape Infrastructure (GI)
- Storage Capacity within the existing system
- Additional Storage Capacity in the City and/or at the Treatment Plant
- Reduction of Inflow and Infiltration
- Reduction of Potable Water Use
- Sewer Separation
- Treatment of CSO Discharge

These technologies will be discussed in more detail in Section C of the Report, along with a Screening Matrix showing the current and recommended implementations of specific technology practices (refer to Appendix B).

SECTION B FUTURE CONDITIONS

B.1 INTRODUCTION

Before any alternative technologies can be evaluated, we must first look at how the City of Paterson is projected to grow, and if any CSO-related projects were being planned while the new CSO Permit was issued. Each of the PVSC Permittees are required to design their technologies for population growth and wastewater flows projected out 30 years from when the LTCP will be enacted, or the year 2050. Moreover, each municipality must consider what combined sewer system improvement projects would be physically and financially feasible over that timeframe to meet the projected flow demands.

B.2 PROJECTIONS FOR POPULATION GROWTH

The Passaic Valley Water Commission (PVWC) serves water supply to the City of Paterson and had developed a report in 2003 projecting population increases in the city through Calendar Year 2050. The CSO municipalities have adopted 2050 as common year for wastewater projection to be used in this LTCP project. As such, the city extracted the population projections from this PVWC report and used as guidance to develop the population projection for Calendar Year 2050. Since this report was prepared prior to the last census record in 2010, a direct comparison of projection for 2010 and actual 2010 census population (146,199 persons) was used to scale down the future growth anticipated in the city. This estimate resulted in a population of 157,079 persons for Year 2050.

New Jersey Transportation Planning Authority (NJTPA) has developed projections for Year 2045 in the various NJ municipalities and its estimate of Year 2045 population for Paterson is 178,907 persons. Although the city is undergoing new and redevelopment and has experienced historical growth due to being along the Interstate Route 80 corridor, the rate of growth projected in the NJTPA study (0.6% annually) is significantly higher than our actual growth rate in the past two decades. Therefore, our projected population of 157,079 persons is used to account for future growth in the LTCP project and associated wastewater flow projections.

B.3 PLANNED PROJECTS

Prior to 2010, the City of Paterson had been experiencing street and basement flooding issues in the V2 flow area during rain events upstream of the V2-1 Regulator, which is located at the intersection of Vreeland Avenue and East 36th Street. The most severe flooding typically occurs on 18th Avenue between East 28th Street and East 31st Street; on 19th Avenue between East 32th Street and East 36st Street; on 20th Avenue between East 19th Street and East 22st Street; and around the St. Joseph's University Medical Center.

In an effort to reduce these ongoing flood issues, a relief sewer design concept was proposed in 2010 that would be an extension of the combined sewer system in the V2 flow area. The 7700-linear foot relief sewer concept was estimated in 2012 to be an $18-19 million project. However, while a general route location was discussed, it has not passed the preliminary discussion & design phase. A sketch that was used by the City for discussion purposes only is included in Appendix C. We have modeled a hypothetical version of this relief sewer in one of the proposed alternative scenarios to analyze its potential impact on the combined sewer system if it was implemented as part of the LTCP.

In addition to this relief sewer, there have been ongoing sewer separation projects in the City. Portions of this separation were implemented prior to 2006 and have been included in the baseline models of the City's sewer system, while more recent projects have been included in the alternatives analysis models of the system. A total of 981.5 acres were separated in the baseline model, which included the partial or complete separation (75-100%) of drainage areas serving outfalls 028, 029, and 031. A total of 47.4 acres were separated in the alternatives models, spread across the drainage areas serving outfalls 003, 014, 015, 021, and 024. The City has planned to completely separate the CSO023 drainage area, adding another 29.8 acres of separated area. In total, there are 1058.7 acres of former combined drainage areas that have been separated, or will be in the near future.

B.4 PROJECTED FUTURE WASTEWATER FLOWS

The PVWC report (2003) referenced earlier used a water demand of 185 gallons per capita per day (GPCD) from early 2000s. Not all the water demand gets translated to sanitary flow (dry weather flow, DWF). When the 2010 population census is used with DWF included in the PVSC model reflecting the sanitary flow contributions from Paterson, the average wastewater generation per capita was estimated to be 90.5 GPCD.

New and redevelopment projects typically use water conservation measures, including low-flow toilets and appliances such as washers and dishwashers. As such, the per-capita wastewater generation is expected to decline over the years. However, as a conservative assumption, the current wastewater flow of 90.5 GPCD will be used as an estimate for Calendar Year 2050, along with the population projection discussed in Section B.2 to develop the DWF estimate for use in the City's sewer system model.

SECTION C SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

This section will explain the City of Paterson's methods of screening the potential technologies as our Preliminary List of Alternatives is developed.

C.2 SOURCE CONTROL

Many source control measures currently exist within the City of Paterson. For example, as previously noted in Section B.4, water conservation from low-flow toilets and appliances is part of the City's established building code for new construction. All newly installed parking lots for the past 20 years have infiltration-based practices. Also, a policy of no-net-increase in runoff rate (based on a 2-year and 25-year, 1 hour storm) has been in effect since the late 1990s.

Although measures such as these reduce the effective impervious cover and source contribution from new and redevelopment projects, we have not accounted for such projects to be implemented until 2050, as another conservative assumption in Paterson's model.

C.2.1 Green Infrastructure

As part of the NJPDES requirement, the use of green infrastructure (GI) must be evaluated. The City of Paterson intends to factor in GI as an early alternative to reduce CSO discharges prior to considering grey infrastructure investments, such as storage tanks and/or tunnels. GI assets help to manage rainfall closer to where it falls, in comparison to tanks or tunnels normally built near the outfalls. History has shown that GI is not anticipated to reduce the annual volume/frequency of overflows significantly, unless it is implemented on a widespread level in the right-of-ways and public/private on-site locations. A breakdown of the implementation and siting processes for GI in Paterson will be provided in Section D.1.1 and D.1.2 of this Report.

C.3 INFILTRATION AND INFLOW CONTROL

When considering control of inflow and infiltration (I/I) within the City's CSS as an alternative technology, a definition of non-excessive inflow and non-excessive infiltration must first be defined for the City. While examining system flows under the City's baseline conditions for the LTCP, it was observed that the citywide level of I/I was approximately 7.5 MGD, or 50 gallons per capita based on the projected 2050 population. This amount of I/I does not meet the threshold for excessive infiltration of 120 gallons per capita as per N.J.A.C 7:14A-1.2. As a result, the City has chosen not to pursue the alternative technology of I/I control any further at this time.

It should be noted that there are also I/I contributions coming into the Paterson sewer system from adjacent communities—notably the Boroughs of Haledon, Totowa, and West Paterson—but are not directly connected to PVSC interceptors. No rainfall derived inflow and infiltration (RDII) controls are being assumed from these separate communities.

C.4 SEWER SYSTEM OPTIMIZATION

In-line storage of combined sewage refers to storage of combined sewage within the sewer system during wet weather events; with conveyance of the stored sewage occurring as the capacity in the downstream conveyance system becomes available. In-line storage is, as the term implies, developed within the sewer conveyance system. In-line storage can be developed in two ways: (1) harnessing the excess storage capacity available in the existing sewer conduits, if any, or (2) replacing portions of the existing sewer conduits with new, larger conduits that would afford additional storage capacity. Both cases employ the use of control structures, such as level sensors and inflatable dams, to produce the in-line storage, with stored flow subsequently diverted to the interceptor sewer for conveyance to the treatment facility. In-line storage is maximized when the sewer conduits are large and have relatively flat slopes. In-line storage is generally not feasible for conduits with diameters 24" or smaller.

C.4.1 Increased Storage Capacity in the Collection System

During the 2007 Schoor DePalma Cost and Performance Analysis, a review of each of the collection sewer systems directly upstream of its corresponding active PVSC regulator was conducted to determine whether existing conditions or improvements to the existing interceptors would produce sufficient storage to reduce or eliminate CSOs. In many instances, the interceptor sewer leading to the regulator is the largest diameter pipe within the given collection sewer system which in turn has the potential for the largest storage capacity. Yet, the evaluation of the storage capacity of the regulator and interceptor sewer lines proved that there is very limited storage capacity available.

Furthermore, an analysis of the City's existing sewer interceptors upstream of each active PVSC regulator was performed in 2007 to determine the total volume of each pipe. Accounting for the volume already occupied by wet weather flow in the pipe, as well as the slope of the pipe, the prismatic volume available for storage was estimated as half the total volume of the pipe segment. Most of the existing sewer conduits are of relatively small diameter and/or have lateral house connections, making them unsuitable for in-line storage purposes. There are five locations (CSO001, 005, 015, 016, and 026) where existing upstream sewers are larger than 24" in diameter, and their potential available volume for storage is sufficient to meet at least one of the CSO frequency targets. In all other cases, the CSO frequency target is either already attained, or utilization of in-line storage would not be sufficient to provide the required storage.

However, the study noted that in-line storage within existing conduits would only remedy specific CSO Areas, for a select few reduction objectives. Thus, in-line storage within existing conduits is not a standalone method of reducing overflows. Similar to GI, it would need to be used in conjunction with other technologies in order to meet the reduction objectives for all of the CSO areas.

Not only that, but flooding concerns exist in the City, especially in low lying areas near the Passaic River, where most of the PVSC regulators—and subsequent in-line storage—would be located. Detailed hydraulic evaluation of the existing sewer pipes was not performed as part of the 2007 report. As these computations must be performed, and upstream conditions must be considered before utilizing any existing conduit for in-line storage, we felt that this method would be less worthwhile to pursue at this time.

While in-line storage within the current infrastructure is not generally sufficient in reducing CSO volume, new conveyance pipelines that will come from the regionalized storage tank Alternative scenarios will increase capacity in the Paterson CSS. Where possible, whether by force or by gravity, these pipelines work to connect drainage areas within particular “regions” to greywater storage. This regional approach will be discussed further in Section D.1.2.

C.5 STORAGE

Combined sewer flow can be stored either within the current network of pipes ("in-line"), as well as "offline" in larger holding tanks near the City's CSO structures and connections to the PVSC interceptor. Through either or both of these techniques, a high reduction of both bacteria and volume in the combined sewer system is achieved. Offline storage requires installation of tanks parallel to drainage that collect flows exceeding a specified water level. Contents of a tank are then pumped back into the system when the PVSC interceptor returns to dry weather conditions that can handle the contents.

The City has evaluated several open locations (city and private owned properties) that could potentially hold offline storage tanks, which will be detailed in Section D.1.2 of this Report. As the optimal number of tanks are strategically sited, additional pump systems and conveyance pipelines must also be accounted for to connect multiple outfall drainage areas to regional tanks. It should also be noted that any potential storage tank facility sites near the Passaic River and falling within the 100-year floodplain are required to be entirely below grade.

Additionally, in-line storage can be achieved through constructing small or large diameter tunnels deep underground. These can serve to connect the flow area of one CSO to another as regional alternative technologies are implemented. As with storage tanks, tunnels pump back wet weather flow into the system when the PVSC interceptor returns to dry weather conditions. One likely application of a storage tunnel in Paterson will be near CSO025. This is an outfall whose drainage area is prone to flooding, lacks available land for a nearby tank, and is currently at the greatest need for greywater storage out of all of Paterson's active outfalls.

The sizing of greywater storage is ultimately limited by the facilities' collective "drain down" time. PVSC has mandated to each of the permittees that the total draining rate from all proposed storage facilities in an individual permittee's drainage area should not be greater than 75% of the permittee's total average dry weather flows. It was further noted that the drainage of the storage facilities to the PVSC interceptor during dry weather should not exceed three (3) days. With these conditions in mind, Paterson's combined sewer system dry weather flow was estimated at 13 MGD, meaning that our storage alternatives must be sized to not exceed 10 MG of drainage per day, and be fully emptied within three (3) days.

C.6 STP EXPANSION OR STORAGE AT THE PLANT

The City of Paterson is a municipality at the northernmost (upstream) end of the PVSC Combined Sewer System. Its only connection to the PVSC Treatment Plant is by way of the PVSC-owned interceptor main, which connects multiple PVSC Districts as flow moves downstream towards the Plant. Given its unique geography in relation to the other districts, the City has chosen not to further evaluate the alternative technology of additional storage at the Treatment Plant at this time.

C.7 SEWER SEPARATION

Sewer Separation involves any practice whereby the flow in the combined sewer system is reduced by cutting off stormwater entry points and/or constructing new separate storm pipes that drain directly into the nearby rivers & waterways. These entry points can range from catch basins along roadways, to roof leaders that tie in underground, to basement sump pumps in areas with a higher groundwater table. The construction of separate storm pipelines that essentially run parallel to the combined sewer pipeline tends to be more disruptive than other alternative technologies, and requires participation from the residents in the affected areas. However, the bacteria and volume levels in the combined sewer benefit greatly from separation.

Separation projects have been ongoing in many parts of the City of Paterson since the early 2000s. Specifically, the drainage areas contributing to CSO028 and CSO029 have undergone significant sewer separation efforts. A prior study performed by H2M reported an approximate 90% sewer separation in the drainage area of CSO028, leading to reduced overflow in A-1 but significantly increased stormwater (MS4) flows through CSO028.

Similarly, the CSO029 drainage area has undergone significant sewer separation over the years. Based on the review of drawings submitted by contractors, it is estimated that over 75% of this drainage area is separated. As such, only 25% of the drainage area was assumed to be served by combined sewers and the direct MS4 stormwater contribution to this outfall was significantly increased in order to account for this 75% sewer separation within this drainage area.

The sewer separation in the drainage areas to CSO028 and CSO029 are explicitly included in the baseline scenario, since the timeline for this effort has extended over two decades. However, since 2006, the city has undertaken targeted sewer separation efforts in some outfall drainage areas to address either localized flooding concerns or eliminate the need for CSO control. After review of Paterson storm sewer record drawings, partial sewer separation was observed in the drainage areas serving outfalls 003, 014, 015, 021, and 024, totaling 47.4 acres (refer to Appendix D). These areas were added to the existing baseline separated areas in order to quantify the estimated CSO reduction benefits that have occurred since 2006. Over the course of the typical year model simulation, these sewer separation projects resulted in a CSO reduction of approximately 10 MG.

Finally, as previously noted in Section B.3 of this Report, the City has identified the drainage area serving CSO023 as a potential site for future sewer separation, totaling 29.8 acres. This additional area was included in the InfoWorks model prior to the evaluation of both green and grey infrastructure alternatives. Over the course of the typical year model simulation, this sewer separation project resulted in a CSO reduction of approximately 9.0 MG.

In total, there are 1058.7 acres of former combined drainage areas that have been separated, or will be in the near future. The drainage areas that have been partially or completely separated are depicted in Appendix D.

C.8 TREATMENT OF CSO DISCHARGE

Where available land near outfall structures is limited, or when required storage volume exceeds the maximum size of a potential regional storage tank, the City of Paterson is evaluating the treatment of discharge by way of adding disinfectant. The City has found that the most feasible disinfectants to utilize are either sodium hypochlorite or peracetic acid.

Hypochlorite systems have been common in wastewater treatment installations. For years, large, densely populated metropolitan areas have employed hypochlorite systems in lieu of chlorine gas for safety reasons. The hypochlorite system uses sodium hypochlorite in a liquid form much like household bleach, and can be delivered in tanker trucks to be stored in above ground tanks. However, the storage life of the solution is only 60 to 90 days, before the disinfecting ability of the solution starts to degrade. Additionally, residual chlorine is toxic to many kinds of aquatic life, and chlorine can react with organic materials in water and wastewater, including CSO, to form carcinogenic trihalomethanes and organochlorines. As a result, dechlorination is often required to remove residual chlorine from wastewater prior to discharge into sensitive aquatic waters.

Peracetic acid (PAA) was chosen for further analysis over sodium hypochlorite for several reasons. It has been used as a disinfectant in various industries, including the food and beverage industries and smaller, more confined applications, including hospital settings. PAA is relatively effective, non-toxic and does not produce toxic byproducts. At the time of the 2007 Cost and Performance Analysis by Schoor DePalma, PAA was not yet permitted for water, wastewater or CSO applications, and was said to be too expensive to acquire due to limited distributors. However, new pilot studies in the United States and Europe have changed this. Very low operations & maintenance costs relative to sodium hypochorite, along with a growing list of suppliers, gives greater justification to utilizing PAA in the City of Paterson's mostly urban landscape.

A summary of the treatment costing methods will be shared later in Section D.

C.9 SCREENING OF CONTROL TECHNOLOGIES

The screening of control technologies was completed by the City of Paterson in September of 2018 using the Alternatives Screening Matrix, which was generated by PVSC for the use of each of their CSS District Permittees (refer to Appendix B). Each of the control technologies previously discussed in this Section C are listed within this Matrix.

As previously stated in Section A, the Matrix was designed by PVSC for each of the Permittees to show specific technology practices that are either active in the City or could be further evaluated. Each practice of each technology group has a Bacteria Reduction level and Volume Reduction level; this can range from "None" up to "High." Additionally, each practice may be able to be combined with other technologies. The entries in the final three columns of the Matrix were completed by Paterson specifically. These include statements of whether a practice is currently being implemented, if the practice is recommended for further evaluation in the LTCP, and any other applicable notes. It is important to mention that, while practices with higher reduction goals may be more beneficial towards achieving the conditions of the Combined Sewer Overflow Individual Permit, the feasibility of each practice in the City may vary.

SECTION D ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

Taking into account each of the alternative technologies discussed in the previous Sections, the City of Paterson has developed a preliminary report of the estimated costs necessary to achieve target levels of CSO control. These levels of control are defined as desired numbers of systemwide overflows on an annual average basis, as well as 85% wet weather capture by volume in the combined system on an annual average basis. To achieve these targets, the technologies that will be incorporated into the City's alternative scenarios include, but are not limited to:

- Existing & Future Sewer Separations
- Planned Relief Sewer along 19th Avenue (In-line Storage)
- Green Infrastructure
- Storage Tanks & Tunnels
- CSO Treatment by Disinfection

Starting with our expanded baseline model, we establish that within the Paterson CSS, our wet weather results in a total CSO volume of about 353 MG, as well as 82.1% wet weather capture. The alternative technologies listed above aim to reduce this volume of CSO flow and increase capture to varying degrees. The alternative scenario that is ultimately selected for Paterson is dependent on the affordability of the system improvements to the City, as well as the overall level of improvement that the PVSC District hopes to achieve after a knee-of-the-curve cost analysis.

D.1.1 Implementability

CSO Treatment by Disinfection

Early research by the PVSC District CSO Permittees yielded varying opinions on the need for primary treatment, such as compressible media filtration (e.g. FlexFilter), prior to disinfection of overflows. Since it is currently unknown if water quality standards can be reached in Paterson with PAA dosage alone, it was discussed amongst the Permittees that each municipality consider developing treatment cost estimates with contingencies that include primary treatment prior to disinfection. If an Alternative containing disinfection is selected in the LTCP, a pilot study project at a single outfall (or group of outfalls) in the CSS should be implemented first to measure the technology's impact. Results from a pilot project within the City would provide the best conclusions towards disinfection on a larger scale in the City. As such, the Alternatives shall be budgeted accordingly to prepare for the possibilities of a need for a higher PAA dosage, primary treatment, or inefficiency and a move towards storage tanks/tunnels instead.

Green Infrastructure

An initial "top-down" approach implemented GI in every outfall at 3% and 6% levels uniformly to quantify their benefits on an outfall-by-outfall basis. Existing drainage areas were split into managed and unmanaged portions. Managed portions were modeled such that they only generated runoff when the cumulative rainfall in a given event exceeded 1.25 inches. This rainfall depth threshold was based on the standard NJDEP water quality storm of 1.25 inches over 2 hours. Generally, for the 3 -6% GI implementation rate, we observed between 4 to 7% reduction in total annual CSO volumes on a citywide scale, with frequencies essentially remaining the same. Volume reductions varied between different outfalls based on the extent of impervious cover and routing within the collection systems of these outfall drainage areas.

In dense urban centers similar to Paterson, there are several major constraints to GI implementation, including: limited infiltration potential; high groundwater table; bedrocks; utilities; smaller lots; and narrow sidewalks. Therefore, we evaluated GI from the key consideration of ownership and anticipated water quality benefits (i.e., CSO reduction). In most cases, where larger and more frequent CSOs are estimated, the prioritization will be on grey infrastructure. Similarly, the GI is prioritized on low volume/less frequently overflowing outfalls, with the intent of making as significant of a difference in water quality outcomes as possible. In order to achieve this objective, we analyzed the types of properties and the potential areas available for possible GI implementation based on the right-of-way and property classification and ownership. We began with a suite of GI tools that would be implementable in a dense urban setting, as shown in Figure 1 of Appendix G.

Based on the “top-down” GI modeling results and lessons learned from other CSO municipalities in the region, we established a target GI implementation rate to manage approximately 2.5% of the impervious cover in the combined sewer drainage area within Paterson (in which the first 1.25 inches of rainfall was managed). After this goal was established, a “bottom-up” approach was undertaken to characterize the different land use types and potential opportunities available in the various outfall drainage areas, both within existing properties (on-site) and within the city, county, state and federal right-of-way. Figure 2 of Appendix G shows the land use types within the city considered in the initial screening.

D.1.2 Siting

Greywater Storage

The active CSO structures of Paterson’s combined sewer system discharging into the Passaic River are located in such a way that, as identified in in the 2007 Schoor DePalma study, the outfalls were grouped into four (4) regions for clustered CSO storage and/or treatment (refer to Appendix E). For the development of this LTCP, a similar regional approach is being taken, but with the exception of CSO025 from the Eastern Region. This structure is set on its own due to its unique location that is prone to flooding, generally lacking available land for a nearby tank, and is currently at the greatest need for greywater storage out of all of Paterson’s active outfalls.

Our siting of potential greywater storage is detailed in Appendix F. When exploring available land for storage tanks in Alternatives 4-9, priority was given to land that was already city-owned in order to minimize land acquisition costs. Private properties closer to the outfall structures were then considered, especially those where lots were mostly vacant or otherwise abandoned.

As previously mentioned in Section C.4.1, additional conveyance pipelines will be required as part of Alternatives 4-9 as greywater storage is regionalized. These pipes would be designed to capture combined sewer flow during wet weather just downstream of an outfall’s regulator chamber. Flow would then be redirected to a regional tank or tunnel for storing until the wet weather has passed, at which time the storage facility can be dewatered to the PVSC interceptor during dry weather. The costing and sizing of these conveyance pipelines, as well as pump stations where necessary to direct combined flow through varying elevations, are factored into Alternatives 4-9, and are detailed further in Appendix F.

Consideration was given when sizing each in-line and offline greywater storage facility so that tank/tunnel pump-down time would not exceed three (3) days of dry weather. Increasing dry weather flow conveyance to the PVSC Interceptor was not considered at this time due to the costs & limitations of upsizing combined sewer pipes between other existing utility infrastructure. Rather, the proposed greywater storage facilities were sized to accommodate the existing combined sewer infrastructure, maintain flow levels to the Interceptor that PVSC has accepted in the past, and collect incremental benefits of the alternative technologies implemented around them (sewer separation, relief sewer, GI). Any potential storage tank sites that fall within the 100-year floodplain are required to be a waterproof, subsurface facility. Conversely, any potential storage tank sites that fall outside of the 100-year floodplain are not required to be a subsurface facility. However, they can still be designed as such due to elevation constraints (land, sewer inverts, etc.), or to pursue potential GI landscape benefits atop a structure built below grade.

Table D-1 below serves as a supplement to the greywater storage siting study and cost estimates that are detailed in Appendix F.

Table D-1 Summary of Greywater Storage Implementability

Outfall Group	Outfall ID	No. of Potential Tanks	Potential Tank Location	Block	Lot(s)	Site Dimensions	Largest Tank Dimensions	Within 100-yr floodplain?	Notes
A	**031**	None (tunnel only)	---	---	---	---	---	---	
B	**015, 016, 028**	Up to 3 Tanks	B1	608	10-11	100' x 50'	45'd x 27'h	NO	May be subgrade to accommodate sewer invert/elevation change.
			B2	601	6	70' x 50'	45'd x 27'h	NO	May be subgrade to accommodate sewer invert/elevation change.
			B3	801	17	225' x 126'	40'd x 8'h	YES	Vacant lots. GI development possible at grade.
C	**026, 027, 030**	Up to 2 Tanks	C1	8020	1	110' diam.	110'd x 18'h	NO	Likely subgrade to accommodate sewer invert.
			C2	7902	1	80' diam.	80'd x 20'h	NO	Likely subgrade to accommodate sewer invert.
D	**001, 003, 029**	Up to 3 Tanks	D1	3701	1-7	250' x 90'	80'd x 15'h (x2)	YES	Vacant lots. GI development possible at grade.
			D2	3713	1-14	260' x 60'	60'd x 13'h	YES	Vacant lots. GI development possible at grade.
			D3	3712	24-36	230' x 180'	160'd x 16'h	YES	Vacant lots. GI development possible at grade.
			D4	1401	1	250' x 220'	---	YES	Option for collection further upstream. Would remove & replace existing ballpark at grade.
E	**005**	1 Tank	E1	3701	14-15	214' x 80'	75'd x 10'h	YES	Vacant lots. GI development possible at grade.
			E2	3701	11-13	125' x 80'	---	YES	Vacant lots. GI development possible at grade.
F	**006**	Up to 2 Tanks	F1	3117	1, 13-14	90' diam.	90'd x 17'h	YES	Vacant lots. GI development possible at grade.
			F2	3116	1-6	100' diam.	100'd x 17'h	YES	Vacant lots. GI development possible at grade.
			F3	3101	7	215' x 125'	---	YES	Vacant lots. GI development possible at grade.
G	**007, 010**	1 Tank	G1	3105	1	200' x 220'	190'd x 13'h	YES	Replace/redevelop existing dog park at grade.
H	**013, 014**	None (tunnel only)	---	---	---	---	---	---	
I	**017**	1 Tank	I1	213	12-16	150' x 75'	70'd x 14'h	YES	May be subgrade to accommodate sewer invert/elevation change.
J	**021, 022, 032**	Up to 4 Tanks	J1	119	3-6	100' x 100'	90'd x 16'h	YES	Properties mostly abandoned or city-owned. GI development at grade likely.
			J2	120	38-40	100' x 100'	90'd x 16'h	YES	Properties mostly abandoned or city-owned. GI development at grade likely.
			J3	120	4-7	125' x 100'	90'd x 15'h	YES	Properties mostly abandoned or city-owned. GI development at grade likely.
			J4	119	1, 48-49	123' x 100'	90'd x 15'h	YES	Properties mostly abandoned or city-owned. GI development at grade likely.
K	**025**	1 Tank	K1	8208	2	425' x 175'	175'd x 21'h	NO	Subgrade. Would remove & replace existing school ballpark at grade.
			K2	8101	1	225' x 150'	140'd x 14'h	NO	May be subgrade to accommodate sewer invert/elevation change.
L	**024**	1 Tank	L1	2403	3-5	400' x 200'	190'd x 13'h	NO	May be subgrade to accommodate sewer invert/elevation change.

Green Infrastructure: Right-of-Way (ROW)

ROW constitutes a major fraction of impervious cover directly connected to sewer systems in urban areas. Roofs, patios, and driveways may drain directly to sewers or runoff of adjacent pervious areas and then eventually connect to the sewers. ROW GI projects can include a variety of design topologies, including bio-swales, continuous tree trenches, green sidewalks, and others. Paterson encompasses the Interstate Route 80 corridor, NJ State 20 and 19 corridors, Passaic County arteries/major roads, and city-owned local roads. With federal, state and county ROW being significant and potential opportunities for grants to fund GI projects and reduce their component impacts on Paterson's sewer system, our GI planning focused entirely on these ROW types. There were approximately 160 acres of available federal, state, and county ROW within the city's combined drainage areas (excluding areas with any level of sewer separation); GI can be implemented on 50 acres of this space. Figure 3 of Appendix G shows the ROW in various outfall drainage areas identified in this analysis.

Green Infrastructure: On-Site

A careful screening of property types was conducted to determine what opportunities may exist for on-site retrofits within the City. Based on available parcel data maintained by Passaic County, a multi-tiered property analysis was conducted to identify which properties fell under one of four classifications (tiers): (1) City-Owned; (2) School District-Owned; (3) Other (federal, state and county) Government-owned; and (4) Tax-exempt (non-profit) properties. Although these are not in any priority order, the chances of applying for and obtaining grants to fund the GI projects generally are better with Tier 1 than the Tier 4 properties. In addition, the ownership of parcels plays a major role in terms of obtaining permits for GI construction and operating and maintaining over lifetime; Tier 1 offers the most feasibility to Tier 4 offering the least feasibility. Figures 4 through 7 in Appendix G show the identified GI opportunities in each of the four tiers. A total of 25 managed impervious acres can be spread evenly between parcels in combined sewer drainage areas (excluding areas with any level of sewer separation). Both ROW and on-site GI were included in the Paterson InfoWorks model to assess the incremental benefit of GI.

D.1.3 Public Acceptance

While each of the screened CSO technologies chosen for further analysis have a level of implementation, they must also be accepted by the public. All of the technologies that become part of the LTCP will have to function for not only the improvement of the City's combined sewer flows, but also for the best interest of the city's residents.

The City realizes that the overall perception of green infrastructure is very good. With this in mind, the City has opted to include its implementation as one of the early Alternatives towards achieving 85% capture. It is understood that green infrastructure does not capture or treat nearly as much volume as other alternative technologies, but its general acceptance with the public gives it consideration for development in the City's CSS.

Storage tunnels are designed to be located deep underground, and as a result, are of minimal impact to the community during and after construction. Similarly, regionalized storage tanks are to be built, maintained and operated below-grade if they are sited within the Passaic River's 100-year floodplain, and also where sufficient depth is required for them to connect to the existing CSS infrastructure.

Disruption to the public would only occur during each tank's installation, and if there is a lack of maintenance during their lifespan, resulting in need for odor control.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

The Alternative scenarios that the City has currently developed in its model runs and cost calculations are described in the list that follows. A summary of each of the City's CSO volumes, overflow frequencies, and wet weather capture percentages under each Alternative scenario can be seen in Appendix H.

- Alternative 1: Baseline Model + Sewer Separation projects completed since 2006
- Alternative 2: Alt. 1 + Planned Sewer Separation for CSO023 + 19th Ave. Relief Sewer for CSO030
- Alternative 3: Alt. 2 + Green Infrastructure (2.5%)
- Alternative 4: Alt. 3 + Storage / Treatment required to reach zero (0) overflows
    - Alternative 4A: Alt. 3 + Storage Tanks and/or Tunnels
    - Alternative 4B: Alt. 3 + Storage & Disinfection hybrid
    - Alternative 4C: Alt. 3 + Treatment by Disinfection
- Alternative 5: Alt. 3 + Storage / Treatment required to reach four (4) overflows
    - Alternative 5A: Alt. 3 + Storage Tanks and/or Tunnels
    - Alternative 5B: Alt. 3 + Storage & Disinfection hybrid
    - Alternative 5C: Alt. 3 + Treatment by Disinfection
- Alternative 6: Alt. 3 + Storage / Treatment required to reach eight (8) overflows
    - Alternative 6A: Alt. 3 + Storage Tanks and/or Tunnels
    - Alternative 6B: Alt. 3 + Storage & Disinfection hybrid
    - Alternative 6C: Alt. 3 + Treatment by Disinfection
- Alternative 7: Alt. 3 + Storage / Treatment required to reach twelve (12) overflows
    - Alternative 7A: Alt. 3 + Storage Tanks and/or Tunnels
    - Alternative 7B: Alt. 3 + Storage & Disinfection hybrid
    - Alternative 7C: Alt. 3 + Treatment by Disinfection
- Alternative 8: Alt. 3 + Storage / Treatment required to reach twenty (20) overflows
    - Alternative 8A: Alt. 3 + Storage Tanks and/or Tunnels
    - Alternative 8B: Alt. 3 + Storage & Disinfection hybrid

  - Alternative 8C: Alt. 3 + Treatment by Disinfection
- Alternative 9: Alt. 3 + Storage required to reach 85% system capture within the City

D.2.1 Summary of Cost Opinions

Working from the City of Paterson's 2006 baseline year model, the City Engineer has reported that sewer separation projects completed since that time have totaled about $5 million. This estimate (plus 20-year lifecycle projected maintenance costs) will serve as the cost for Alternative 1, which concludes the categorization of existing improvements made to the City's CSS that can be taken credit for under this LTCP.

Alternative 2 is a proposed separation/in-line storage scenario that brings together the benefits of two planned projects aimed to reduce overflows and mitigate known flooding issues in the City. The first project aims to fully separate the storm and sanitary flows in the collection area of CSO023. The City Engineer has projected the costs of implementing this sewer separation project to be about $2.5-3 million. Secondly, as previously mentioned in Section B.3 and seen in Appendix C, a concept plan for a flood relief sewer in the V2 flow area (towards CSO030) has been discussed since 2010, but has been unable to pass the preliminary discussion & design phase. The 7700-linear foot relief sewer concept was estimated in 2012 by the City Engineer to be an $18-19 million project. Together, the construction costs of the planned projects in Alternative 2 will total to an estimated $22 million. Factoring in their respective 20-year lifecycle projected maintenance costs, as well as the costs of the existing improvements from Alternative 1, Alternative 2 will cost approximately $36 million to implement. Sewer separation costs across Alternatives 1 and 2 are summarized below in Table D-~~1~~2.

Table D-~~1~~2 Cost of Completed Sewer Separation & Planned Projects (Alternatives 1 & 2)

Projects	Construction Cost	Annual Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
▪ Sewer Separation Projects Completed in Paterson Since 2006	$5,000,000	$100,000	$1,522,700	$6,522,700
Including Baseline Conditions (Alternative 1):				**$6,522,700**
▪ Planned Sewer Separation for CSO023 Service Area	$3,000,000	$60,000	$913,620	$3,913,620
▪ Planned 19th Avenue Relief Sewer for V2 Area (CSO030)	$19,000,000	$380,000	$5,786,260	$24,786,260
Cost of Planned Projects:				$28,699,880
Including Alternative 1 System Changes (Alternative 2):				**$35,222,580**

Alternative 3 proposes to add green infrastructure technologies. For budget purposes, an estimate to manage the water quality-based storm event (1.25 inches over 2 hours) for approximately 2.5% of land area was conducted (seen below in Table D-~~2~~3).

Table D-~~2~~3 Cost of Green Infrastructure (Alternative 3)

GI Asset	Total Volume (CF)	Construction Cost	Annual Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
▪ On-Site (Raingarden)	113,437	$2,382,187	$19,284	$293,640	$2,675,828
▪ ROW (Bioswales)	226,875	$10,209,375	$54,450	$829,107	$11,038,482
Cost of Green Infrastructure:					$13,714,310
Including Alternative 2 System Changes (Alternative 3):					**$48,936,890**

The dichotomy considered was management of approximately two-thirds of the runoff volume with ROW BMPs (bioswales). The remaining third of this volume is proposed for management in on-site areas (rain gardens). In addition, an estimated maintenance cost is also documented for operational considerations for a 20-year lifecycle. Factoring in the costs of the proposed improvements listed in the previous Alternatives on top of the 2.5% GI scenario, the estimated cost of Alternative 3 is approximately $49 million.

After implementing GI, the City then calculated the remaining storage volume necessary to reach the targets of 0, 4, 8, 12, and 20 untreated overflows at each outfall within the City's CSS, as established earlier in this report. First, the costs of the "A" Alternatives are made up of regionalized storage tanks and/or tunnels, along with the necessary conveyance pipe to connect flow areas, over a projected 20-year lifecycle. Storage tanks are only proposed where they are most feasible to be implemented, otherwise a deep tunnel is costed to hold the required storage volume instead. The zero-overflow scenario requires additional storage beyond greywater to effectively eliminate the overflows at CSO028, which are present only in this scenario. We solved this by estimating costs for bending weirs at each of three (3) regulators in the A1 drainage area. Next, the "C" Alternatives were developed by costing the necessary disinfection facility to handle corresponding peak 5-minute CSO flow for each outfall group, as well as costing the annual required dosage of the disinfectant, which Paterson has selected to be peracetic acid (PAA). These costs include all necessary conveyance pipes and pumps needed in the "A" Alternatives. Then, the "B" Alternatives costs were intended to be a hybrid of greywater storage tanks and treatment by disinfection. In instances where a storage tank was not feasible, disinfection would be chosen. Finally, Alternative 9 was created to show the minimum amount of greywater storage necessary to reach at least 85% system capture in the City after Alternative 3.

Moreover, the City of Paterson took the approach of structuring their Development and Evaluation of Alternatives study into two levels. Alternatives 1 through 3 use existing and proposed sewer separation technologies along with potential green infrastructure to improve the PVSC District's connected system efforts towards attaining 85% system-wide capture. It should be noted that these scenarios were not intended as means to reach that same level of percent capture in the City of Paterson. Instead, Alternatives 4 through ~~8~~9 explore the additional storage and/or treatment of flow required to achieve the percent capture and overflow targets of the Permit within Paterson's CSS, whilst including the cumulative benefits of the technologies present in Alternative 3.

Appendix H contains summary tables of each Alternative's changes to CSO volume, frequency, and wet weather percent captures, as well as cost breakdowns for Alternatives 4-9. The overall costs of the necessary infrastructure in each Alternative are summarized below in Table D-~~3~~4, by level of control, in millions of U.S. Dollars.

Table D-~~3~~4 Cost of Alternatives Summary Table by Level of Control

Life Cycle Costs by Overflows / yr or % Capture ($ Million)	85% Capture	0 Overflows	4 Overflows	8 Overflows	12 Overflows	20 Overflows
▪ Alternative 1 *	$7					
▪ Alternative 2 *	$36					
▪ Alternative 3 *	$49					
▪ Alternatives 4-8A		$819	$468	$368	$327	$268
▪ Alternatives 4-8B		$645	$380	$250	$232	$227
▪ Alternatives 4-8C		$637	$363	$234	$203	$172
▪ Alternative 9	$78					

* Note: Alternatives 1-3 improve the District's connected system efforts toward 85% system-wide wet weather capture, but not exclusively for Paterson. Alternatives 4-9 achieve at least 85% capture in Paterson.

D.3 PRELIMINARY SELECTION OF ALTERNATIVES

The initial conclusion that can be drawn from the cost estimates shown in Table D-2 is that the implementation of flow treatment technology appears to be more cost-effective than greywater storage. It should be noted that reaching the overflow targets using PAA disinfection does not change the volume of flow that is discharged at each of the City's outfalls. Rather, overflow events will be treated to water quality standards up to the specified target number of overflows that is selected under the LTCP. Also, while a generally cheaper alternative compared to storage, conclusions drawn from PAA disinfection are limited to several pilot studies, and logistical issues may arise with the storage treatment chemicals at the majority of the active outfalls in the City. The main focus for the City in the next phase of the LTCP will be determining the balance of greywater storage and treatment of flow by disinfection that it can afford and can adequately staff and maintain.

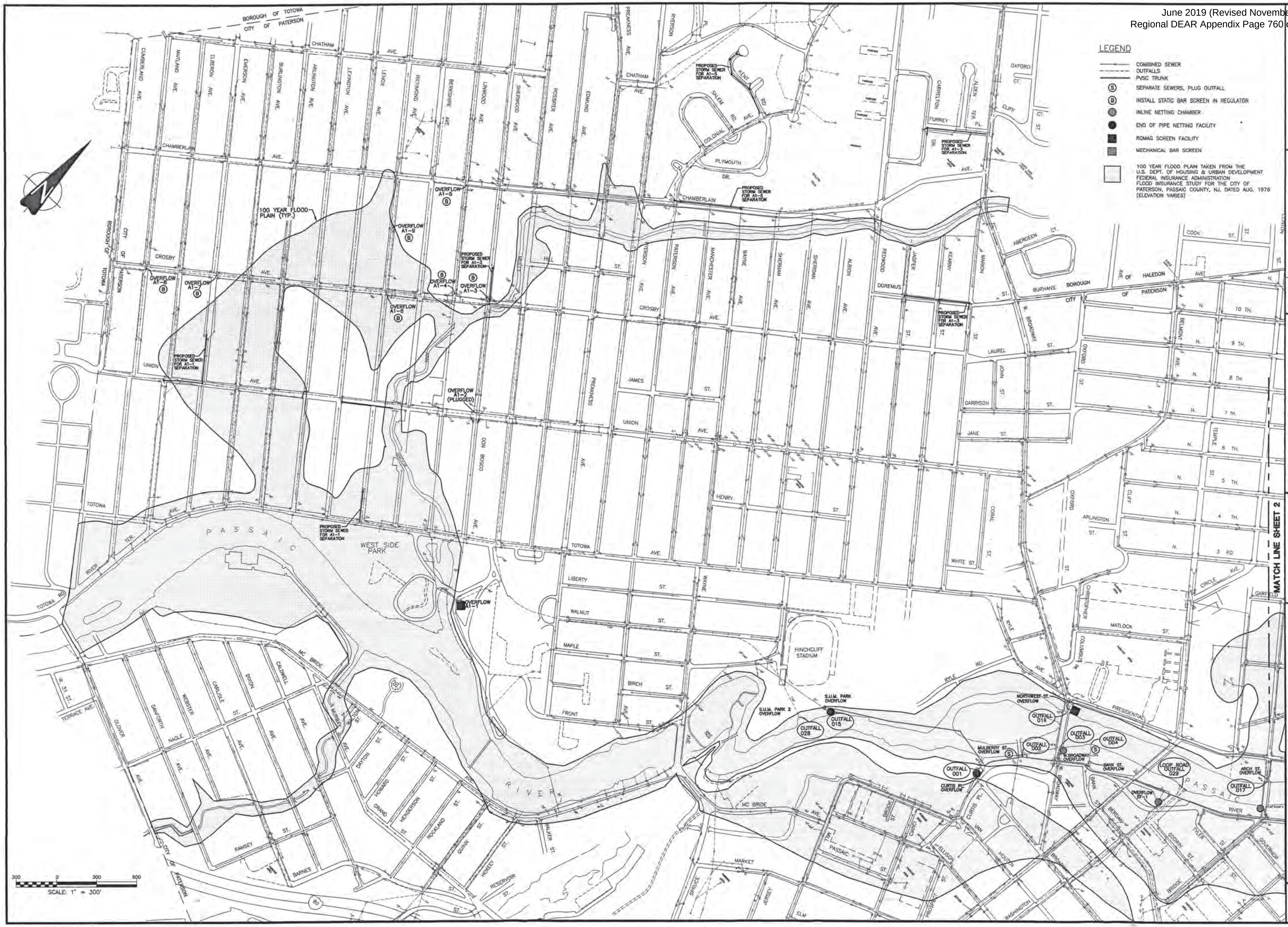
Table D-~~4~~5 below contains a list of the Alternatives that the City of Paterson will pursue for further evaluation in the Selection of Alternatives Report to be published next year.

Table D-~~4~~5 List of Preliminary Alternatives

Alternative	Proposed Technologies in Each Alternative
▪ Alternative 4 (A-C)	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage / Treatment required to reach **zero (0) overflows**
▪ Alternative 5 (A-C)	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage / Treatment required to reach **four (4) overflows**
▪ Alternative 6 (A-C)	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage / Treatment required to reach **eight (8) overflows**
▪ Alternative 7 (A-C)	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage / Treatment required to reach **twelve (12) overflows**
▪ Alternative 8 (A-C)	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage / Treatment required to reach **twenty (20) overflows**
▪ Alternative 9	Baseline Model; Sewer Separation projects completed since 2006; Planned Sewer Separation for CSO023; 19th Ave. Relief Sewer for CSO030; Green Infrastructure (2.5%); Storage required to reach **85% system capture** within the City

APPENDIX A

Paterson Sewer System Killam Maps



CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
CSO SOLIDS/FLOATABLES CONTROL PLANNING STUDY
RECOMMENDED CONTROL PLAN-
ALTERNATIVE 2
PLATE C

Killam
Associates Consulting Engineers
27 Bleeker Street
Millburn, New Jersey 07041

JOHN S. ROLAK, JR.
Professional Engineer – N.J. Lic. No. 29108

Date

Designed	Drawn	Checked	Approved	Date
RAA	RCC	RAA	JSR	7/17/97

Revision	Date

Job	No.	
227405	B/0	1 Total 5

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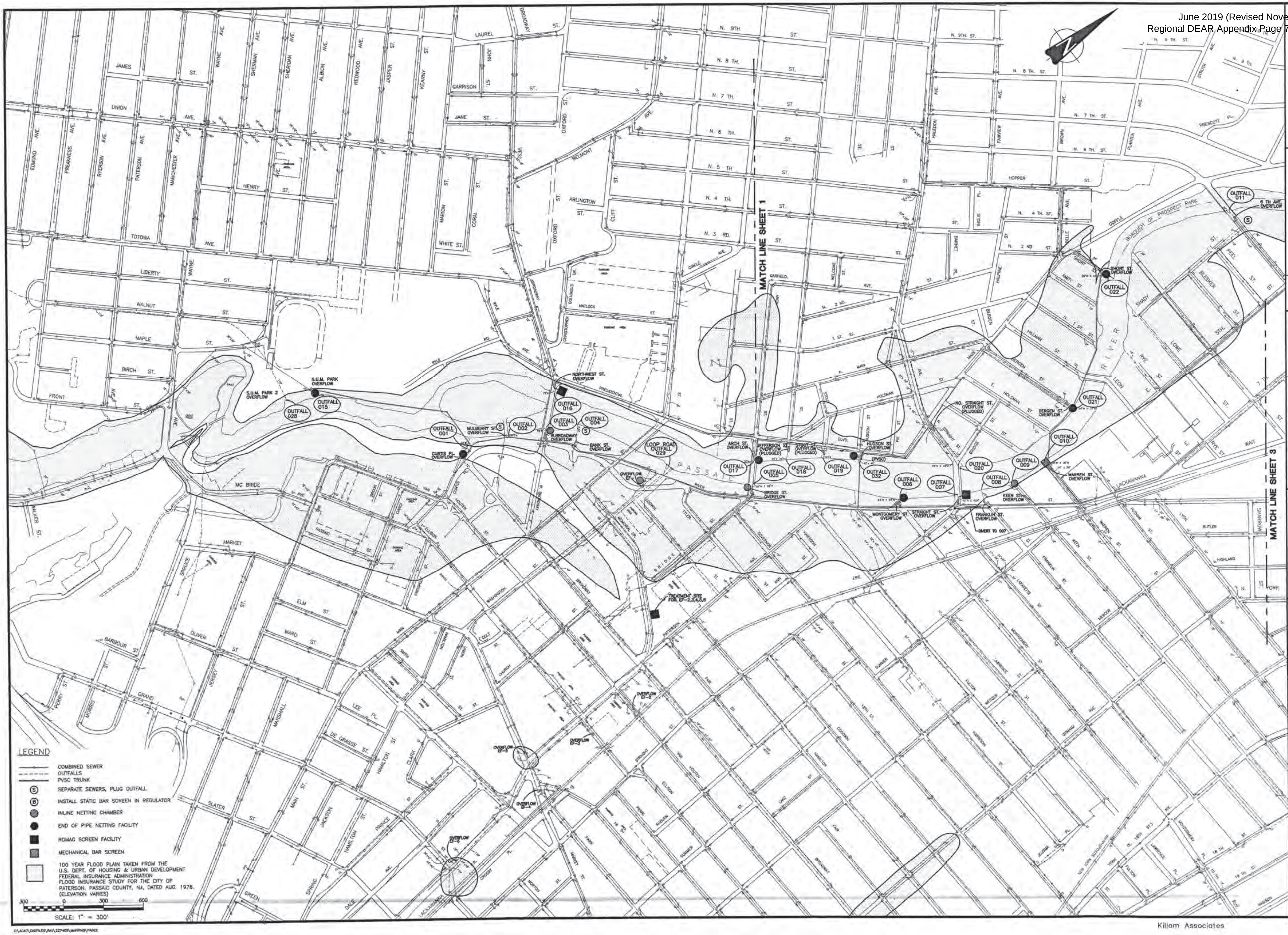
Killam Associates

Contract No.



LEGEND

- COMBINED SEWER
- OUTFALLS
- PVSC TRUNK
- Ⓢ SEPARATE SEWERS, PLUG OUTFALL
- Ⓑ INSTALL STATIC BAR SCREEN IN REGULATOR
- ● INLINE NETTING CHAMBER
- ● END OF PIPE NETTING FACILITY
- ■ ROMAG SCREEN FACILITY
- ▨ MECHANICAL BAR SCREEN
- ☐ 100 YEAR FLOOD PLAIN TAKEN FROM THE U.S. DEPT. OF HOUSING & URBAN DEVELOPMENT FEDERAL INSURANCE ADMINISTRATION FLOOD INSURANCE STUDY FOR THE CITY OF PATERSON, PASSAIC COUNTY, NJ. DATED AUG. 1976. (ELEVATION VARIES)

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SCALE: 1" = 300'

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CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
CSO SOLIDS/FLOATABLES CONTROL PLANNING STUDY
RECOMMENDED CONTIVE PLAN-
ALTERNATIVE 2
PLATE C

Killam
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RAA	RCC	RAA	JSR	7/17/97

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Revision

Job	No.
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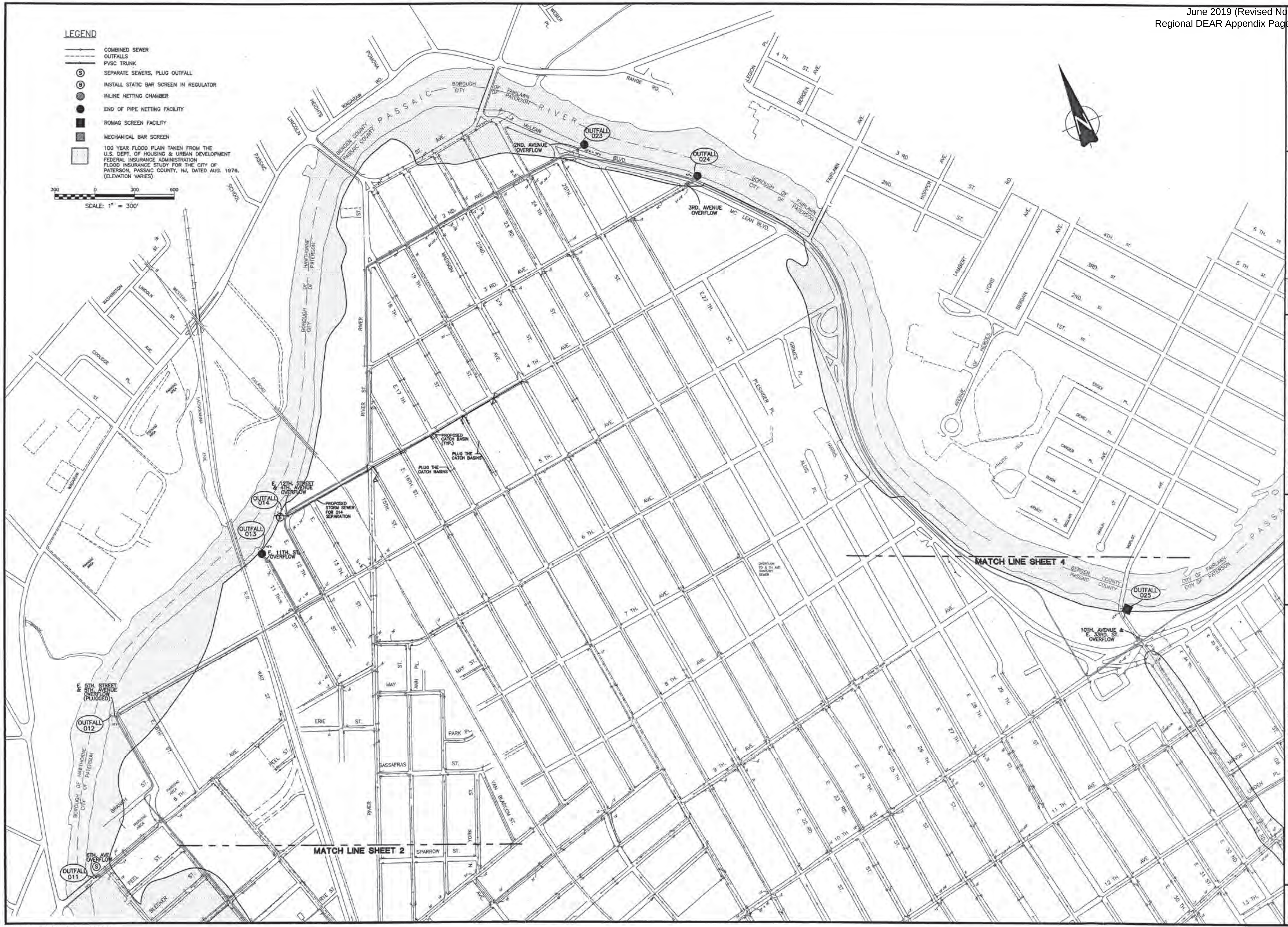
B/0	Total 5

Print Date

Killam Associates

Contract No.



CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
CSO SOLIDS/FLOATABLES CONTROL PLANNING STUDY

RECOMMENDED CONTIVE PLAN-

ALTERNATIVE 2

PLATE C

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RAA	RCC	RAA	JSR	7/17/97

Job	No.	
227405	3	
	B/O	Total 5

Date

Revision

Print Date

LEGEND

- ——•—— COMBINED SEWER
- - - - - - OUTFALLS
- ━━•━━ PVSC TRUNK
- Ⓢ SEPARATE SEWERS, PLUG OUTFALL
- Ⓑ INSTALL STATIC BAR SCREEN IN REGULATOR
- ◍ INLINE NETTING CHAMBER
- ● END OF PIPE NETTING FACILITY
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300 0 300 600

SCALE: 1" = 300'

CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
CSO SOLIDS/FLOATABLES CONTROL PLANNING STUDY

RECOMMENDED CONTROL PLAN-
ALTERNATIVE 2

PLATE C

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RAA	RCC	RAA	JSR	7/17/97

Date	Revision

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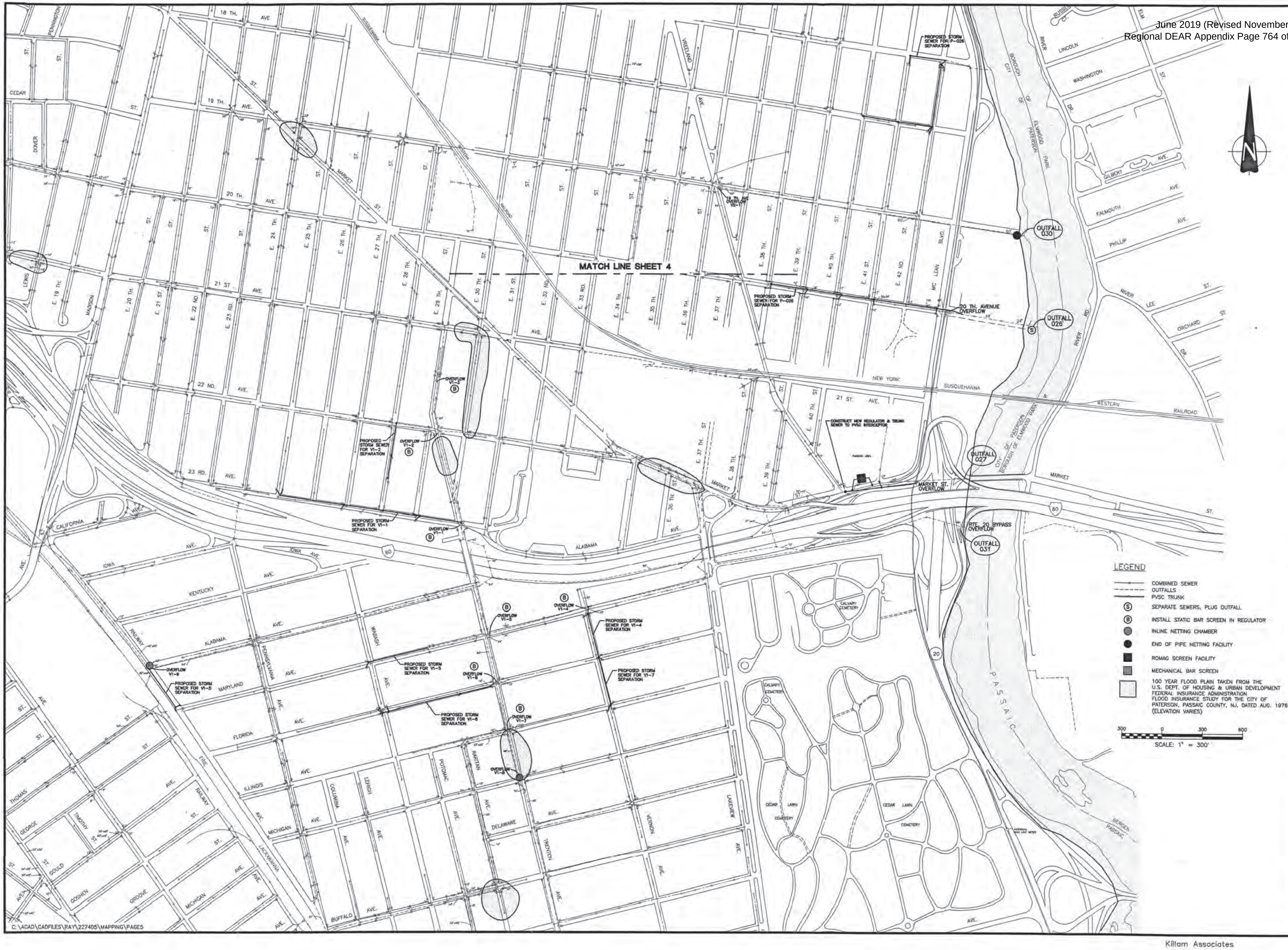
	B/O	Total 5



Revision	Date

JOHN S. ROLAK, JR.
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Date ____

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CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
CSO SOLIDS/FLOATABLES CONTROL PLANNING STUDY
RECOMMENDED CONTROL PLAN-
ALTERNATIVE 2
PLATE C

Job	No.	
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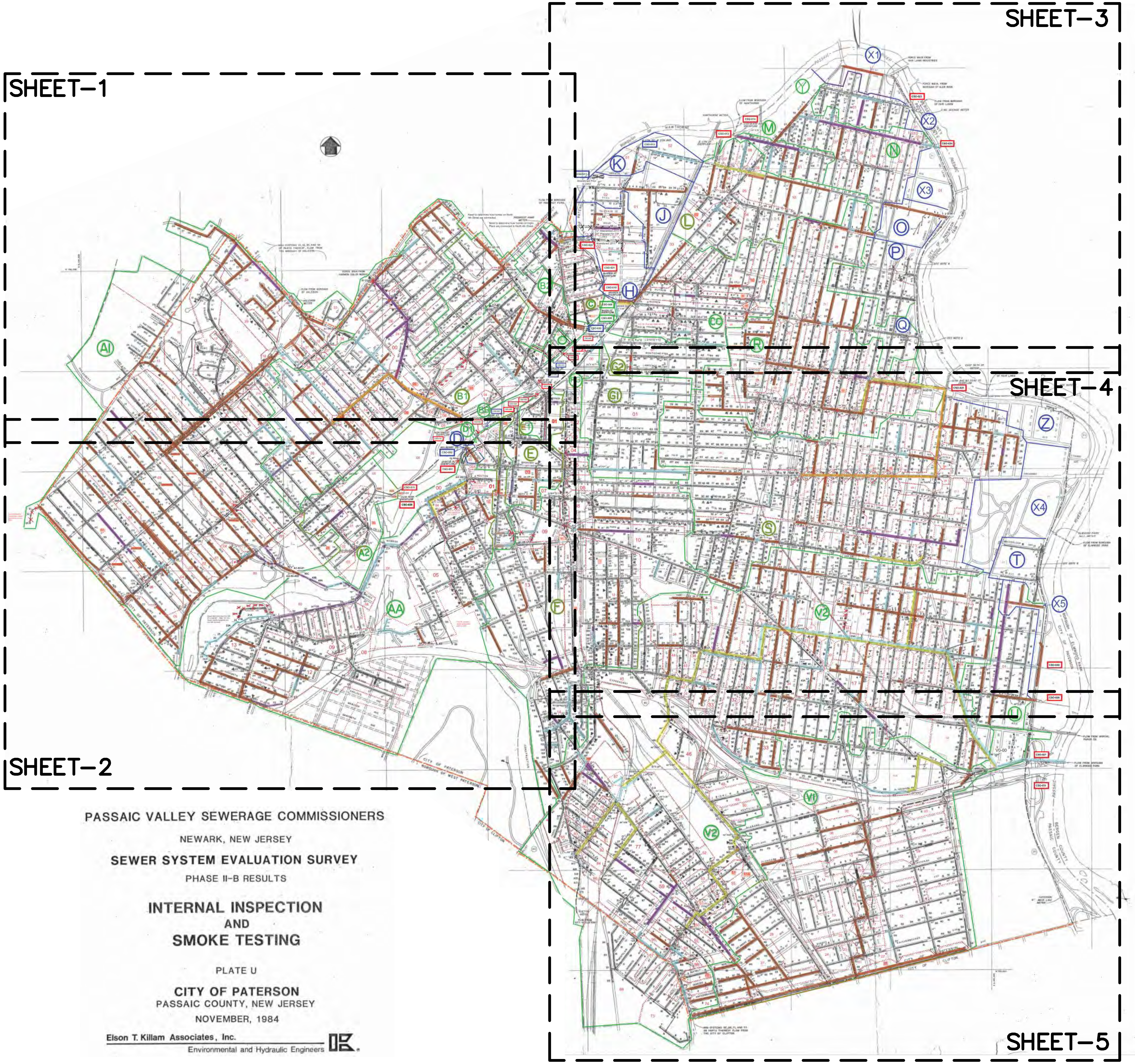
	B/O	Total 5

Killam Associates

Contract No.



LEGEND

- Municipal Boundary
- Cleaned and Inspected, 2008 to Present
- CIPP, 2000 to Present
- Spot Repaired if required, Ready for Lining, 2000 to Present
- New, Rebuilt or Inspected and Found to be Satisfactory Main, 1990 to Present
- Gunited Sewer Mains
- SANITARY SEWER WITH DESIGNATED MANHOLE NUMBERING
  - PIPE END NOT DETERMINED
- MUNICIPAL/SUB AREA INTERCEPTOR WITH DESIGNATED MANHOLE NUMBERING
- PUMPING STATION WITH FORCE MAIN
- PVSC MAIN OR BRANCH INTERCEPTOR SEWER (MANHOLES ARE NOT NUMBERED)
- SUB AREA LIMIT
- SUB AREA INDENTIFICATION
- MINI SYSTEM LIMIT
- 83 MINI SYSTEM NUMBER
- SANITARY SEWERS RECOMMENDED FOR REHABILITATION
- SANITARY SEWERS ENTIRELY OR PARTIALLY DELETED
- SANITARY SEWERS INTERNALLY INSPECTED: NON COST-EFFECTIVE FOR REHABILITATION BUT HAVING STRUCTURAL DAMAGE
- SANITARY SEWERS INTERNALLY INSPECTED BUT NON COST-EFFECTIVE FOR REHABILITATION
- MANHOLES RECOMMENDED FOR INFILTRATION REHABILITATION
- SANITARY SEWERS CONTAINING INFLOW SOURCES
- MANHOLES RECOMMENDED FOR INFLOW REHABILITATION

NOTES:

1. COMBINED SEWERS ARE BASED UPON STUDY MAPS DEVELOPED FOR PHASE I ANALYSIS. MAPS HAVE BEEN MODIFIED TO REFLECT FIELD INFORMATION FOR AREAS INCLUDED IN THE SURVEY ONLY.
2. BASE MAP DEVELOPED BY AERO SERVICE IN 1974.
3. PLAN GRID IS BASED ON NEW JERSEY STATE PLANE COORDINATE SYSTEM AND IS DRAWN 2000 FEET BETWEEN GRIDS.
4. ALL SANITARY SEWERS SHOWN ARE 8"ø UNLESS OTHERWISE NOTED.
5. "TEE" CONNECTIONS ARE NUMBERED THE SAME AS THE DOWNSTREAM MANHOLE AND DESIGNATED WITH THE LETTER "T". WHERE MORE THAN ONE "TEE" CONNECTION EXISTS WITHIN THE MANHOLE REACH, CONNECTIONS ARE NUMBERED IN AN UPSTREAM SEQUENCE (T1, T2, T3, ETC.).

   EXAMPLE: 4 4T 5 5T1 5T2 6

6. SPECIAL CONDITIONS: SUB-AREA, OR SECTIONS THEREOF, HAVE BEEN INDICATED AS CONSISTING OF SEPARATE SANITARY SEWERS.

PASSAIC VALLEY SEWERAGE COMMISSIONERS

NEWARK, NEW JERSEY

SEWER SYSTEM EVALUATION SURVEY

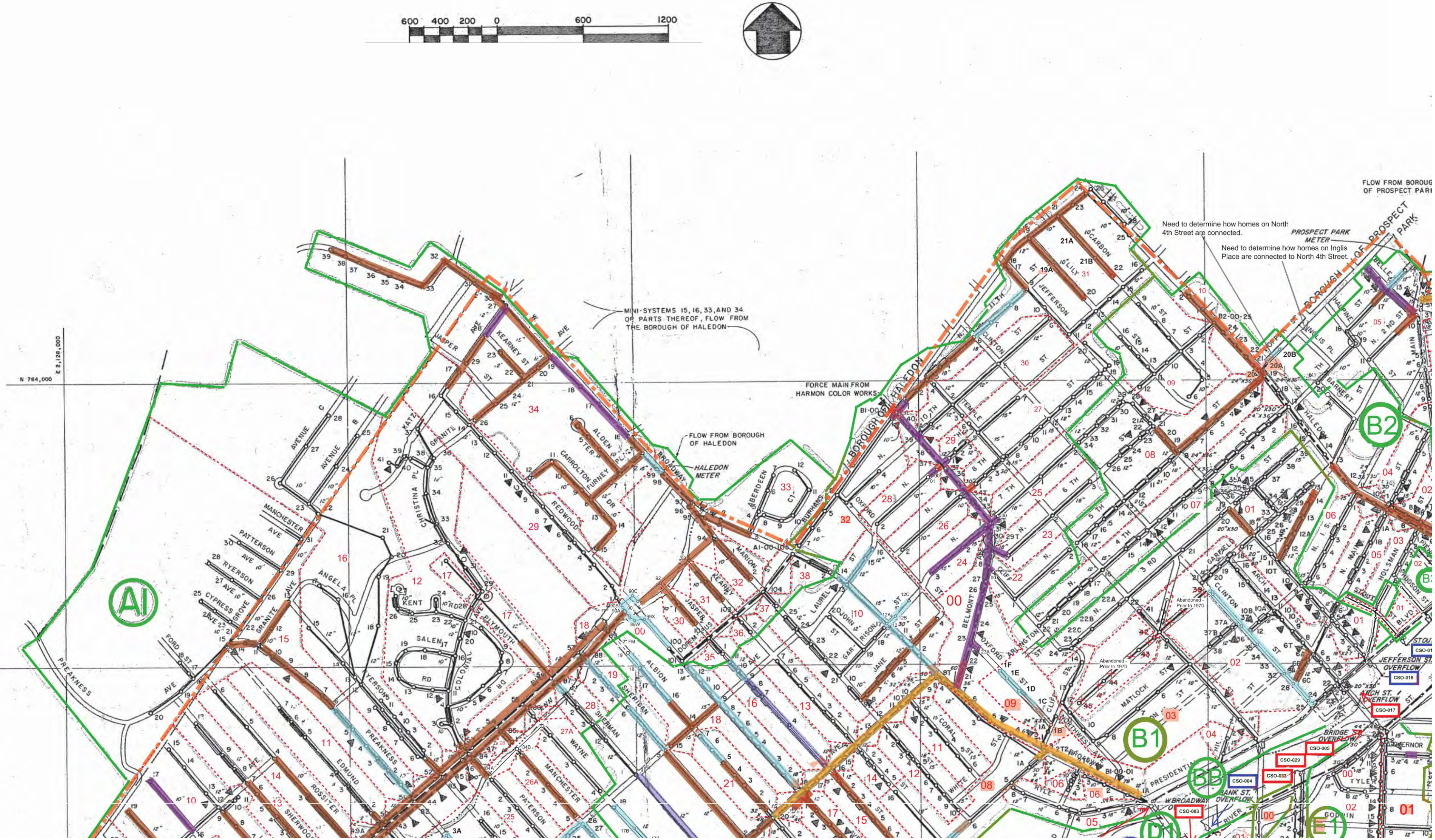
PHASE II-B RESULTS

INTERNAL INSPECTION
AND
SMOKE TESTING

PLATE U

CITY OF PATERSON
PASSAIC COUNTY, NEW JERSEY
NOVEMBER, 1984

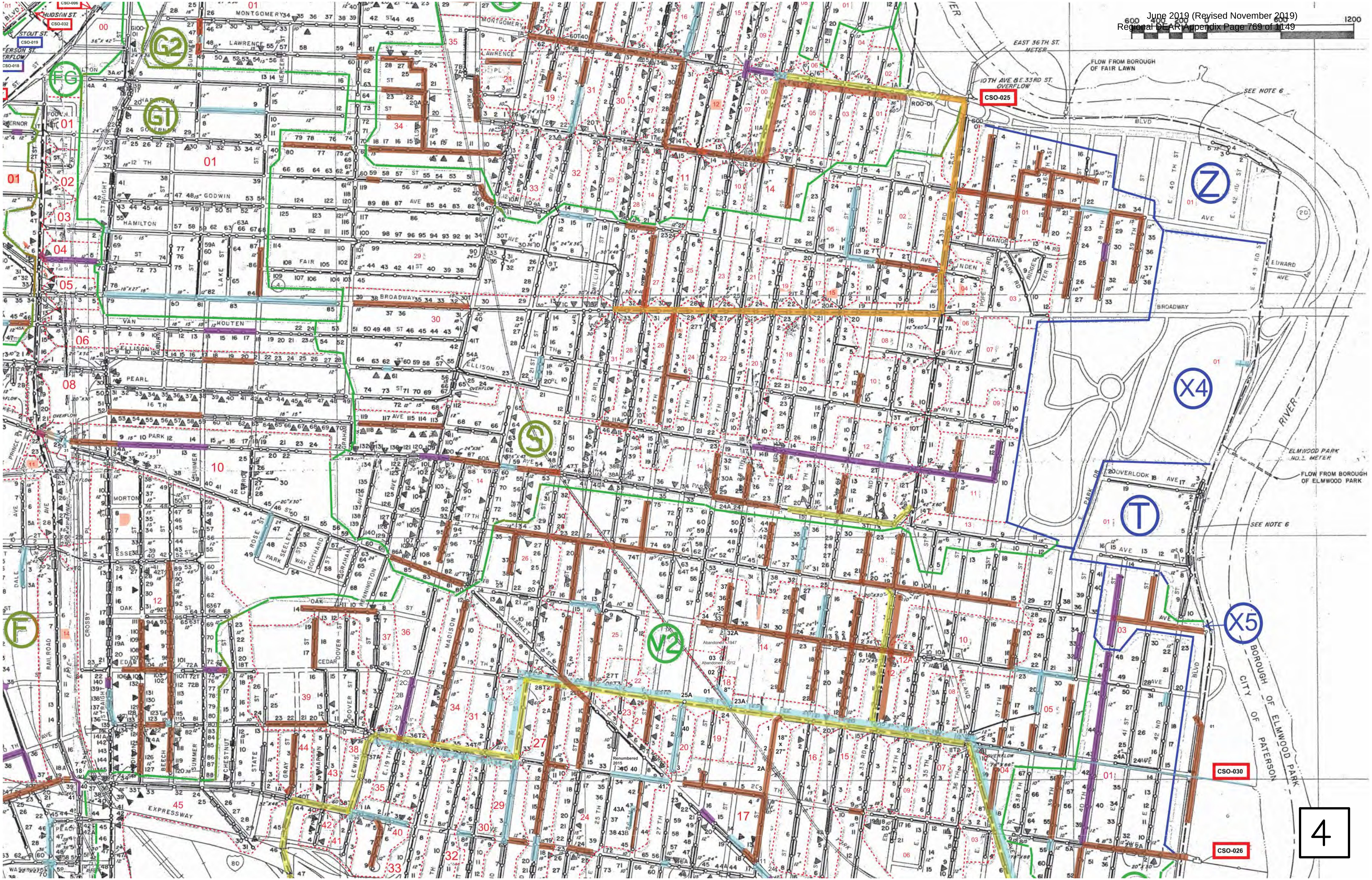
Elson T. Killam Associates, Inc.
Environmental and Hydraulic Engineers


600 400 200 0 600 1200
N 764,000
E 2,128,000
AI
B1
B2
BB
MINI-SYSTEMS 15, 16, 33, AND 34 OR PARTS THEREOF, FLOW FROM THE BOROUGH OF HALEDON
FLOW FROM BOROUGH OF HALEDON
HALEDON METER
FORCE MAIN FROM HARMON COLOR WORKS
BOROUGH OF HALEDON
Need to determine how homes on North 4th Street are connected.
PROSPECT PARK METER
Need to determine how homes on Inglis Place are connected to North 4th Street.
BOROUGH OF PROSPECT PARK
FLOW FROM BOROUG OF PROSPECT PARI
BRIDGE ST. OVERFLOW
BANK ST. OVERFLOW
ARCH ST. OVERFLOW
JEFFERSON ST. OVERFLOW
CSO-003
CSO-004
CSO-005
CSO-017
CSO-018
CSO-029
CSO-033
Abandoned - Prior to 1970
PREAKNESS AVE
MANCHESTER AVE
PATTERSON AVE
RYERSON AVE
CYPRESS
GROVE
GRANITE AVE
KATZ
CHRISTINA PL
ANGELA PL
KENT
SALEM
COLONIAL
PLYMOUTH
JASPER
KEARNEY ST
ALDEN
CARROLTON
FURNEY DR
REDWOOD
BROADWAY
W. BROADWAY
ABERDEEN
BURHANS CT
OXFORD
JEFFERSON
CARBON
LILLY
CLINTON
TEMPLE
BELMONT AVE
ARLINGTON
MATLOCK
PRESIDENTIAL
GARFIELD
HALEDON
BARNETT ST
INGLIS PL
MAIN
HOLSMAN
TYLER
GODWIN
RIVER
SHERMAN
WAYNE
ALBION
SHERIDAN
LAUREL
JOHN
GARRISON
JANE
CORAL
WHITE
RYLE
CLIFF
EDMUND
ROSSITER
SHERWOOD
PATERSON
FORD
VERNOR


CSO-016
NORTHWEST OVERFLOW
D
MULBERRY ST.
CSO-002
CURTIS PL. OVERFLOW
CSO-001
E
BROADWAY
HOUTEN
CSO-015
S.U.M. PARK OVERFLOW
CSO-028
Furman St. vacated, sewer abandoned, prior to 2000.
Brook St. vacated, sewer abandoned, prior to 2000.
Flow redirected to Totowa Boro, sewer abandoned, prior to 2008.
A2
A1-00-01
AA-00-40D
AA-00-01
A2-00-00
A2-00-01
A2-00-07
AA
F
Abandoned
Abandoned - 1990
Sewer Reconstructed from MH #7 to MH #27 - 1990, 15" PVC, Sewer slightly realigned and one MH removed.
Pine St. vacated, sewer abandoned, prior to 2000.
Abandoned circa 1968
Lamphole
CHATHAM
CUMBERLAND
MAITLAND
ELBERON
EMERSON
BURLINGTON
ARLINGTON
LEXINGTON
LENOX
RICHMOND
BERKSHIRE
LINWOOD
MOLLY
HILL
JAMES
HENRY
LIBERTY
WALNUT
MAPLE
BIRCH
FRONT
FALLS
MCBRIDE
MARKET
SPRUCE
OLIVER
BARBOUR
MORRIS
JERSEY
WARD
MARSHALL
PASSAIC
PROSPECT
MAIN
WASHINGTON
COLT
CHURCH
UNION
HAMILTON
SMITH
PRINCE
LEE
CLARK
JACKSON
DALE
GREEN
SLATER
PERRY
WALKER
HOXEY
RESERVOIR
DUNN
ROCKLAND
HENDERSON
HOWARD
DAYTON
WALTON
GRAND
CALDWELL
DIXON
CARLISLE
WEBSTER
DANFORTH
GLOVER
TERRACE
EAGLE
FERRER
RAMSEY
BARNES
NEW
TURNER
SUMMIT
GARRET
MOUNTAIN
UNDER CONSTRUCTION
TOTOWA
DON BOSCO
RIVER
RYLE
VAN WINKLE
CHADWICK
BRAUN
WASHINGTON
CITY OF PATERSON
BOROUGH OF TOTOWA
CITY OF PATERSON
BOROUGH OF WEST PATERSON
600 400 200 0 600 1200
2

3


PASSAIC RIVER
FORCE MAIN FROM FAIR LAWN INDUSTRIES
FORCE MAIN, FROM BOROUGH OF GLEN ROCK
FLOW FROM BOROUGH OF FAIR LAWN
2 ND. AVENUE METER
FLOW FROM BOROUGH OF HAWTHORNE
HAWTHORNE METER
BOROUGH OF HAWTHORNE
BERGEN COUNTY
PASSAIC COUNTY
CITY OF PATERSON
BOROUGH OF FAIR LAWN
SEE NOTE 6
EAST 36TH ST. METER
RIVERSIDE
CSO-023
CSO-024
CSO-014
E. 12TH & 4TH AVE. OVERFLOW
CSO-013
E. 11TH ST. OVERFLOW
CSO-012
E. 5TH ST. & 5TH AVE.
CSO-011
6TH AVE. OVERFLOW
Abandoned Prior to 2002
12" Abandoned 2013
20" Prepared for CIP
Abandoned 2011
SHORT ST. OVERFLOW
CSO-022
CSO-021
BERGEN ST. OVERFLOW
CSO-010
WARREN ST. OVERFLOW
CSO-009
IKEEN ST. OVERFLOW
CSO-008
CSO-020
STRAIGHT ST. OVERFLOW
CSO-007
CSO-006
CSO-032
CSO-019
CC-12. (Former Keen St 01)
X1
X2
X3
Y
M
N
K
J
L
O
P
H
C
CC
Q
R
B3
G2
600 400 200 0 600 1200


600 400 200 0 600 1200
CSO-006
HUDSON ST.
CSO-032
STOUT ST.
CSO-019
JEFFERSON ST.
OVERFLOW
CSO-018
G2
FG
G1
F
S
V2
Z
X4
T
X5
MONTGOMERY
LAWRENCE
GODWIN
HAMILTON
FAIR
BROADWAY
VAN
HOUTEN
ELLISON
PEARL
PARK
MORTON
OAK
CEDAR
MADISON
MARKET
VREELAND
EXPRESSWAY
EAST 36TH ST. METER
FLOW FROM BOROUGH OF FAIR LAWN
10TH AVE & E 33RD ST. OVERFLOW
CSO-025
SEE NOTE 6
RIVER
ELMWOOD PARK NO.1 METER
FLOW FROM BOROUGH OF ELMWOOD PARK
OVERLOOK AVE
BOROUGH OF ELMWOOD PARK
CITY OF PATERSON
Abandoned - 1947
Abandoned - 2012
Renumbered 2010
CSO-030
CSO-026


FLOW FROM MARCAL PAPER CO.
FLOW FROM BOROUGH OF ELMWOOD PARK
CSO-027
CSO-031
V0-00
V1
V2
BERGEN COUNTY
PASSAIC COUNTY
PASSAIC
PATERSON MAIN LINE METER
BERGEN-PASSAIC EXPRESSWAY
ERIE LACKAWANNA RAILWAY
CITY OF PATERSON
CITY OF CLIFTON
FLOW FROM CITY OF CLIFTON
MINI-SYSTEMS 67, 69, 71, AND 73 OR PARTS THEREOF FLOW FROM THE CITY OF CLIFTON
SUSQUEHANNA AVE
MC LEAN
ALABAMA AVE
MARYLAND
FLORIDA
ILLINOIS
MICHIGAN AVE
DELAWARE AVE
KNICKERBOCKER AVE
BUFFALO
GENESEE
CROOKS AVE
MADISON
PARK AVE
ELIZABETH ST
HEMLOCK ST
KENTUCKY
IOWA AVE
CALIFORNIA AVE
LAKEVIEW
N 780,000
E 2,146,000
600 400 200 0 600 1200

5

APPENDIX B

Alternatives Screening Matrix

Source Control Technologies

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Paterson Notes
		Bacteria Reduction	Volume Reduction						
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	- Reduced surface flooding potential	Flow restrictions to the CSS can cause flooding in lots, yards and buildings; potential for freezing in lots; low operational cost. Effective at reducing peak flows during wet weather events but can cause dangerous conditions for the public if pedestrian areas freeze during flooding.	No	Yes	Yes	All newly installed parking lots for the past 20 years have infiltration-based practices.
	Catch Basin Modification (for Floatables Control)	Low	None	- Water quality improvements - Reduced surface flooding potential	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No	No	No	Not practical.
	Catch Basin Modification (Leaching)	Low	Low	- Reduced surface flooding potential - Water quality improvements	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	No	Not practical.
Public Education and Outreach	Water Conservation	None	Low	- Reduced surface flooding potential - Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	Yes	Yes	Code requires low flush units in new construction.
	Catch Basin Stenciling	None	None	- Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	Yes	Yes	There are catch basin stenciling projects that we can take credit for.
	Community Cleanup Programs	None	None	- Water quality improvements - Align with goals for a sustainable community	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes	Yes	Yes	
	Public Outreach Programs	Low	None	- Align with goals for a sustainable community	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes	Yes	Yes	
	FOG Program	Low	None	- Water quality improvements - Improves collection system efficiency	Requires communication with business owners; Permittee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes	Yes	No	PVSC is already implementing FOG, but Paterson doesn't see it doing so on its own.
	Garbage Disposal Restriction	Low	None	- Water quality improvements	Permittee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes	No	No	This is not common in Paterson.
	Pet Waste Management	Medium	None	- Water quality improvements	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	Yes	Yes	An ordinance is currently in place.
	Lawn and Garden Maintenance	Low	Low	- Water quality improvements	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes	No	No	
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	Yes	
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	- Cost-effective water quality improvements	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permittee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	Yes	Hudson, Essex and Passaic Soil Conservation Services does the enforcement.
	Illegal Dumping Control	Low	None	- Water quality improvements - Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	Yes	
	Pet Waste Control	Medium	None	- Water quality improvements - Reduced surface flooding	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	No	No	
	Litter Control	None	None	- Property value uplift - Water quality improvements - Reduced surface flooding	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes	No	No	There is limited enforcement of litter control.
	Illicit Connection Control	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	Yes	Yes	The City funds the cross-connection to stormwater program that applies to sanitary system also.
Good Housekeeping	Street Sweeping/Flushing	Low	None	- Reduced surface flooding potential	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	Yes	Sweeping is performed by the City on a weekly basis (city streets), and flushing by PVWC.
	Leaf Collection	Low	None	- Reduced surface flooding potential - Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	Yes	
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	Yes	
	Storage/Loading/Unloading Areas	None	None	- Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	Yes	Yes	NJDEP requirements, City doesn't have its own. Larger facilities may have SWPPPs that govern this.
	Industrial Spill Control	Low	None	- Protect surface waters - Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	Yes	

Green Infrastructure Buildings	Green Roofs	None	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes	The City does not currently have any green roof projects, but welcomes anyone who wants to do this GI.
	Blue Roofs	None	Medium	- Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	Yes	Yes	
	Rainwater Harvesting	None	Medium	- Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community - Water Saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	Yes	Yes	There are rainwater harvesting projects over the last 5 years that we can take credit for.
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Cost-effective water quality improvements - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes	
	Planter Boxes	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	Yes	Yes	
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	Yes	Yes	Smaller diameter contracts to put in bioswales to reduce the sizing of stormwater infrastructure are needed.
	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	Yes	Yes	These are primarily through grants; no city funded initiatives.

Collection System Technologies

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Paterson Notes
		Bacteria Reduction	Volume Reduction						
Operation and Maintenance	I/I Reduction	Low	Medium	- Water quality improvements - Reduced basement sewage flooding	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	Yes	Yes	Groundwater comes in through older brick sewers in Paterson and other combined systems. Surrounded on both sides by Passaic River, so combined sewers act as dewatering systems.
	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	Yes	Yes	
	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	Yes	Yes	Flushing is performed monthly, primarily in internal structures/screening facilities. Collection system is flushed less frequently, and trunks are done more than laterals. Lots of bricks, sand, and sediment seen in trunk sewers.
	Catch Basin Cleaning	Low	None	- Water quality improvements - Reduced surface flooding	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	Yes	Every basin is cleaned every year (goal), but some facilities are cleaned almost weekly to monthly.
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	Yes	Hillcrest flow area (A1 in Killam map) - roof leaders are connected originally, but many homeowners have disconnected on their own due to flooding occurrences.
	Sump Pump Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	Yes	Same Hillcrest flow area as above.
	Combined Sewer Separation	High	High	- Water quality improvements - Reduced basement sewage flooding - Reduced surface flooding	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	Yes	Yes	Area A1 is almost 90% separated. Where sewers are being reconstructed, and if there is opportunity to run storm and sanitary lines in the future, sewer separation may be done in limited areas. Bridge Street outfall area mostly separated already.
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	Yes	Yes	Extension of the relief sewer to convey the stream coming into the sewers.
	Regulator Modifications	Medium	Medium	- Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. Permitees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	Yes	Yes	In the Memorial Drive area, 6 internal structures in downtown. Weirs are adjusted to optimal levels.
	Outfall Consolidation/Relocation	High	High	- Water quality improvements - Passive and active recreational improvements	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	Yes	Yes	
	Real Time Control	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	Yes	Yes	There may be opportunities to look at weirs and optimize their levels to increase the inline storage.

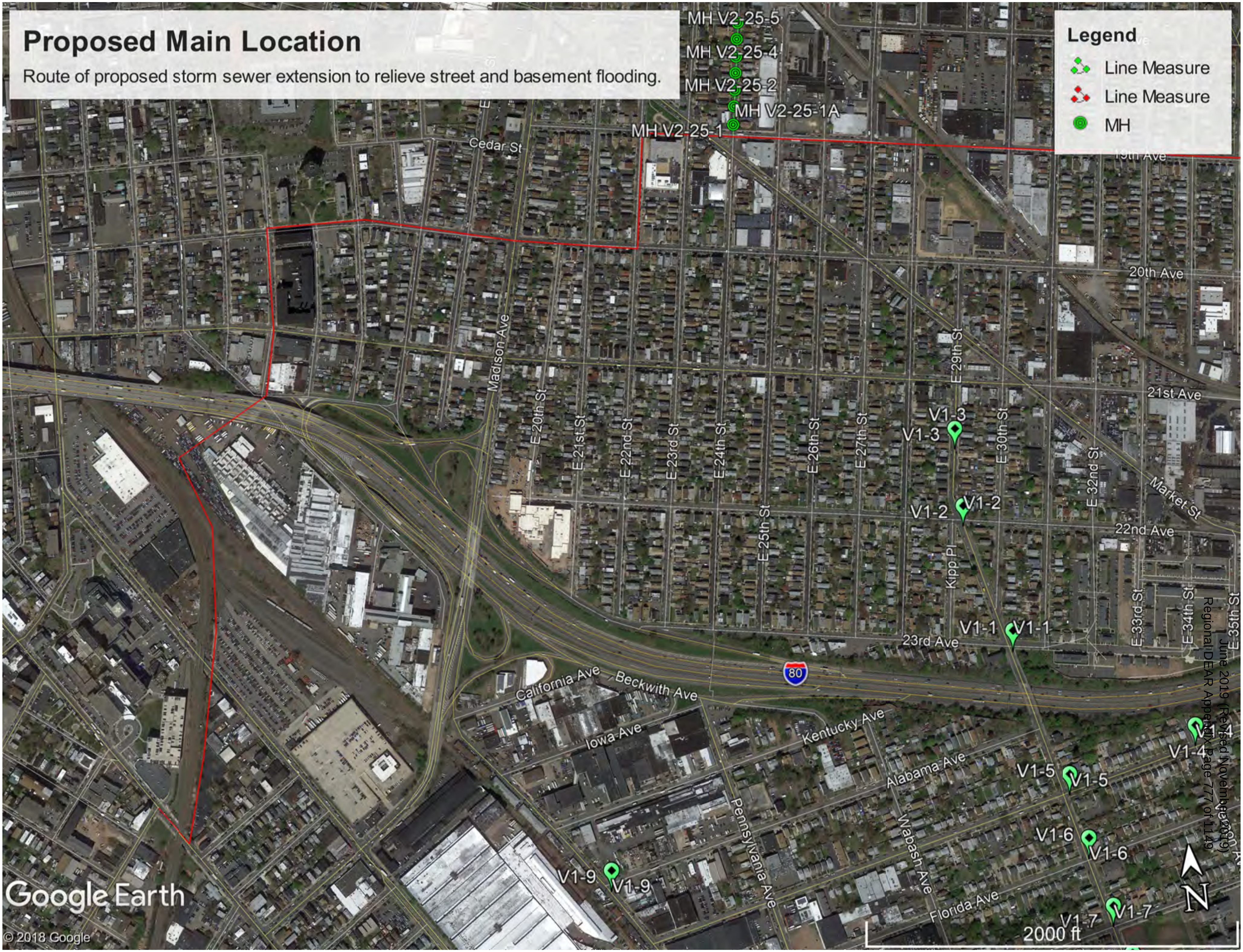
Storage and Treatment Technologies									
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Paterson Notes
		Bacteria Reduction	Volume Reduction						
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	Yes	Yes	
	Tunnel	High	High	- Water quality improvements - Reduced surface flooding potential	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	Yes	Yes	Screening at Loop Road tunnel has lot of capacity that can be utilized for small to medium sized storms. Stormwater diversion tunnel - receives CSOs from A-1 Hillcrest area, a flood diversion tunnel (Mollyanne Brook periodically discharges into it during large storms).
Point Storage	Tank (Above or Below Ground)	High	High	- Water quality improvements - Reduced basement sewage flooding	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	Yes	Yes	
	Industrial Discharge Detention	Low	Low	- Water quality improvements	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No	Jim DeBlock operates several landfills. This is PVSC's responsibility.
Treatment-CSO Facility	Vortex Separators	None	None	- Water quality improvements	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	Yes	
	Screens and Trash Racks	None	None	- Water quality improvements	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	Yes	Yes	
	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes	
	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No	
	Baffles	None	None	- Water quality improvements	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	Yes	
	Disinfection & Satellite Treatment	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	Yes	
	High Rate Physical/Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	- Water quality improvements	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	Yes	
	High Rate Physical (Fuzzy Filters)	None	None	- Water quality improvements	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	Yes	
Treatment-WRTP	Additional Treatment Capacity	High	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	No	
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	No	
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	No	This is PVSC's program.

APPENDIX C

Proposed 19th Avenue Relief Sewer Route

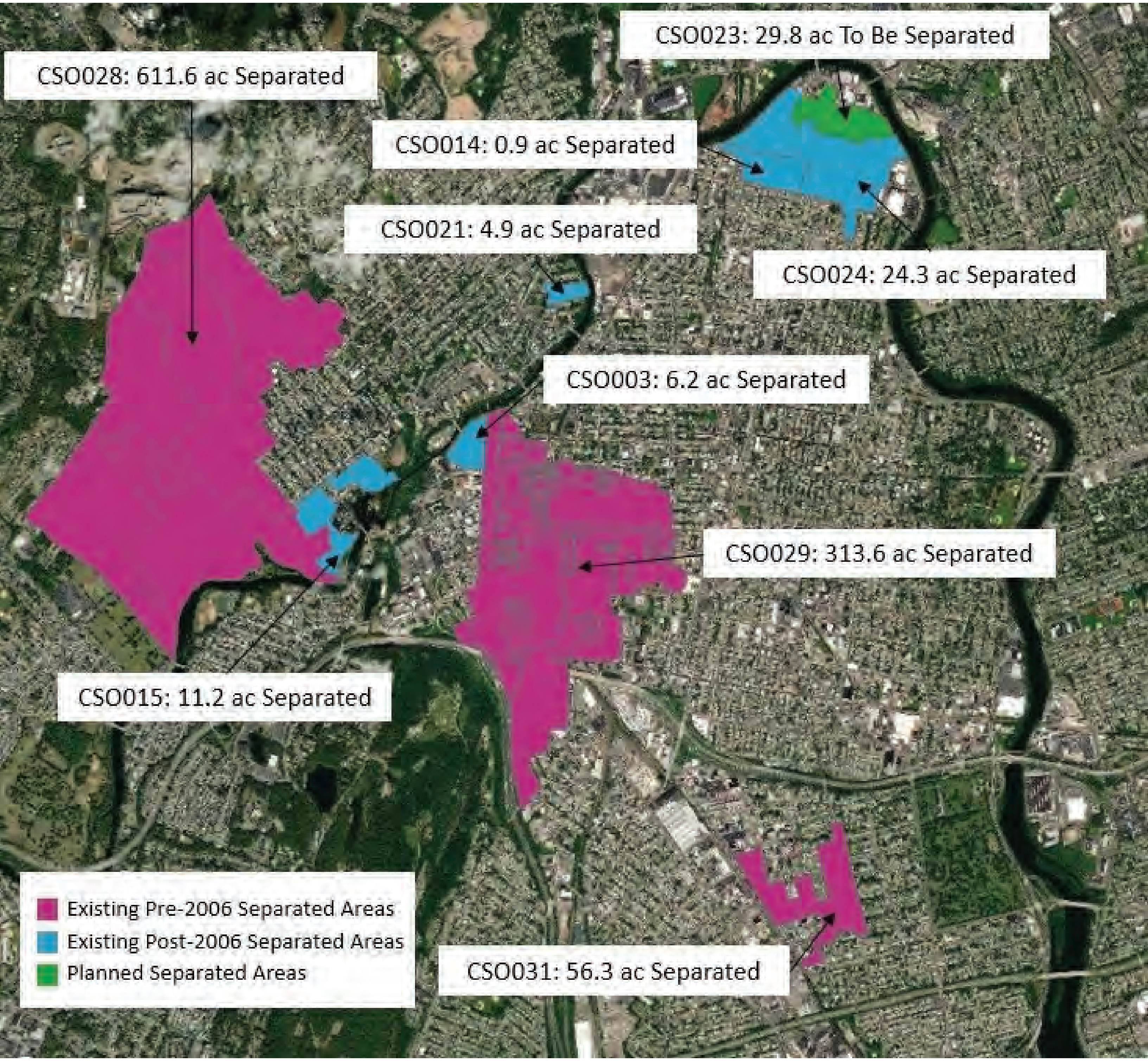
Proposed Main Location

Route of proposed storm sewer extension to relieve street and basement flooding.



APPENDIX D

Summary of Partial or Complete Sewer Separation


CSO028: 611.6 ac Separated
CSO023: 29.8 ac To Be Separated
CSO014: 0.9 ac Separated
CSO021: 4.9 ac Separated
CSO024: 24.3 ac Separated
CSO003: 6.2 ac Separated
CSO029: 313.6 ac Separated
CSO015: 11.2 ac Separated
CSO031: 56.3 ac Separated
Existing Pre-2006 Separated Areas
Existing Post-2006 Separated Areas
Planned Separated Areas

APPENDIX E

Four-Region Grouping of CSO Outfalls

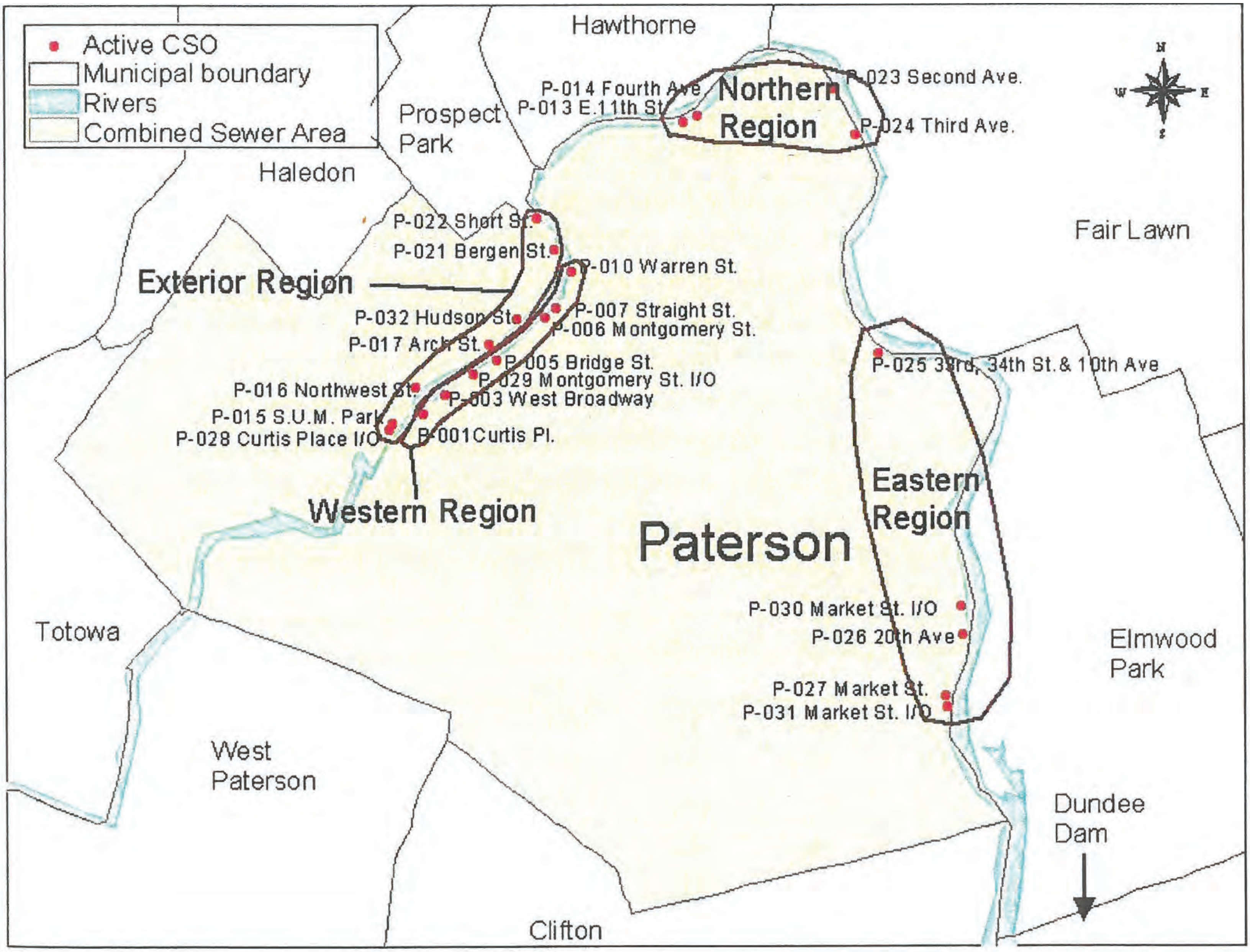


Figure 6 - Four-Region Grouping of CSO Outfalls

APPENDIX F

Siting of Potential Greywater Storage

Group A	
CSO Location	031 Rt 20 Bypass
Proposed Tank(s)	
1 Property Owner	
Block	
Lot	
Available space	
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$28,792,460

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	2.396			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	2.396	30	500	2.644	YES	$7,500,000	$470,000	$150,000	$9,440,740	$16,940,740
0	2.396	15	2000	2.644	YES	$16,000,000	$470,000	$320,000	$12,029,330	$28,029,330
0	2.396	12	3125	2.644	YES	$21,875,000	$470,000	$437,500	$13,818,503	$35,693,503

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	1.322	$584,980	$0	$11,700	$178,150	$763,130

* Assume 2-day dewatering period for greywater storage.

Group B	
CSO Location	016 Northwest St
Proposed Tank(s)	Belmont Ave (CR-675); W. Broadway
1 Property Owner	CITY OF PATERSON
Block	608
Lot	10-11
Available space	100' x 50'
Land Acquisition	$0
Land Clearing	$50,000
2 Property Owner	DILISIO, FRANCA
Block	601
Lot	6
Available space	70' x 50'
Land Acquisition	$189,800
Land Clearing	$100,000
3 Property Owner	CITY OF PATERSON
Block	801
Lot	17
Available space	225' x 126'
Land Acquisition	$0
Land Clearing	$0

Bending Weir(s) for CSO028 + Tunnel (15' diam.)	
	$10,184,717
	$32,707,727
	$42,892,444

Overflow Target	Prop. Location	Width (ft)	Height (ft)	Bending Weir Construction Cost	Annual Weir O&M Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	A1-3	16	1	$8,000,000	$32,000	$487,264	$8,487,264
	A1-6	3.2	1	$1,600,000	$6,400	$97,453	$1,697,453

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.819			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.819	30	350	1.851	YES	$5,250,000	$470,000	$105,000	$8,755,525	$14,005,525
0	1.819	15	1400	1.851	YES	$11,200,000	$470,000	$224,000	$10,567,538	$21,767,538
0	1.819	12	2188	1.851	YES	$15,316,000	$470,000	$306,320	$11,821,025	$27,137,025

* Pump station operation for tunnels included.

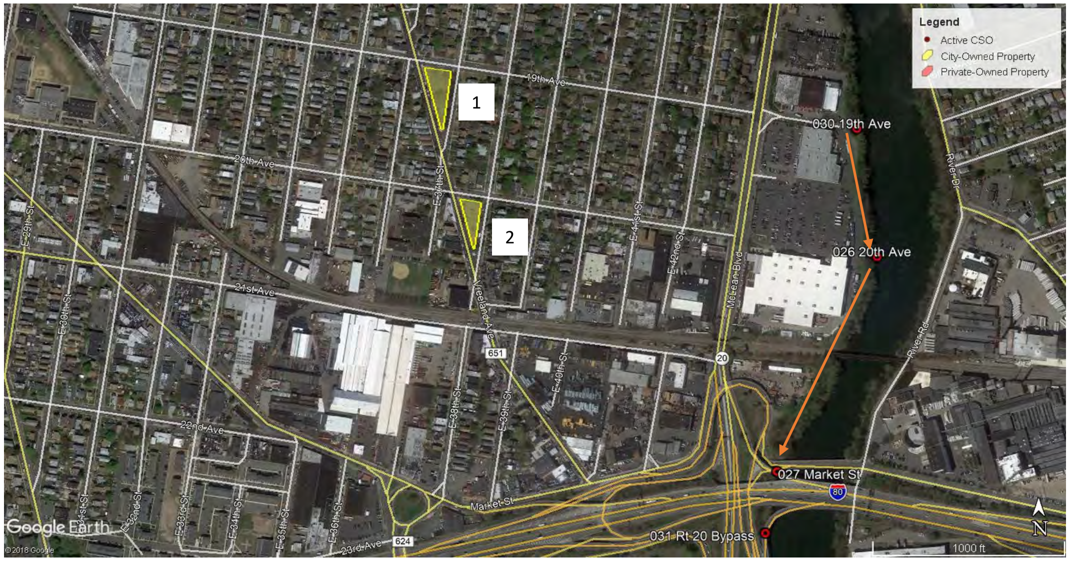
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	30	2400	$1,200,000	$24,000	$365,448	$1,565,448

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
028+015	17.130	$3,995,572	$235,000	$79,911	$4,795,156	$8,790,728
Tunnel	0.925	$447,677	$0	$8,954	$136,336	$584,012

* Assume 2-day dewatering period for greywater storage.

	Group C	
	CSO Location	027 Market St
	Proposed Tank(s)	Vreeland/19th Aves; Vreeland/20th Aves
1	Property Owner	CITY OF PATERSON
	Block	8020
	Lot	1
	Available space	110' diam.
	Land Acquisition	$0
	Land Clearing	$100,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	7902
	Lot	1
	Available space	80' diam.
	Land Acquisition	$0
	Land Clearing	$100,000

Tunnel (15' diam.)	$89,593,374



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	8.885			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	8.885	30	1700	8.988	YES	$25,500,000	$470,000	$510,000	$14,922,460	$40,422,460
0	8.885	15	6800	8.988	YES	$54,400,000	$470,000	$1,088,000	$23,723,666	$78,123,666
0	8.885	12	10625	8.988	YES	$74,375,000	$470,000	$1,487,500	$29,806,853	$104,181,853

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	2000	$1,150,000	$23,000	$350,221	$1,500,221

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
030+026	14.000	$3,434,448	$235,000	$68,689	$4,624,272	$8,058,720
Tunnel	4.494	$1,464,706	$0	$29,294	$446,061	$1,910,767

* Assume 2-day dewatering period for greywater storage.

	Group D	
	CSO Location	029 Loop Rd
	Proposed Tank(s)	River St, Main St
1	Property Owner	NRVP, LLC
	Block	3701
	Lot	1-7
	Available space	250' x 90'
	Land Acquisition	$556,900
	Land Clearing	$200,000
2	Property Owner	NRVP, LLC
	Block	3713
	Lot	1-14
	Available space	260' x 60'
	Land Acquisition	$326,400
	Land Clearing	$0
3	Property Owner	NRVP, LLC
	Block	3712
	Lot	24-27, 29-36
	Available space	230' x 180'
	Land Acquisition	$998,500
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	1401
	Lot	1
	Available space	250' x 220'
	Land Acquisition	$0
	Land Clearing	$50,000

Tunnel (15' diam.)	$62,047,239

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	4.208			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	4.208	30	850	4.494	YES	$12,750,000	$470,000	$255,000	$11,039,575	$23,789,575
0	4.208	15	3400	4.494	YES	$27,200,000	$470,000	$544,000	$15,440,178	$42,640,178
0	4.208	12	5312	4.494	YES	$37,184,000	$470,000	$743,680	$18,480,705	$55,664,705

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	72	1600	$1,960,000	$39,200	$596,898	$2,556,898

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
001+003	52.860	$9,302,642	$235,000	$186,053	$6,411,372	$15,714,013
Tunnel	2.247	$870,919	$0	$17,418	$265,230	$1,136,149

* Assume 2-day dewatering period for greywater storage.


Legend
Active CSOs
City-Owned Property
Private-Owned Property
001 Curtis Place
015 SUM Park
028 SUM Park 2
4
Broadway
College Blvd
Van Houten St
Ellison St
McGee's Alley
Mill St
Market St
Spruce St
Wayne Ave
Paterson Ave
Front St
Birch St
Maple St
Walnut St
Liberty St
Pleasantness Ave
McBride Ave
Totowa Ave
Jasper St
Kearney St
Ryle Rd
666
900 ft
N
Google Earth

	Group E	
	CSO Location	005 Bridge St
	Proposed Tank(s)	River St, Bridge St
1	Property Owner	CITY OF PATERSON
	Block	3701
	Lot	14-15
	Available space	214' x 80'
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	JEFFJEN, LLC
	Block	3701
	Lot	11-13
	Available space	25' x 80'; 50' x 80'; 50' x 80'; (= 125' x 80')
	Land Acquisition	$153,500
	Land Clearing	$300,000

Storage Tank(s)	$13,282,696
Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	0.325	75	10	0.330	YES	$4,094,959	$235,000	$122,849	$5,448,963	$9,543,923

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	0.325	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
0	0.325	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
0	0.325	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.165	$122,977	$235,000	$2,460	$3,615,796	$3,738,773
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

	Group F	
	CSO Location	006 Montgomery St
	Proposed Tank(s)	River St, Harrison St
1	Property Owner	CITY OF PATERSON
	Block	3117
	Lot	1, 13-14
	Available space	90' diam.
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	CITY OF PATERSON
	Block	3116
	Lot	1-6
	Available space	100' diam.
	Land Acquisition	$0
	Land Clearing	$200,000
3	Property Owner	PANCO INVESTMENTS, LLC
	Block	3101
	Lot	7
	Available space	215' x 125'
	Land Acquisition	$379,000
	Land Clearing	$200,000

Tunnel (15' diam.)	$43,776,327

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	4.289			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	4.289	30	850	4.494	YES	$12,750,000	$470,000	$255,000	$11,039,575	$23,789,575
0	4.289	15	3400	4.494	YES	$27,200,000	$470,000	$544,000	$15,440,178	$42,640,178
0	4.289	12	5312	4.494	YES	$37,184,000	$470,000	$743,680	$18,480,705	$55,664,705

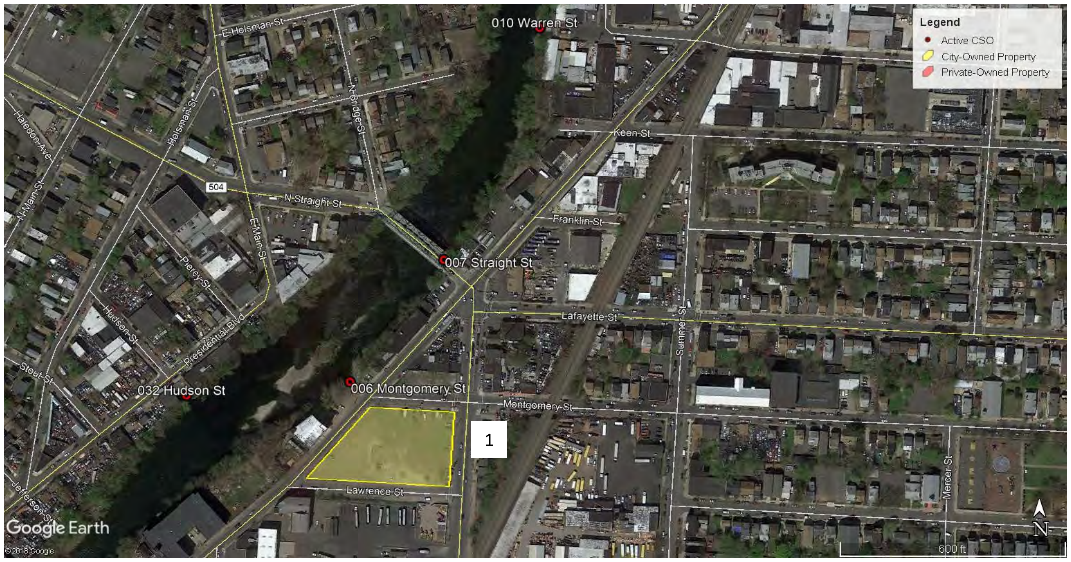
* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	2.247	$870,919	$0	$17,418	$265,230	$1,136,149

* Assume 2-day dewatering period for greywater storage.

Group G	
CSO Location	007 Straight St
Proposed Tank(s)	Montgomery St, Straight St
1 Property Owner	CITY OF PATERSON
Block	3105
Lot	1
Available space	200' x 220'
Land Acquisition	$0
Land Clearing	$10,000

Tunnel (15' diam.)	$62,988,085



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	6.561			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	6.561	30	1300	6.873	YES	$19,500,000	$470,000	$390,000	$13,095,220	$32,595,220
0	6.561	15	5200	6.873	YES	$41,600,000	$470,000	$832,000	$19,825,554	$61,425,554
0	6.561	12	8125	6.873	YES	$56,875,000	$470,000	$1,137,500	$24,477,403	$81,352,403

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	3.437	$1,197,764	$0	$23,955	$364,767	$1,562,531

* Assume 2-day dewatering period for greywater storage.

	Group H	
	CSO Location	013 E 11th St
	Proposed Tank(s)	105-119 E. 11th St
1	Property Owner	KIRKER ENTERPRISES INC.
	Block	2002
	Lot	1
	Available space	65' x 45'
	Land Acquisition	$0
	Land Clearing	$0

Tunnel (15' diam.)	$22,351,550

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.676			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.676	30	350	1.851	YES	$5,250,000	$470,000	$105,000	$8,755,525	$14,005,525
0	1.676	15	1400	1.851	YES	$11,200,000	$470,000	$224,000	$10,567,538	$21,767,538
0	1.676	12	2188	1.851	YES	$15,316,000	$470,000	$306,320	$11,821,025	$27,137,025

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.925	$447,677	$0	$8,954	$136,336	$584,012

* Assume 2-day dewatering period for greywater storage.

	Group I	
	CSO Location	017 Arch Street
	Proposed Tank(s)	Presidential Blvd/Jefferson St
1	Property Owner	PATERSON HOPE 98 URBAN RENEWAL, LLC
	Block	213
	Lot	12-16
	Available space	150' x 75'
	Land Acquisition	$151,100
	Land Clearing	$100,000

Tunnel (15' diam.)	$18,046,770

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.184			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	1.184	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
0	1.184	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
0	1.184	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.

Group J

	CSO Location	021 Bergen St
	Proposed Tank(s)	Bergen St
1	Property Owner	CITY OF PATERSON
	Block	119
	Lot	3-6
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
2	Property Owner	CITY OF PATERSON
	Block	120
	Lot	38-40
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
3	Property Owner	CITY OF PATERSON
	Block	120
	Lot	4-7
	Available space	~ 125' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON
	Block	119
	Lot	1, 48-49
	Available space	~ 123' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000

Tunnel (15' diam.)	$87,337,829

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	6.977			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	6.977	30	1350	7.138	YES	$20,250,000	$470,000	$405,000	$13,323,625	$33,573,625
0	6.977	15	5400	7.138	YES	$43,200,000	$470,000	$864,000	$20,312,818	$63,512,818
0	6.977	12	8438	7.138	YES	$59,066,000	$470,000	$1,181,320	$25,144,650	$84,210,650

* Pump station operation for tunnels included.

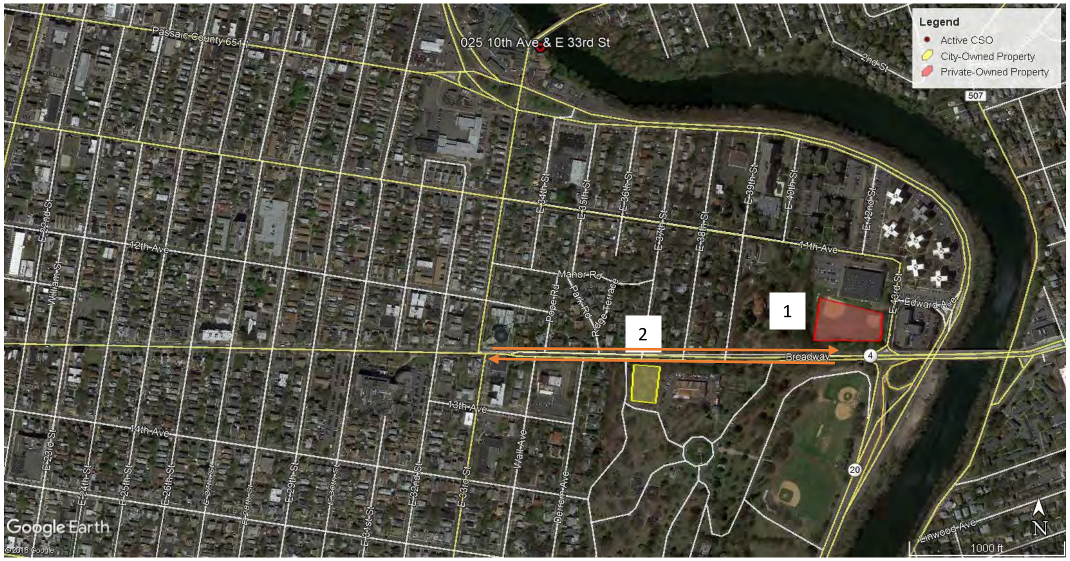
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	48	1000	$750,000	$15,000	$228,405	$978,405
RCP	42	1600	$1,040,000	$20,800	$316,722	$1,356,722

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
032	27.780	$5,741,959	$235,000	$114,839	$5,327,001	$11,068,961
022	17.230	$4,013,053	$235,000	$80,261	$4,800,480	$8,813,533
Tunnel	3.569	$1,232,151	$0	$24,643	$375,239	$1,607,390

* Assume 2-day dewatering period for greywater storage.

Group K	
CSO Location	025 10th Ave & E. 33rd St
Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1 Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
Block	8208
Lot	2
Available space	425' x 175'
Land Acquisition	$0
Land Clearing	$50,000
2 Property Owner	CITY OF PATERSON (PARKS DEPT)
Block	8101
Lot	1
Available space	225' x 150'
Land Acquisition	$0
Land Clearing	$200,000

Tunnel (15' diam.)	$120,447,346



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	13.890			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	13.890	30	2650	14.011	YES	$39,750,000	$470,000	$795,000	$19,262,155	$59,012,155
0	13.890	15	10600	14.011	YES	$84,800,000	$470,000	$1,696,000	$32,981,682	$117,781,682
0	13.890	12	16562	14.011	YES	$115,934,000	$470,000	$2,318,680	$42,463,230	$158,397,230

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	7.006	$2,043,375	$0	$40,867	$622,289	$2,665,664

* Assume 2-day dewatering period for greywater storage.

Group L	
CSO Location	3rd Ave
Proposed Tank(s)	Madison Ave/3rd Ave
1 Property Owner	CITY OF PATERSON
Block	2403
Lot	3-5
Available space	400' x 200'
Land Acquisition	$0
Land Clearing	$0

Storage Tank(s)	$39,350,751
Tunnel (15' diam.)	$30,936,272

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	2.659	190	13	2.757	YES	$21,558,414	$235,000	$646,752	$13,426,444	$34,984,858

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	2.659	30	550	2.908	YES	$8,250,000	$470,000	$165,000	$9,669,145	$17,919,145
0	2.659	15	2200	2.908	YES	$17,600,000	$470,000	$352,000	$12,516,594	$30,116,594
0	2.659	12	3437	2.908	YES	$24,059,000	$470,000	$481,180	$14,483,618	$38,542,618

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	1.379	$603,698	$235,000	$12,074	$3,762,195	$4,365,893
Tunnel	1.454	$628,327	$0	$12,567	$191,351	$819,678

* Assume 2-day dewatering period for greywater storage.

Group A	
CSO Location	031 Rt 20 Bypass
Proposed Tank(s)	
1 Property Owner	
Block	
Lot	
Available space	
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$18,046,770

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	1.257			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	1.257	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
4	1.257	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
4	1.257	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.

	Group B	
	CSO Location	016 Northwest St
	Proposed Tank(s)	Belmont Ave (CR-675); W. Broadway
1	Property Owner	CITY OF PATERSON
	Block	608
	Lot	10-11
	Available space	100' x 50'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	DILISIO, FRANCA
	Block	601
	Lot	6
	Available space	70' x 50'
	Land Acquisition	$189,800
	Land Clearing	$100,000
3	Property Owner	CITY OF PATERSON
	Block	801
	Lot	17
	Available space	225' x 126'
	Land Acquisition	$0
	Land Clearing	$0

Bending Weir(s) for CSO028 + Tunnel (15' diam.)	$1,697,453 $21,856,218 $23,553,671

Overflow Target	Prop. Location	Width (ft)	Height (ft)	Bending Weir Construction Cost	Annual Weir O&M Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
0	A1-6	3.2	1	$1,600,000	$6,400	$97,453	$1,697,453

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.931			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.931	30	200	1.057	YES	$3,000,000	$470,000	$60,000	$8,070,310	$11,070,310
4	0.931	15	800	1.057	YES	$6,400,000	$470,000	$128,000	$9,105,746	$15,505,746
4	0.931	12	1250	1.057	YES	$8,750,000	$470,000	$175,000	$9,821,415	$18,571,415

* Pump station operation for tunnels included.

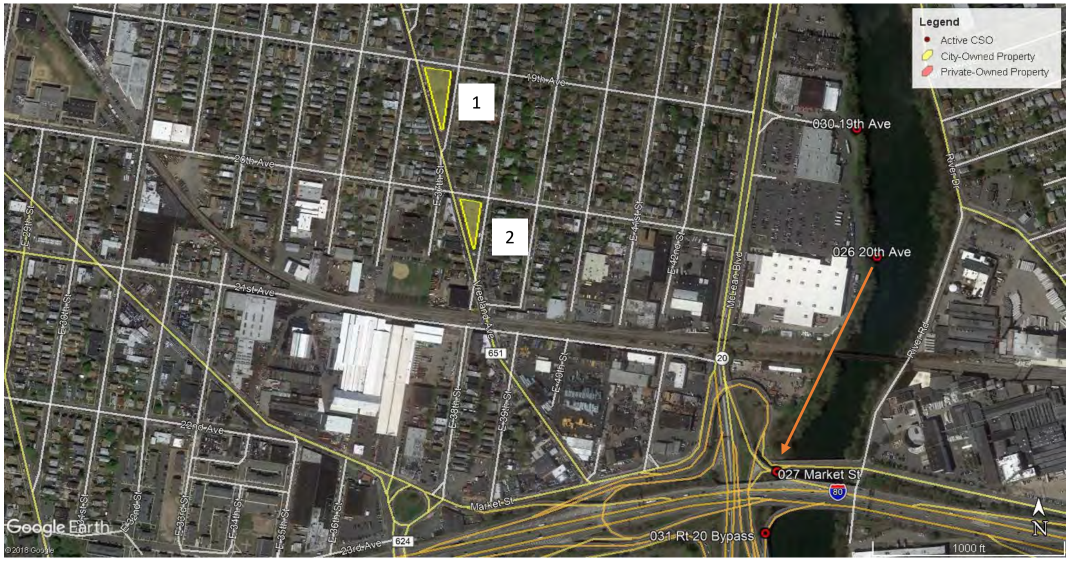
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	30	2000	$1,000,000	$20,000	$304,540	$1,304,540

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
015	2.110	$830,755	$235,000	$16,615	$3,831,343	$4,662,098
Tunnel	0.529	$294,229	$0	$5,885	$89,605	$383,834

* Assume 2-day dewatering period for greywater storage.

	Group C	
	CSO Location	027 Market St
	Proposed Tank(s)	Vreeland/19th Aves; Vreeland/20th Aves
1	Property Owner	CITY OF PATERSON
	Block	8020
	Lot	1
	Available space	110' diam.
	Land Acquisition	$0
	Land Clearing	$100,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	7902
	Lot	1
	Available space	80' diam.
	Land Acquisition	$0
	Land Clearing	$100,000

Tunnel (15' diam.)	$47,390,602



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	3.837			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	3.837	30	750	3.965	YES	$11,250,000	$470,000	$225,000	$10,582,765	$21,832,765
4	3.837	15	3000	3.965	YES	$24,000,000	$470,000	$480,000	$14,465,650	$38,465,650
4	3.837	12	4687	3.965	YES	$32,809,000	$470,000	$656,180	$17,148,343	$49,957,343

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	1500	$862,500	$17,250	$262,666	$1,125,166

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
026	8.890	$2,443,078	$235,000	$48,862	$4,322,360	$6,765,437
Tunnel	1.983	$792,884	$0	$15,858	$241,465	$1,034,349

* Assume 2-day dewatering period for greywater storage.

	Group D		
	CSO Location	029 Loop Rd	
	Proposed Tank(s)	River St, Main St	
1	Property Owner	NRVP, LLC	
	Block	3701	
	Lot	1-7	
	Available space	250' x 90'	
	Land Acquisition		$556,900
	Land Clearing		$200,000
2	Property Owner	NRVP, LLC	
	Block	3713	
	Lot	1-14	
	Available space	260' x 60'	
	Land Acquisition		$326,400
	Land Clearing		$0
3	Property Owner	NRVP, LLC	
	Block	3712	
	Lot	24-27, 29-36	
	Available space	230' x 180'	
	Land Acquisition		$998,500
	Land Clearing		$500,000
4	Property Owner	CITY OF PATERSON (PARKS DEPT)	
	Block	1401	
	Lot	1	
	Available space	250' x 220'	
	Land Acquisition		$0
	Land Clearing		$50,000

Storage Tank(s)	$52,919,239
Tunnel (15' diam.)	$43,524,429

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.273	160	16	2.406	YES	$19,783,591	$235,000	$593,508	$12,615,687	$32,399,278

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.273	30	500	2.644	YES	$7,500,000	$470,000	$150,000	$9,440,740	$16,940,740
4	2.273	15	2000	2.644	YES	$16,000,000	$470,000	$320,000	$12,029,330	$28,029,330
4	2.273	12	3125	2.644	YES	$21,875,000	$470,000	$437,500	$13,818,503	$35,693,503

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	72	1600	$1,960,000	$39,200	$596,898	$2,556,898

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
001+003	33.380	$6,589,852	$235,000	$131,797	$5,585,219	$12,175,071
Tank	1.203	$545,132	$235,000	$10,903	$3,744,360	$4,289,492
Tunnel	1.322	$584,980	$0	$11,700	$178,150	$763,130

* Assume 2-day dewatering period for greywater storage.


Legend
Active CSOs
City-Owned Property
Private-Owned Property
001 Curtis Place
015 SUM Park
028 SUM Park 2
4
Broadway
College Blvd
Van Houten St
Ellison St
McGee's Alley
Mill St
Market St
Spruce St
Wayne Ave
Totowa Ave
Jasper St
Kearney St
Ryle Rd
Liberty St
Walnut St
Maple St
Birch St
Front St
Paterson Ave
Presidential Blvd
Pleasantness Ave
McBride Ave
Google Earth
900 ft

	Group E	
	CSO Location	005 Bridge St
	Proposed Tank(s)	River St, Bridge St
1	Property Owner	CITY OF PATERSON
	Block	3701
	Lot	14-15
	Available space	214' x 80'
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	JEFFJEN, LLC
	Block	3701
	Lot	11-13
	Available space	25' x 80'; 50' x 80'; 50' x 80'; (= 125' x 80')
	Land Acquisition	$153,500
	Land Clearing	$300,000

Storage Tank(s)	$12,565,054
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.229	75	8	0.264	YES	$3,619,317	$235,000	$108,580	$5,231,685	$8,851,003

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.229	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
4	0.229	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
4	0.229	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.132	$104,026	$235,000	$2,081	$3,610,025	$3,714,051
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group F	
	CSO Location	006 Montgomery St
	Proposed Tank(s)	River St, Harrison St
1	Property Owner	CITY OF PATERSON
	Block	3117
	Lot	1, 13-14
	Available space	90' diam.
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	CITY OF PATERSON
	Block	3116
	Lot	1-6
	Available space	100' diam.
	Land Acquisition	$0
	Land Clearing	$200,000
3	Property Owner	PANCO INVESTMENTS, LLC
	Block	3101
	Lot	7
	Available space	215' x 125'
	Land Acquisition	$379,000
	Land Clearing	$200,000

Storage Tank(s)	$39,440,524
Tunnel (15' diam.)	$22,351,550

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	1.760	100	17	0.999	YES	$9,104,227	$235,000	$273,127	$7,737,247	$16,841,474
		90	17	0.809		$7,538,606	$235,000	$226,158	$7,022,056	$14,560,662

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	1.760	30	350	1.851	YES	$5,250,000	$470,000	$105,000	$8,755,525	$14,005,525
4	1.760	15	1400	1.851	YES	$11,200,000	$470,000	$224,000	$10,567,538	$21,767,538
4	1.760	12	2188	1.851	YES	$15,316,000	$470,000	$306,320	$11,821,025	$27,137,025

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank 1	0.499	$281,883	$235,000	$5,638	$3,664,190	$3,946,072
Tank 2	0.404	$240,676	$235,000	$4,814	$3,651,640	$3,892,316
Tunnel	0.925	$447,677	$0	$8,954	$136,336	$584,012

* Assume 2-day dewatering period for greywater storage.

	Group G	
	CSO Location	007 Straight St
	Proposed Tank(s)	Montgomery St, Straight St
1	Property Owner	CITY OF PATERSON
	Block	3105
	Lot	1
	Available space	200' x 220'
	Land Acquisition	$0
	Land Clearing	$10,000

Storage Tank(s)	$50,241,405
Tunnel (15' diam.)	$39,658,546

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.588	190	13	2.757	YES	$21,568,414	$235,000	$647,052	$13,431,012	$34,999,426

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.588	30	500	2.644	YES	$7,500,000	$470,000	$150,000	$9,440,740	$16,940,740
4	2.588	15	2000	2.644	YES	$16,000,000	$470,000	$320,000	$12,029,330	$28,029,330
4	2.588	12	3125	2.644	YES	$21,875,000	$470,000	$437,500	$13,818,503	$35,693,503

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	700	$402,500	$8,050	$122,577	$525,077

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
010	24.240	$5,183,945	$235,000	$103,679	$5,157,064	$10,341,009
Tank	1.379	$603,698	$235,000	$12,074	$3,762,195	$4,365,893
Tunnel	1.322	$584,980	$0	$11,700	$178,150	$763,130

* Assume 2-day dewatering period for greywater storage.

Group H	
CSO Location	013 E 11th St
Proposed Tank(s)	105-119 E. 11th St
1 Property Owner	KIRKER ENTERPRISES INC.
Block	2002
Lot	1
Available space	65' x 45'
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$15,889,580

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.909			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.909	30	200	1.057	YES	$3,000,000	$470,000	$60,000	$8,070,310	$11,070,310
4	0.909	15	800	1.057	YES	$6,400,000	$470,000	$128,000	$9,105,746	$15,505,746
4	0.909	12	1250	1.057	YES	$8,750,000	$470,000	$175,000	$9,821,415	$18,571,415

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.529	$294,229	$0	$5,885	$89,605	$383,834

* Assume 2-day dewatering period for greywater storage.

	Group I	
	CSO Location	017 Arch Street
	Proposed Tank(s)	Presidential Blvd/Jefferson St
1	Property Owner	PATERSON HOPE 98 URBAN RENEWAL, LLC
	Block	213
	Lot	12-16
	Available space	150' x 75'
	Land Acquisition	$151,100
	Land Clearing	$100,000

Storage Tank(s)	$14,862,137
Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.389	70	14	0.403	YES	$4,868,208	$235,000	$146,046	$5,802,191	$10,670,399

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.389	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
4	0.389	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
4	0.389	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	24	300	$135,000	$2,700	$41,113	$176,113

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.202	$142,717	$235,000	$2,854	$3,621,808	$3,764,525
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

	Group J	
	CSO Location	021 Bergen St
	Proposed Tank(s)	Bergen St
1	Property Owner	CITY OF PATERSON
	Block	119
	Lot	3-6
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
2	Property Owner	CITY OF PATERSON
	Block	120
	Lot	38-40
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
3	Property Owner	CITY OF PATERSON
	Block	120
	Lot	4-7
	Available space	~ 125' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON
	Block	119
	Lot	1, 48-49
	Available space	~ 123' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000

Storage Tank(s)	$95,510,505
Tunnel (15' diam.)	$50,798,835

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.871	90	16	0.761	YES	$7,696,144	$235,000	$230,884	$7,094,021	$14,790,165
		90	16	0.761		$7,696,144	$235,000	$230,884	$7,094,021	$14,790,165
		90	15	0.714		$7,353,682	$235,000	$220,610	$6,937,580	$14,291,262
		90	15	0.714		$7,353,682	$235,000	$220,610	$6,937,580	$14,291,262

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	2.871	30	550	2.908	YES	$8,250,000	$470,000	$165,000	$9,669,145	$17,919,145
4	2.871	15	2200	2.908	YES	$17,600,000	$470,000	$352,000	$12,516,594	$30,116,594
4	2.871	12	3438	2.908	YES	$24,066,000	$470,000	$481,320	$14,485,750	$38,551,750

* Pump station operation for tunnels included.

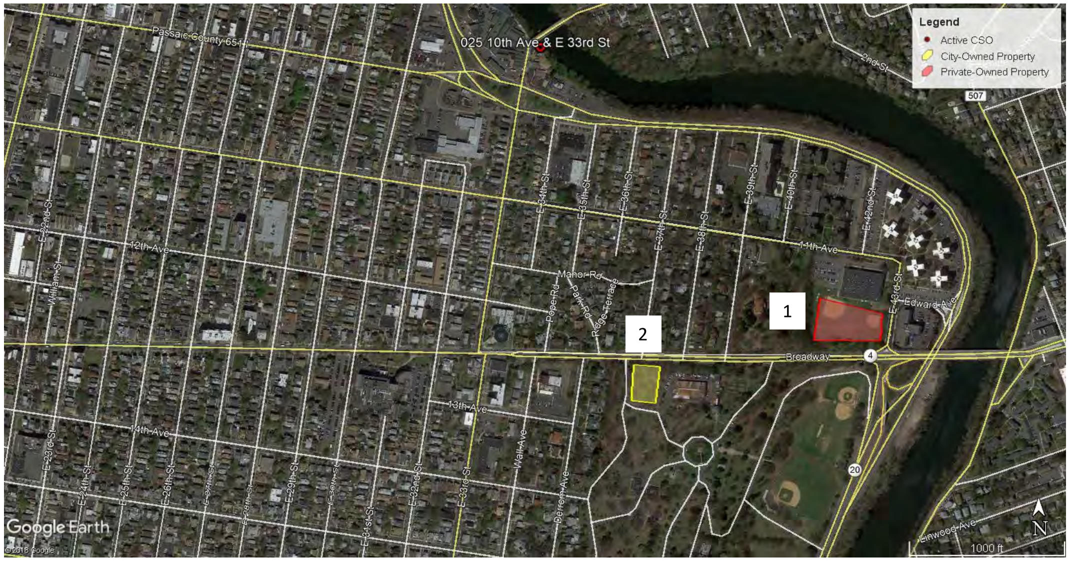
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	48	1000	$750,000	$15,000	$228,405	$978,405
RCP	42	1600	$1,040,000	$20,800	$316,722	$1,356,722

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
032	22.850	$4,959,359	$235,000	$99,187	$5,088,668	$10,048,028
022	11.640	$2,990,375	$235,000	$59,808	$4,489,034	$7,479,409
Tank 1	0.381	$229,978	$235,000	$4,600	$3,648,382	$3,878,360
Tank 2	0.381	$229,978	$235,000	$4,600	$3,648,382	$3,878,360
Tank 3	0.357	$219,111	$235,000	$4,382	$3,645,073	$3,864,184
Tank 4	0.357	$219,111	$235,000	$4,382	$3,645,073	$3,864,184
Tunnel	1.454	$628,327	$0	$12,567	$191,351	$819,678

* Assume 2-day dewatering period for greywater storage.

Group K	
CSO Location	025 10th Ave & E. 33rd St
Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1 Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
Block	8208
Lot	2
Available space	425' x 175'
Land Acquisition	$0
Land Clearing	$50,000
2 Property Owner	CITY OF PATERSON (PARKS DEPT)
Block	8101
Lot	1
Available space	225' x 150'
Land Acquisition	$0
Land Clearing	$200,000

Tunnel (15' diam.)	$54,455,026



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	5.624			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	5.624	30	1100	5.816	YES	$16,500,000	$470,000	$330,000	$12,181,600	$28,681,600
4	5.624	15	4400	5.816	YES	$35,200,000	$470,000	$704,000	$17,876,498	$53,076,498
4	5.624	12	6875	5.816	YES	$48,125,000	$470,000	$962,500	$21,812,678	$69,937,678

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	2.908	$1,056,716	$0	$21,134	$321,812	$1,378,528

* Assume 2-day dewatering period for greywater storage.

Group L	
CSO Location	3rd Ave
Proposed Tank(s)	Madison Ave/3rd Ave
1 Property Owner	CITY OF PATERSON
Block	2403
Lot	3-5
Available space	400' x 200'
Land Acquisition	$0
Land Clearing	$0

Storage Tank(s)	$20,432,967
Tunnel (15' diam.)	$15,889,580

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.954	130	10	0.993	YES	$8,861,947	$235,000	$265,858	$7,626,571	$16,488,519

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
4	0.954	30	200	1.057	YES	$3,000,000	$470,000	$60,000	$8,070,310	$11,070,310
4	0.954	15	800	1.057	YES	$6,400,000	$470,000	$128,000	$9,105,746	$15,505,746
4	0.954	12	1250	1.057	YES	$8,750,000	$470,000	$175,000	$9,821,415	$18,571,415

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.496	$280,638	$235,000	$5,613	$3,663,811	$3,944,449
Tunnel	0.529	$294,229	$0	$5,885	$89,605	$383,834

* Assume 2-day dewatering period for greywater storage.

Group A	
CSO Location	031 Rt 20 Bypass
Proposed Tank(s)	
1 Property Owner	
Block	
Lot	
Available space	
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$13,727,824

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.554			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.554	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
8	0.554	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
8	0.554	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

	Group B	
	CSO Location	016 Northwest St
	Proposed Tank(s)	Belmont Ave (CR-675); W. Broadway
1	Property Owner	CITY OF PATERSON
	Block	608
	Lot	10-11
	Available space	100' x 50'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	DILISIO, FRANCA
	Block	601
	Lot	6
	Available space	70' x 50'
	Land Acquisition	$189,800
	Land Clearing	$100,000
3	Property Owner	CITY OF PATERSON
	Block	801
	Lot	17
	Available space	225' x 126'
	Land Acquisition	$0
	Land Clearing	$0

Storage Tank(s)	$44,094,866
Tunnel (15' diam.)	$19,702,157

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.631	45	27	0.321	YES	$4,078,369	$235,000	$122,351	$5,441,385	$9,519,754
		45	27	0.321		$4,318,169	$235,000	$129,545	$5,550,928	$9,869,097
	0.017	40	8	0.075	YES	$2,547,725	$235,000	$76,432	$4,742,171	$7,289,896

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.648	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
8	0.648	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
8	0.648	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

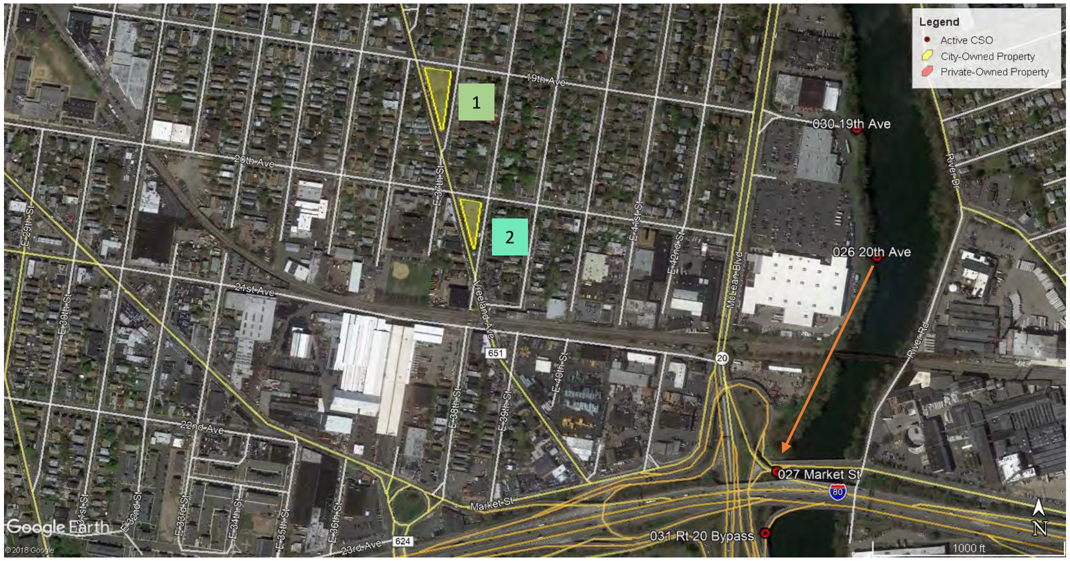
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	30	2000	$1,000,000	$20,000	$304,540	$1,304,540

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
015	2.130	$836,653	$235,000	$16,733	$3,833,139	$4,669,793
Tank 1	0.161	$120,385	$235,000	$2,408	$3,615,007	$3,735,392
Tank 2	0.161	$120,385	$235,000	$2,408	$3,615,007	$3,735,392
Tank 3	0.038	$40,517	$235,000	$810	$3,590,684	$3,631,201
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

	Group C	
	CSO Location	027 Market St
	Proposed Tank(s)	Vreeland/19th Aves; Vreeland/20th Aves
1	Property Owner	CITY OF PATERSON
	Block	8020
	Lot	1
	Available space	110' diam.
	Land Acquisition	$0
	Land Clearing	$100,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	7902
	Lot	1
	Available space	80' diam.
	Land Acquisition	$0
	Land Clearing	$100,000

Storage Tank(s)	$47,878,245
Tunnel (15' diam.)	$30,533,005



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	2.019	110	18	1.280	YES	$11,025,176	$235,000	$330,755	$8,614,756	$19,639,932
		80	20	0.752		$7,228,497	$235,000	$216,855	$6,880,395	$14,108,892

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	2.019	30	400	2.115	YES	$6,000,000	$470,000	$120,000	$8,983,930	$14,983,930
8	2.019	15	1600	2.115	YES	$12,800,000	$470,000	$256,000	$11,054,802	$23,854,802
8	2.019	12	2500	2.115	YES	$17,500,000	$470,000	$350,000	$12,486,140	$29,986,140

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	1500	$862,500	$17,250	$262,666	$1,125,166

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
026	2.770	$1,018,875	$235,000	$20,377	$3,888,633	$4,907,508
Tank 1	0.640	$339,449	$235,000	$6,789	$3,681,721	$4,021,170
Tank 2	0.376	$227,845	$235,000	$4,557	$3,647,733	$3,875,578
Tunnel	1.057	$494,833	$0	$9,897	$150,696	$645,529

* Assume 2-day dewatering period for greywater storage.

	Group D	
	CSO Location	029 Loop Rd
	Proposed Tank(s)	River St, Main St
1	Property Owner	NRVP, LLC
	Block	3701
	Lot	1-7
	Available space	250' x 90'
	Land Acquisition	$556,900
	Land Clearing	$200,000
2	Property Owner	NRVP, LLC
	Block	3713
	Lot	1-14
	Available space	260' x 60'
	Land Acquisition	$326,400
	Land Clearing	$0
3	Property Owner	NRVP, LLC
	Block	3712
	Lot	24-27, 29-36
	Available space	230' x 180'
	Land Acquisition	$998,500
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	1401
	Lot	1
	Available space	250' x 220'
	Land Acquisition	$0
	Land Clearing	$50,000

Storage Tank(s)	$57,169,077
Tunnel (15' diam.)	$29,305,243

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.389	80	15	0.564	YES	$6,532,460	$235,000	$195,974	$6,562,438	$13,094,899
		80	15	0.564		$6,532,460	$235,000	$195,974	$6,562,438	$13,094,899
		60	13	0.275		$4,021,820	$235,000	$120,655	$5,415,553	$9,437,373

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.389	30	300	1.586	YES	$4,500,000	$470,000	$90,000	$8,527,120	$13,027,120
8	1.389	15	1200	1.586	YES	$9,600,000	$470,000	$192,000	$10,080,274	$19,680,274
8	1.389	12	1875	1.586	YES	$13,125,000	$470,000	$262,500	$11,153,778	$24,278,778

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	72	1600	$1,960,000	$39,200	$596,898	$2,556,898

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
001+003	8.090	$2,276,262	$235,000	$45,525	$4,271,558	$6,547,820
Tank 1	0.282	$183,626	$235,000	$3,673	$3,634,267	$3,817,893
Tank 2	0.282	$183,626	$235,000	$3,673	$3,634,267	$3,817,893
Tank 3	0.137	$107,131	$235,000	$2,143	$3,610,971	$3,718,102
Tunnel	0.793	$398,799	$0	$7,976	$121,450	$520,250

* Assume 2-day dewatering period for greywater storage.


Legend
Active CSOs
City-Owned Property
Private-Owned Property
001 Curtis Place
015 SUM Park
028 SUM Park 2
4
N
900 ft
Broadway
College Blvd
Wayne Ave
Paterson Ave
Market St
Mill St
Totowa Ave
Kearney St
Jasper St
Liberty St
Walnut St
Maple St
Birch St
Front St
McBride Ave
Google Earth

	Group E	
	CSO Location	005 Bridge St
	Proposed Tank(s)	River St, Bridge St
1	Property Owner	CITY OF PATERSON
	Block	3701
	Lot	14-15
	Available space	214' x 80'
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	JEFFJEN, LLC
	Block	3701
	Lot	11-13
	Available space	25' x 80'; 50' x 80'; 50' x 80'; (= 125' x 80')
	Land Acquisition	$153,500
	Land Clearing	$300,000

Storage Tank(s)	$10,718,543
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.089	45	8	0.095	YES	$2,401,674	$235,000	$72,050	$4,675,454	$7,077,128

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.089	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
8	0.089	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
8	0.089	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.048	$48,347	$235,000	$967	$3,593,069	$3,641,415
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group F	
	CSO Location	006 Montgomery St
	Proposed Tank(s)	River St, Harrison St
1	Property Owner	CITY OF PATERSON
	Block	3117
	Lot	1, 13-14
	Available space	90' diam.
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	CITY OF PATERSON
	Block	3116
	Lot	1-6
	Available space	100' diam.
	Land Acquisition	$0
	Land Clearing	$200,000
3	Property Owner	PANCO INVESTMENTS, LLC
	Block	3101
	Lot	7
	Available space	215' x 125'
	Land Acquisition	$379,000
	Land Clearing	$200,000

Storage Tank(s)	$33,709,649
Tunnel (15' diam.)	$20,200,524

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.262	100	12	0.705	YES	$6,990,263	$235,000	$209,708	$6,771,567	$13,761,830
		90	12	0.571		$5,826,296	$235,000	$174,789	$6,239,855	$12,066,151

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.262	30	300	1.586	YES	$4,500,000	$470,000	$90,000	$8,527,120	$13,027,120
8	1.262	15	1200	1.586	YES	$9,600,000	$470,000	$192,000	$10,080,274	$19,680,274
8	1.262	12	1875	1.586	YES	$13,125,000	$470,000	$262,500	$11,153,778	$24,278,778

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank 1	0.352	$217,079	$235,000	$4,342	$3,644,454	$3,861,533
Tank 2	0.286	$185,345	$235,000	$3,707	$3,634,790	$3,820,135
Tunnel	0.793	$398,799	$0	$7,976	$121,450	$520,250

* Assume 2-day dewatering period for greywater storage.

Group G	
CSO Location	007 Straight St
Proposed Tank(s)	Montgomery St, Straight St
1 Property Owner	CITY OF PATERSON
Block	3105
Lot	1
Available space	200' x 220'
Land Acquisition	$0
Land Clearing	$10,000

Storage Tank(s)	$37,548,765
Tunnel (15' diam.)	$31,003,588

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.909	175	11	1.979	YES	$15,969,581	$235,000	$479,087	$10,873,409	$26,842,990

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	1.909	30	400	2.115	YES	$6,000,000	$470,000	$120,000	$8,983,930	$14,983,930
8	1.909	15	1600	2.115	YES	$12,800,000	$470,000	$256,000	$11,054,802	$23,854,802
8	1.909	12	2500	2.115	YES	$17,500,000	$470,000	$350,000	$12,486,140	$29,986,140

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	700	$402,500	$8,050	$122,577	$525,077

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
010	6.090	$1,839,602	$235,000	$36,792	$4,138,577	$5,978,180
Tank	0.990	$470,797	$235,000	$9,416	$3,721,721	$4,192,518
Tunnel	1.057	$494,833	$0	$9,897	$150,696	$645,529

* Assume 2-day dewatering period for greywater storage.

	Group H	
	CSO Location	013 E 11th St
	Proposed Tank(s)	105-119 E. 11th St
1	Property Owner	KIRKER ENTERPRISES INC.
	Block	2002
	Lot	1
	Available space	65' x 45'
	Land Acquisition	$0
	Land Clearing	$0

Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.387			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.387	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
8	0.387	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
8	0.387	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

Group I	
CSO Location	017 Arch Street
Proposed Tank(s)	Presidential Blvd/Jefferson St
1 Property Owner	PATERSON HOPE 98 URBAN RENEWAL, LLC
Block	213
Lot	12-16
Available space	150' x 75'
Land Acquisition	$151,100
Land Clearing	$100,000

Storage Tank(s)	$14,862,137
Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.324	70	14	0.403	YES	$4,868,208	$235,000	$146,046	$5,802,191	$10,670,399

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.324	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
8	0.324	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
8	0.324	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	24	300	$135,000	$2,700	$41,113	$176,113

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.202	$142,717	$235,000	$2,854	$3,621,808	$3,764,525
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

	Group J	
	CSO Location	021 Bergen St
	Proposed Tank(s)	Bergen St
1	Property Owner	CITY OF PATERSON
	Block	119
	Lot	3-6
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
2	Property Owner	CITY OF PATERSON
	Block	120
	Lot	38-40
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
3	Property Owner	CITY OF PATERSON
	Block	120
	Lot	4-7
	Available space	~ 125' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000

Storage Tank(s)	$78,448,441
Tunnel (15' diam.)	$45,121,395

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
8	2.627	90	19	0.904	YES	$8,723,530	$235,000	$261,706	$7,563,341	$16,286,871
		90	19	0.904		$8,723,530	$235,000	$261,706	$7,563,341	$16,286,871
		90	19	0.904		$8,723,530	$235,000	$261,706	$7,563,341	$16,286,871

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
8	2.627	30	500	2.644	YES	$7,500,000	$470,000	$150,000	$9,440,740	$16,940,740
8	2.627	15	2000	2.644	YES	$16,000,000	$470,000	$320,000	$12,029,330	$28,029,330
8	2.627	12	3125	2.644	YES	$21,875,000	$470,000	$437,500	$13,818,503	$35,693,503

* Pump station operation for tunnels included.

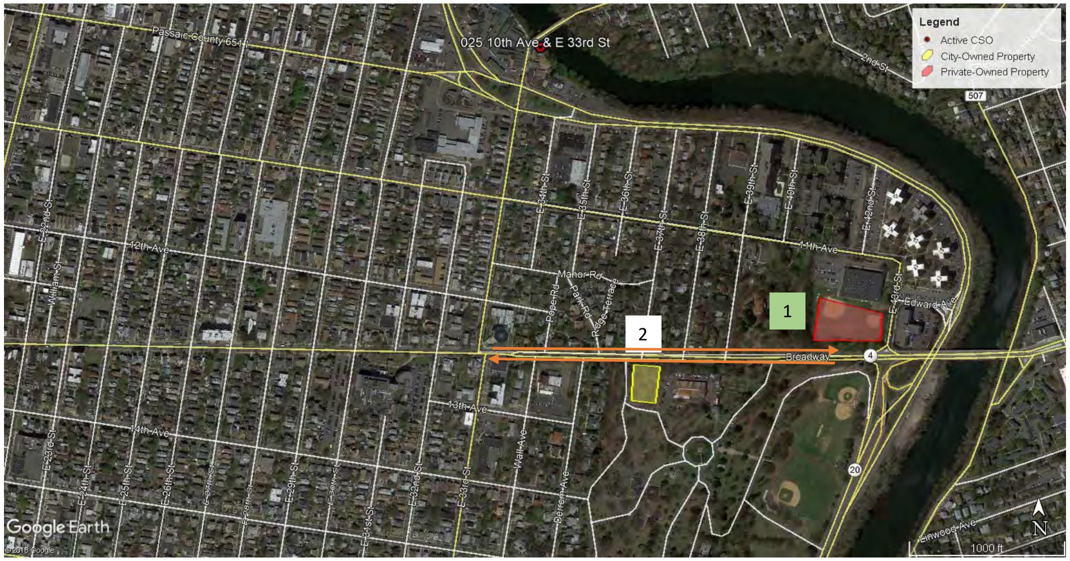
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
RCP	48	1000	$750,000	$15,000	$228,405	$978,405
RCP	42	1600	$1,040,000	$20,800	$316,722	$1,356,722

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	TOTAL 20-yr Lifespan Cost
032	11.76	$3,013,467	$235,000	$60,269	$4,496,066	$7,509,533
022	7.86	$2,227,552	$235,000	$44,551	$4,256,724	$6,484,276
Tank 1	0.452	$261,614	$235,000	$5,232	$3,658,017	$3,919,631
Tank 2	0.452	$261,614	$235,000	$5,232	$3,658,017	$3,919,631
Tank 3	0.452	$261,614	$235,000	$5,232	$3,658,017	$3,919,631
Tunnel	1.322	$584,980	$0	$11,700	$178,150	$763,130

* Assume 2-day dewatering period for greywater storage.

Group K	
CSO Location	025 10th Ave & E. 33rd St
Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1 Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
Block	8208
Lot	2
Available space	425' x 175'
Land Acquisition	$0
Land Clearing	$50,000
2 Property Owner	CITY OF PATERSON (PARKS DEPT)
Block	8101
Lot	1
Available space	225' x 150'
Land Acquisition	$0
Land Clearing	$200,000

Storage Tank(s)	$72,568,680
Tunnel (15' diam.)	$39,499,999



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	3.675	175	21	3.778	YES	$29,107,609	$235,000	$873,228	$16,874,992	$45,982,600

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	3.675	30	750	3.965	YES	$11,250,000	$470,000	$225,000	$10,582,765	$21,832,765
8	3.675	15	3000	3.965	YES	$24,000,000	$470,000	$480,000	$14,465,650	$38,465,650
8	3.675	12	4687	3.965	YES	$32,809,000	$470,000	$656,180	$17,148,343	$49,957,343

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	54	2200	$1,870,000	$37,400	$569,490	$2,439,490

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
025	75.100	$12,105,727	$235,000	$242,115	$7,265,023	$19,370,750
Tank	1.889	$764,633	$235,000	$15,293	$3,811,206	$4,575,840
Tunnel	1.983	$792,884	$0	$15,858	$241,465	$1,034,349

* Assume 2-day dewatering period for greywater storage.

Group L	
CSO Location	3rd Ave
Proposed Tank(s)	Madison Ave/3rd Ave
1 Property Owner	CITY OF PATERSON
Block	2403
Lot	3-5
Available space	400' x 200'
Land Acquisition	$0
Land Clearing	$0

Storage Tank(s)	$17,395,362
Tunnel (15' diam.)	$13,727,824

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.708	110	10	0.711	YES	$6,832,542	$235,000	$204,976	$6,699,519	$13,532,061

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
8	0.708	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
8	0.708	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
8	0.708	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.355	$218,434	$235,000	$4,369	$3,644,867	$3,863,301
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

	Group A	
	CSO Location	031 Rt 20 Bypass
	Proposed Tank(s)	
1	Property Owner	
	Block	
	Lot	
	Available space	
	Land Acquisition	$0
	Land Clearing	$0

Tunnel (15' diam.)	$13,727,824

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.553			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.553	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
12	0.553	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
12	0.553	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

	Group B	
	CSO Location	016 Northwest St
	Proposed Tank(s)	Belmont Ave (CR-675); W. Broadway
1	Property Owner	CITY OF PATERSON
	Block	608
	Lot	10-11
	Available space	100' x 50'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	DILISIO, FRANCA
	Block	601
	Lot	6
	Available space	70' x 50'
	Land Acquisition	$189,800
	Land Clearing	$100,000
3	Property Owner	CITY OF PATERSON
	Block	801
	Lot	17
	Available space	225' x 126'
	Land Acquisition	$0
	Land Clearing	$0

Storage Tank(s)	$44,087,171
Tunnel (15' diam.)	$19,694,462

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.626	45	27	0.321	YES	$4,078,369	$235,000	$122,351	$5,441,385	$9,519,754
		45	27	0.321		$4,318,169	$235,000	$129,545	$5,550,928	$9,869,097
	0.016	40	8	0.075	YES	$2,547,725	$235,000	$76,432	$4,742,171	$7,289,896

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.642	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
12	0.642	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
12	0.642	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

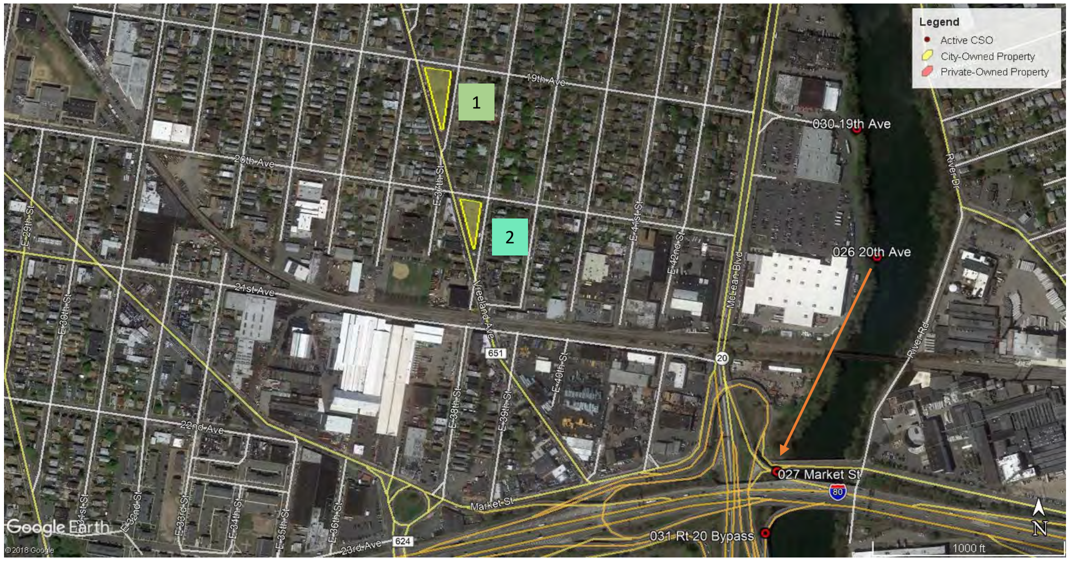
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	30	2000	$1,000,000	$20,000	$304,540	$1,304,540

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
015	2.110	$830,755	$235,000	$16,615	$3,831,343	$4,662,098
Tank 1	0.161	$120,385	$235,000	$2,408	$3,615,007	$3,735,392
Tank 2	0.161	$120,385	$235,000	$2,408	$3,615,007	$3,735,392
Tank 3	0.038	$40,517	$235,000	$810	$3,590,684	$3,631,201
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

Group C	
CSO Location	027 Market St
Proposed Tank(s)	Vreeland/19th Aves; Vreeland/20th Aves
1 Property Owner	CITY OF PATERSON
Block	8020
Lot	1
Available space	110' diam.
Land Acquisition	$0
Land Clearing	$100,000
2 Property Owner	CITY OF PATERSON (PARKS DEPT)
Block	7902
Lot	1
Available space	80' diam.
Land Acquisition	$0
Land Clearing	$100,000

Storage Tank(s)	$47,396,507
Tunnel (15' diam.)	$30,051,267



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.986	110	18	1.280	YES	$11,025,176	$235,000	$330,755	$8,614,756	$19,639,932
		80	20	0.752		$7,228,497	$235,000	$216,855	$6,880,395	$14,108,892

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.986	30	400	2.115	YES	$6,000,000	$470,000	$120,000	$8,983,930	$14,983,930
12	1.986	15	1600	2.115	YES	$12,800,000	$470,000	$256,000	$11,054,802	$23,854,802
12	1.986	12	2500	2.115	YES	$17,500,000	$470,000	$350,000	$12,486,140	$29,986,140

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	1500	$862,500	$17,250	$262,666	$1,125,166

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
026	1.520	$649,596	$235,000	$12,992	$3,776,173	$4,425,770
Tank 1	0.640	$339,449	$235,000	$6,789	$3,681,721	$4,021,170
Tank 2	0.376	$227,845	$235,000	$4,557	$3,647,733	$3,875,578
Tunnel	1.057	$494,833	$0	$9,897	$150,696	$645,529

* Assume 2-day dewatering period for greywater storage.

	Group D	
	CSO Location	029 Loop Rd
	Proposed Tank(s)	River St, Main St
1	Property Owner	NRVP, LLC
	Block	3701
	Lot	1-7
	Available space	250' x 90'
	Land Acquisition	$556,900
	Land Clearing	$200,000
2	Property Owner	NRVP, LLC
	Block	3713
	Lot	1-14
	Available space	260' x 60'
	Land Acquisition	$326,400
	Land Clearing	$0
3	Property Owner	NRVP, LLC
	Block	3712
	Lot	24-27, 29-36
	Available space	230' x 180'
	Land Acquisition	$998,500
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	1401
	Lot	1
	Available space	250' x 220'
	Land Acquisition	$0
	Land Clearing	$50,000

Storage Tank(s)	$42,931,886
Tunnel (15' diam.)	$26,396,172

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.124	80	15	0.564	YES	$6,532,460	$235,000	$195,974	$6,562,438	$13,094,899
		80	15	0.564		$6,532,460	$235,000	$195,974	$6,562,438	$13,094,899

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.124	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
12	1.124	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
12	1.124	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	72	1600	$1,960,000	$39,200	$596,898	$2,556,898

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
001	5.470	$1,697,272	$235,000	$33,945	$4,095,232	$5,792,504
Tank 1	0.282	$183,626	$235,000	$3,673	$3,634,267	$3,817,893
Tank 2	0.282	$183,626	$235,000	$3,673	$3,634,267	$3,817,893
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.


Legend
● Active CSOs
City-Owned Property
Private-Owned Property
001 Curtis Place
015 SUM Park
028 SUM Park 2
4
Kearney St
Jasper St
Totowa Ave
Ryle Rd
Broadway
Curtis Pl
College Blvd
Van Houten St
Ellison St
McGee's Alley
Mill St
Market St
Spruce St
Wayne Ave
Liberty St
Paterson Ave
Front St
Walnut St
Maple St
Birch St
Pleasantness Ave
666
McBride Ave
900 ft
Google Earth

	Group E	
	CSO Location	005 Bridge St
	Proposed Tank(s)	River St, Bridge St
1	Property Owner	CITY OF PATERSON
	Block	3701
	Lot	14-15
	Available space	214' x 80'
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	JEFFJEN, LLC
	Block	3701
	Lot	11-13
	Available space	25' x 80'; 50' x 80'; 50' x 80'; (= 125' x 80')
	Land Acquisition	$153,500
	Land Clearing	$300,000

Storage Tank(s)	$10,498,914
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.071	40	8	0.075	YES	$2,257,925	$235,000	$67,738	$4,609,788	$6,867,712

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.071	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
12	0.071	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
12	0.071	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.038	$40,517	$235,000	$810	$3,590,684	$3,631,201
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group F	
	CSO Location	006 Montgomery St
	Proposed Tank(s)	River St, Harrison St
1	Property Owner	CITY OF PATERSON
	Block	3117
	Lot	1, 13-14
	Available space	90' diam.
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	CITY OF PATERSON
	Block	3116
	Lot	1-6
	Available space	100' diam.
	Land Acquisition	$0
	Land Clearing	$200,000
3	Property Owner	PANCO INVESTMENTS, LLC
	Block	3101
	Lot	7
	Available space	215' x 125'
	Land Acquisition	$379,000
	Land Clearing	$200,000

Storage Tank(s)	$17,823,363
Tunnel (15' diam.)	$13,727,824

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.629	100	12	0.705	YES	$6,990,263	$235,000	$209,708	$6,771,567	$13,761,830

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.629	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
12	0.629	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
12	0.629	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.352	$217,079	$235,000	$4,342	$3,644,454	$3,861,533
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

Group G	
CSO Location	007 Straight St
Proposed Tank(s)	Montgomery St, Straight St
1 Property Owner	CITY OF PATERSON
Block	3105
Lot	1
Available space	200' x 220'
Land Acquisition	$0
Land Clearing	$10,000

Storage Tank(s)	$29,613,482
Tunnel (15' diam.)	$23,665,859

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.185	150	10	1.322	YES	$11,239,587	$235,000	$337,188	$8,712,701	$19,952,287

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.185	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
12	1.185	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
12	1.185	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	700	$402,500	$8,050	$122,577	$525,077

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
010	3.30	$1,161,840	$235,000	$23,237	$3,932,172	$5,094,012
Tank	0.661	$347,831	$235,000	$6,957	$3,684,274	$4,032,105
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.

Group H	
CSO Location	013 E 11th St
Proposed Tank(s)	105-119 E. 11th St
1 Property Owner	KIRKER ENTERPRISES INC.
Block	2002
Lot	1
Available space	65' x 45'
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.379			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.379	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
12	0.379	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
12	0.379	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

Group I	
CSO Location	017 Arch Street
Proposed Tank(s)	Presidential Blvd/Jefferson St
1 Property Owner	PATERSON HOPE 98 URBAN RENEWAL, LLC
Block	213
Lot	12-16
Available space	150' x 75'
Land Acquisition	$151,100
Land Clearing	$100,000

Storage Tank(s)	$12,718,830
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.185	50	14	0.206	YES	$3,447,625	$235,000	$103,429	$5,153,254	$8,600,879

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.185	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
12	0.185	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
12	0.185	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

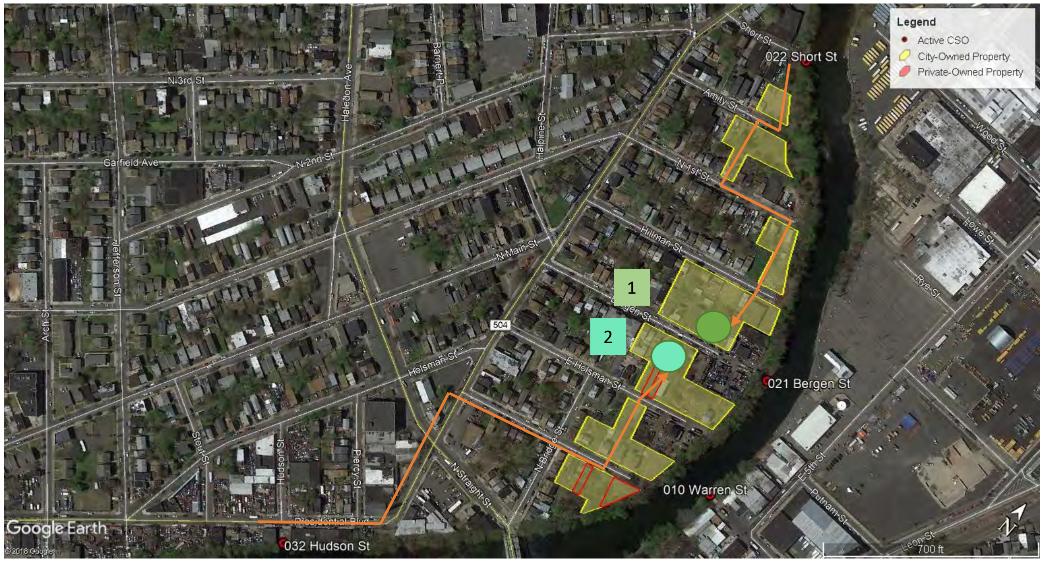
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	24	300	$135,000	$2,700	$41,113	$176,113

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.103	$86,155	$235,000	$1,723	$3,604,583	$3,690,738
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group J	
	CSO Location	021 Bergen St
	Proposed Tank(s)	Bergen St
1	Property Owner	CITY OF PATERSON
	Block	119
	Lot	3-6
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000
2	Property Owner	CITY OF PATERSON
	Block	120
	Lot	38-40
	Available space	~ 100' x 100'
	Land Acquisition	$0
	Land Clearing	$500,000

Storage Tank(s)	$53,789,598
Tunnel (15' diam.)	$35,653,073



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.514	90	16	0.761	YES	$7,696,144	$235,000	$230,884	$7,094,021	$14,790,165
		90	16	0.761		$7,696,144	$235,000	$230,884	$7,094,021	$14,790,165

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	1.514	30	300	1.586	YES	$4,500,000	$470,000	$90,000	$8,527,120	$13,027,120
12	1.514	15	1200	1.586	YES	$9,600,000	$470,000	$192,000	$10,080,274	$19,680,274
12	1.514	12	1875	1.586	YES	$13,125,000	$470,000	$262,500	$11,153,778	$24,278,778

* Pump station operation for tunnels included.

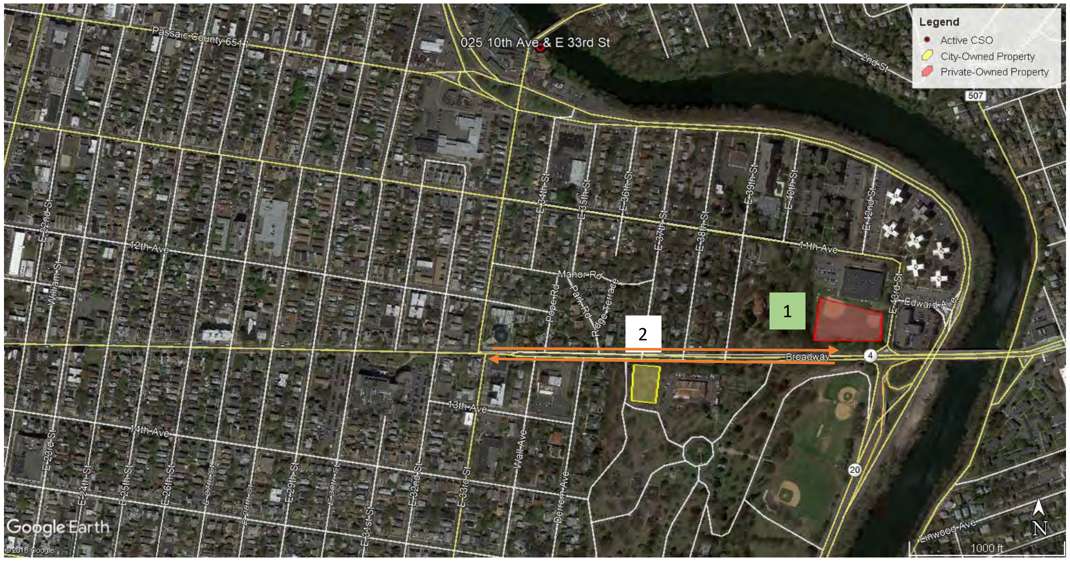
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	48	1000	$750,000	$15,000	$228,405	$978,405
RCP	42	1600	$1,040,000	$20,800	$316,722	$1,356,722

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
032	9.890	$2,646,416	$235,000	$52,928	$4,384,285	$7,030,701
022	6.460	$1,922,805	$235,000	$38,456	$4,163,916	$6,086,721
Tank 1	0.381	$229,978	$235,000	$4,600	$3,648,382	$3,878,360
Tank 2	0.381	$229,978	$235,000	$4,600	$3,648,382	$3,878,360
Tunnel	0.793	$398,799	$0	$7,976	$121,450	$520,250

* Assume 2-day dewatering period for greywater storage.

	Group K	
	CSO Location	025 10th Ave & E. 33rd St
	Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1	Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
	Block	8208
	Lot	2
	Available space	425' x 175'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	8101
	Lot	1
	Available space	225' x 150'
	Land Acquisition	$0
	Land Clearing	$200,000

Storage Tank(s)	$62,703,016
Tunnel (15' diam.)	$33,078,811



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	3.020	175	17	3.059	YES	$23,928,397	$235,000	$717,852	$14,509,076	$38,437,474

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	3.020	30	600	3.172	YES	$9,000,000	$470,000	$180,000	$9,897,550	$18,897,550
12	3.020	15	2400	3.172	YES	$19,200,000	$470,000	$384,000	$13,003,858	$32,203,858
12	3.020	12	3750	3.172	YES	$26,250,000	$470,000	$525,000	$15,150,865	$41,400,865

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	54	2200	$1,870,000	$37,400	$569,490	$2,439,490

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
025	61.640	$10,438,976	$235,000	$208,780	$6,757,431	$17,196,407
Tank	1.529	$652,568	$235,000	$13,051	$3,777,078	$4,429,646
Tunnel	1.586	$670,698	$0	$13,414	$204,254	$874,953

* Assume 2-day dewatering period for greywater storage.

Group L	
CSO Location	3rd Ave
Proposed Tank(s)	Madison Ave/3rd Ave
1 Property Owner	CITY OF PATERSON
Block	2403
Lot	3-5
Available space	400' x 200'
Land Acquisition	$0
Land Clearing	$0

Storage Tank(s)	$13,282,696
Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.302	75	10	0.330	YES	$4,094,959	$235,000	$122,849	$5,448,963	$9,543,923

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
12	0.302	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
12	0.302	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
12	0.302	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.165	$122,977	$235,000	$2,460	$3,615,796	$3,738,773
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

Group A	
CSO Location	031 Rt 20 Bypass
Proposed Tank(s)	
1 Property Owner	
Block	
Lot	
Available space	
Land Acquisition	$0
Land Clearing	$0

Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.095			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.095	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.095	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.095	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group B	
	CSO Location	016 Northwest St
	Proposed Tank(s)	Belmont Ave (CR-675); W. Broadway
1	Property Owner	CITY OF PATERSON
	Block	608
	Lot	10-11
	Available space	100' x 50'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	DILISIO, FRANCA
	Block	601
	Lot	6
	Available space	70' x 50'
	Land Acquisition	$189,800
	Land Clearing	$100,000
3	Property Owner	CITY OF PATERSON
	Block	801
	Lot	17
	Available space	225' x 126'
	Land Acquisition	$0
	Land Clearing	$0

Storage Tank(s)	$39,121,845
Tunnel (15' diam.)	$14,715,835

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.237	40	13	0.122	YES	$2,646,159	$235,000	$79,385	$4,787,137	$7,433,296
		40	13	0.122		$2,885,959	$235,000	$86,579	$4,896,680	$7,782,639
	0.003	40	8	0.075	YES	$2,547,725	$235,000	$76,432	$4,742,171	$7,289,896

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.240	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.240	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.240	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

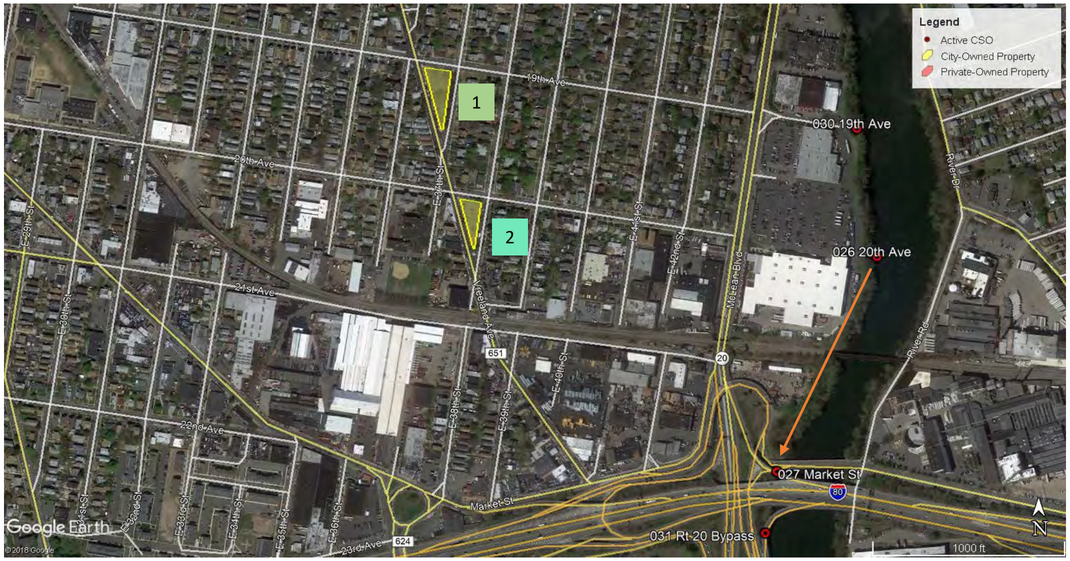
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	30	2000	$1,000,000	$20,000	$304,540	$1,304,540

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
015	0.660	$347,471	$235,000	$6,949	$3,684,164	$4,031,635
Tank 1	0.061	$58,315	$235,000	$1,166	$3,596,104	$3,654,419
Tank 2	0.061	$58,315	$235,000	$1,166	$3,596,104	$3,654,419
Tank 3	0.038	$40,517	$235,000	$810	$3,590,684	$3,631,201
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group C	
	CSO Location	027 Market St
	Proposed Tank(s)	Vreeland/19th Aves; Vreeland/20th Aves
1	Property Owner	CITY OF PATERSON
	Block	8020
	Lot	1
	Available space	110' diam.
	Land Acquisition	$0
	Land Clearing	$100,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	7902
	Lot	1
	Available space	80' diam.
	Land Acquisition	$0
	Land Clearing	$100,000

Storage Tank(s)	$36,334,604
Tunnel (15' diam.)	$23,112,828



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.040	100	12	0.705	YES	$6,890,263	$235,000	$206,708	$6,725,886	$13,616,149
		70	12	0.345		$4,302,771	$235,000	$129,083	$5,543,894	$9,846,665

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.040	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
20	1.040	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
20	1.040	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	1500	$862,500	$17,250	$262,666	$1,125,166

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
026	0.490	$277,912	$235,000	$5,558	$3,662,980	$3,940,893
Tank 1	0.352	$217,079	$235,000	$4,342	$3,644,454	$3,861,533
Tank 2	0.173	$127,135	$235,000	$2,543	$3,617,063	$3,744,198
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.

	Group D	
	CSO Location	029 Loop Rd
	Proposed Tank(s)	River St, Main St
1	Property Owner	NRVP, LLC
	Block	3701
	Lot	1-7
	Available space	250' x 90'
	Land Acquisition	$556,900
	Land Clearing	$200,000
2	Property Owner	NRVP, LLC
	Block	3713
	Lot	1-14
	Available space	260' x 60'
	Land Acquisition	$326,400
	Land Clearing	$0
3	Property Owner	NRVP, LLC
	Block	3712
	Lot	24-27, 29-36
	Available space	230' x 180'
	Land Acquisition	$998,500
	Land Clearing	$500,000
4	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	1401
	Lot	1
	Available space	250' x 220'
	Land Acquisition	$0
	Land Clearing	$50,000

Storage Tank(s)	$21,645,821
Tunnel (15' diam.)	$18,525,334

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.275	70	10	0.288	YES	$4,545,334	$235,000	$136,360	$5,654,699	$10,200,034

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.275	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
20	0.275	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
20	0.275	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	72	1600	$1,960,000	$39,200	$596,898	$2,556,898

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
001	1.480	$636,733	$235,000	$12,735	$3,772,256	$4,408,988
Tank	0.144	$110,887	$235,000	$2,218	$3,612,114	$3,723,001
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.


Legend
Active CSOs
City-Owned Property
Private-Owned Property
001 Curtis Place
015 SUM Park
028 SUM Park 2
4
N
900 ft
Google Earth
Kearney St
Jasper St
Totowa Ave
Wayne Ave
Liberty St
Paterson Ave
Front St
Walnut St
Maple St
Birch St
666
McBride Ave
Broadway
College Blvd
Van Houten St
Ellison St
McGee's Alley
Mill St
Market St
Spruce St
Ryle Rd

	Group E	
	CSO Location	005 Bridge St
	Proposed Tank(s)	River St, Bridge St
1	Property Owner	CITY OF PATERSON
	Block	3701
	Lot	14-15
	Available space	214' x 80'
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	JEFFJEN, LLC
	Block	3701
	Lot	11-13
	Available space	25' x 80'; 50' x 80'; 50' x 80'; (= 125' x 80')
	Land Acquisition	$153,500
	Land Clearing	$300,000

Storage Tank(s)	$10,498,914
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.008	40	8	0.075	YES	$2,257,925	$235,000	$67,738	$4,609,788	$6,867,712

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.008	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.008	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.008	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.038	$40,517	$235,000	$810	$3,590,684	$3,631,201
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group F	
	CSO Location	006 Montgomery St
	Proposed Tank(s)	River St, Harrison St
1	Property Owner	CITY OF PATERSON
	Block	3117
	Lot	1, 13-14
	Available space	90' diam.
	Land Acquisition	$0
	Land Clearing	$0
2	Property Owner	CITY OF PATERSON
	Block	3116
	Lot	1-6
	Available space	100' diam.
	Land Acquisition	$0
	Land Clearing	$200,000
3	Property Owner	PANCO INVESTMENTS, LLC
	Block	3101
	Lot	7
	Available space	215' x 125'
	Land Acquisition	$379,000
	Land Clearing	$200,000

Storage Tank(s)	$13,774,058
Tunnel (15' diam.)	$11,559,447

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.312	75	10	0.330	YES	$4,294,959	$235,000	$128,849	$5,540,325	$9,835,285

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.312	30	100	0.529	YES	$1,500,000	$470,000	$30,000	$7,613,500	$9,113,500
20	0.312	15	400	0.529	YES	$3,200,000	$470,000	$64,000	$8,131,218	$11,331,218
20	0.312	12	625	0.529	YES	$4,375,000	$470,000	$87,500	$8,489,053	$12,864,053

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.165	$122,977	$235,000	$2,460	$3,615,796	$3,738,773
Tunnel	0.264	$174,950	$0	$3,499	$53,279	$228,229

* Assume 2-day dewatering period for greywater storage.

Group G	
CSO Location	007 Straight St
Proposed Tank(s)	Montgomery St, Straight St
1 Property Owner	CITY OF PATERSON
Block	3105
Lot	1
Available space	200' x 220'
Land Acquisition	$0
Land Clearing	$10,000

Storage Tank(s)	$22,532,784
Tunnel (15' diam.)	$17,941,329

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.770	130	8	0.794	YES	$7,442,908	$235,000	$223,287	$6,978,340	$14,421,248

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.770	30	150	0.793	YES	$2,250,000	$470,000	$45,000	$7,841,905	$10,091,905
20	0.770	15	600	0.793	YES	$4,800,000	$470,000	$96,000	$8,618,482	$13,418,482
20	0.770	12	937	0.793	YES	$6,559,000	$470,000	$131,180	$9,154,168	$15,713,168

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	36	700	$402,500	$8,050	$122,577	$525,077

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
010	0.100	$84,384	$235,000	$1,688	$3,604,043	$3,688,428
Tank	0.397	$237,391	$235,000	$4,748	$3,650,640	$3,888,031
Tunnel	0.397	$237,128	$0	$4,743	$72,215	$309,342

* Assume 2-day dewatering period for greywater storage.

	Group H	
	CSO Location	013 E 11th St / 014 E 12th St
	Proposed Tank(s)	105-119 E. 11th St
1	Property Owner	KIRKER ENTERPRISES INC.
	Block	2002
	Lot	1
	Available space	65' x 45'
	Land Acquisition	$0
	Land Clearing	$0

Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.076			0.000	NO					

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.076	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.076	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.076	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group I	
	CSO Location	017 Arch Street
	Proposed Tank(s)	Presidential Blvd/Jefferson St
1	Property Owner	PATERSON HOPE 98 URBAN RENEWAL, LLC
	Block	213
	Lot	12-16
	Available space	150' x 75'
	Land Acquisition	$151,100
	Land Clearing	$100,000

Storage Tank(s)	$11,498,658
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.083	40	10	0.094	YES	$2,644,318	$235,000	$79,330	$4,786,296	$7,430,614

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.083	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.083	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.083	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

* Pump station operation for tunnels included.

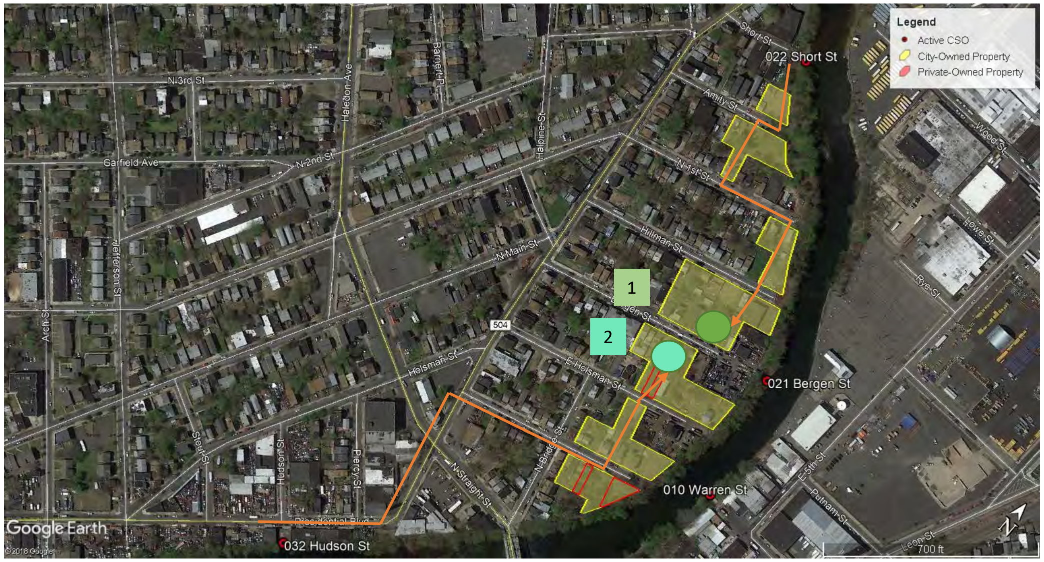
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	24	300	$135,000	$2,700	$41,113	$176,113

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.047	$47,898	$235,000	$958	$3,592,932	$3,640,830
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

Group J	
CSO Location	021 Bergen St
Proposed Tank(s)	Bergen St
1 Property Owner	CITY OF PATERSON
Block	119
Lot	3-6
Available space	~ 100' x 100'
Land Acquisition	$0
Land Clearing	$500,000
2 Property Owner	CITY OF PATERSON
Block	120
Lot	38-40
Available space	~ 100' x 100'
Land Acquisition	$0
Land Clearing	$500,000

Storage Tank(s)	$49,169,997
Tunnel (15' diam.)	$31,959,661



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.158	90	13	0.619	YES	$6,668,758	$235,000	$200,063	$6,624,700	$13,293,458
		90	13	0.619		$6,668,758	$235,000	$200,063	$6,624,700	$13,293,458

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.158	30	250	1.322	YES	$3,750,000	$470,000	$75,000	$8,298,715	$12,048,715
20	1.158	15	1000	1.322	YES	$8,000,000	$470,000	$160,000	$9,593,010	$17,593,010
20	1.158	12	1563	1.322	YES	$10,941,000	$470,000	$218,820	$10,488,662	$21,429,662

* Pump station operation for tunnels included.

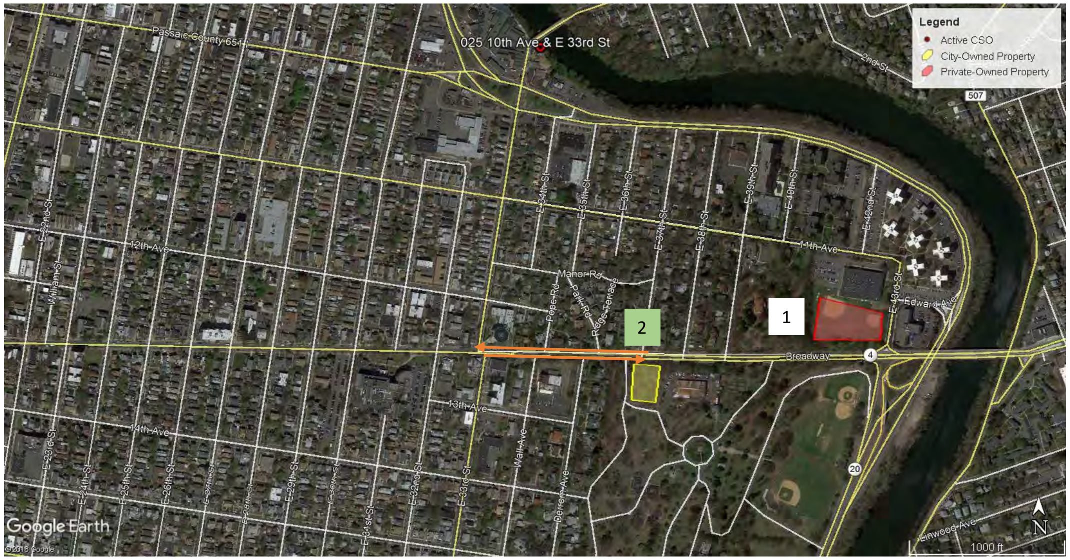
Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	48	1000	$750,000	$15,000	$228,405	$978,405
RCP	42	1600	$1,040,000	$20,800	$316,722	$1,356,722

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
032	5.750	$1,762,024	$235,000	$35,240	$4,114,952	$5,876,976
022	5.170	$1,626,967	$235,000	$32,539	$4,073,822	$5,700,789
Tank 1	0.309	$196,813	$235,000	$3,936	$3,638,282	$3,835,095
Tank 2	0.309	$196,813	$235,000	$3,936	$3,638,282	$3,835,095
Tunnel	0.661	$347,831	$0	$6,957	$105,929	$453,760

* Assume 2-day dewatering period for greywater storage.

	Group K	
	CSO Location	025 10th Ave & E. 33rd St
	Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1	Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
	Block	8208
	Lot	2
	Available space	425' x 175'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	8101
	Lot	1
	Available space	225' x 150'
	Land Acquisition	$0
	Land Clearing	$200,000

Storage Tank(s)	$42,467,941
Tunnel (15' diam.)	$24,500,331



Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.527	140	14	1.612	YES	$13,518,183	$235,000	$405,545	$9,753,586	$23,271,769

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	1.527	30	400	2.115	YES	$6,000,000	$470,000	$120,000	$8,983,930	$14,983,930
20	1.527	15	1600	2.115	YES	$12,800,000	$470,000	$256,000	$11,054,802	$23,854,802
20	1.527	12	2500	2.115	YES	$17,500,000	$470,000	$350,000	$12,486,140	$29,986,140

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	54	2200	$1,870,000	$37,400	$569,490	$2,439,490

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
025	34.820	$6,801,935	$235,000	$136,039	$5,649,806	$12,451,742
Tank	0.806	$403,664	$235,000	$8,073	$3,701,277	$4,104,941
Tunnel	1.057	$494,833	$0	$9,897	$150,696	$645,529

* Assume 2-day dewatering period for greywater storage.

	Group L	
	CSO Location	3rd Ave
	Proposed Tank(s)	Madison Ave/3rd Ave
1	Property Owner	CITY OF PATERSON
	Block	2403
	Lot	3-5
	Available space	400' x 200'
	Land Acquisition	$0
	Land Clearing	$0

Storage Tank(s)	$10,979,485
Tunnel (15' diam.)	$9,379,660

Overflow Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.087	45	10	0.119	YES	$2,572,905	$235,000	$77,187	$4,753,674	$7,326,579

Overflow Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
20	0.087	30	50	0.264	YES	$750,000	$470,000	$15,000	$7,385,095	$8,135,095
20	0.087	15	200	0.264	YES	$1,600,000	$470,000	$32,000	$7,643,954	$9,243,954
20	0.087	12	312	0.264	YES	$2,184,000	$470,000	$43,680	$7,821,805	$10,005,805

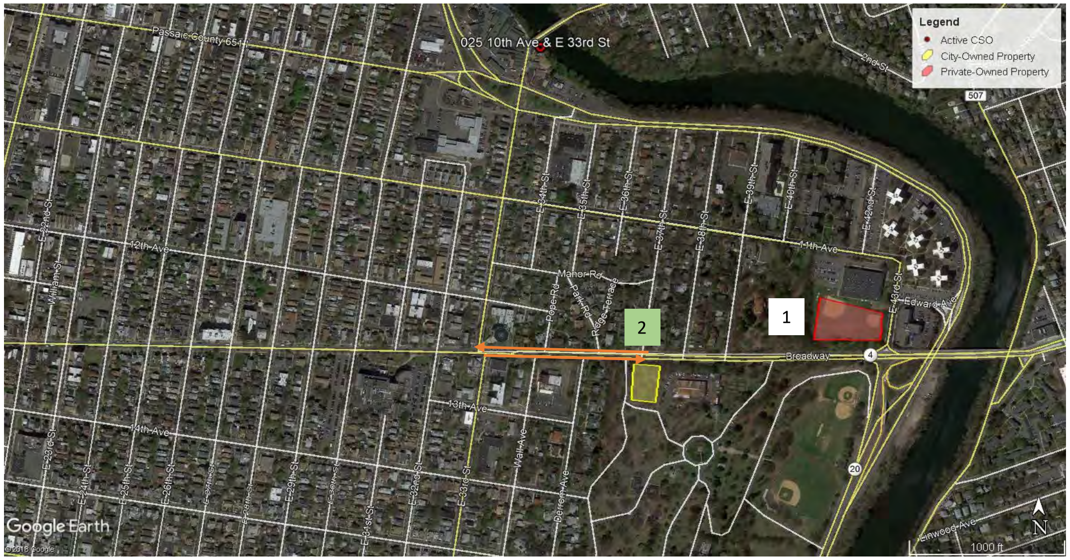
* Pump station operation for tunnels included.

Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
Tank	0.059	$57,155	$235,000	$1,143	$3,595,751	$3,652,905
Tunnel	0.132	$104,026	$0	$2,081	$31,680	$135,706

* Assume 2-day dewatering period for greywater storage.

	Group K	
	CSO Location	025 10th Ave & E. 33rd St
	Proposed Tank(s)	Eastside Park (small); school ballfield (large)
1	Property Owner	NEW JERSEY SCHOOLS DEVELOPMENT AUTH
	Block	8208
	Lot	2
	Available space	425' x 175'
	Land Acquisition	$0
	Land Clearing	$50,000
2	Property Owner	CITY OF PATERSON (PARKS DEPT)
	Block	8101
	Lot	1
	Available space	225' x 150'
	Land Acquisition	$0
	Land Clearing	$200,000

Storage Tank(s)	$42,467,941
Tunnel (15' diam.)	$24,500,331



Capture Target	Target Storage (MG)	Tank Diam. (ft)	Tank Height (ft)	Capacity (MG)	Meets Target Storage Volume?	Tank Construction Cost	Annual Tank Operation Cost	Annual Tank Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
85%	1.500	140	14	1.612	YES	$13,518,183	$235,000	$405,545	$9,753,586	$23,271,769

Capture Target	Target Storage (MG)	Tunnel Diam. (ft)	Length (ft)	Capacity (MG)	Meets Target Storage Volume?	Tunnel Construction Cost	Annual Tunnel Operation Cost*	Annual Tunnel Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
85%	1.500	30	400	2.115	YES	$6,000,000	$470,000	$120,000	$8,983,930	$14,983,930
85%	1.500	15	1600	2.115	YES	$12,800,000	$470,000	$256,000	$11,054,802	$23,854,802
85%	1.500	12	2500	2.115	YES	$17,500,000	$470,000	$350,000	$12,486,140	$29,986,140

* Pump station operation for tunnels included.

Pipe Type	Pipe Diameter (in)	Conveyance Pipe Needed (LF)	Conveyance Pipe Construction Cost	Annual Conv. Pipe Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
RCP	54	2200	$1,870,000	$37,400	$569,490	$2,439,490

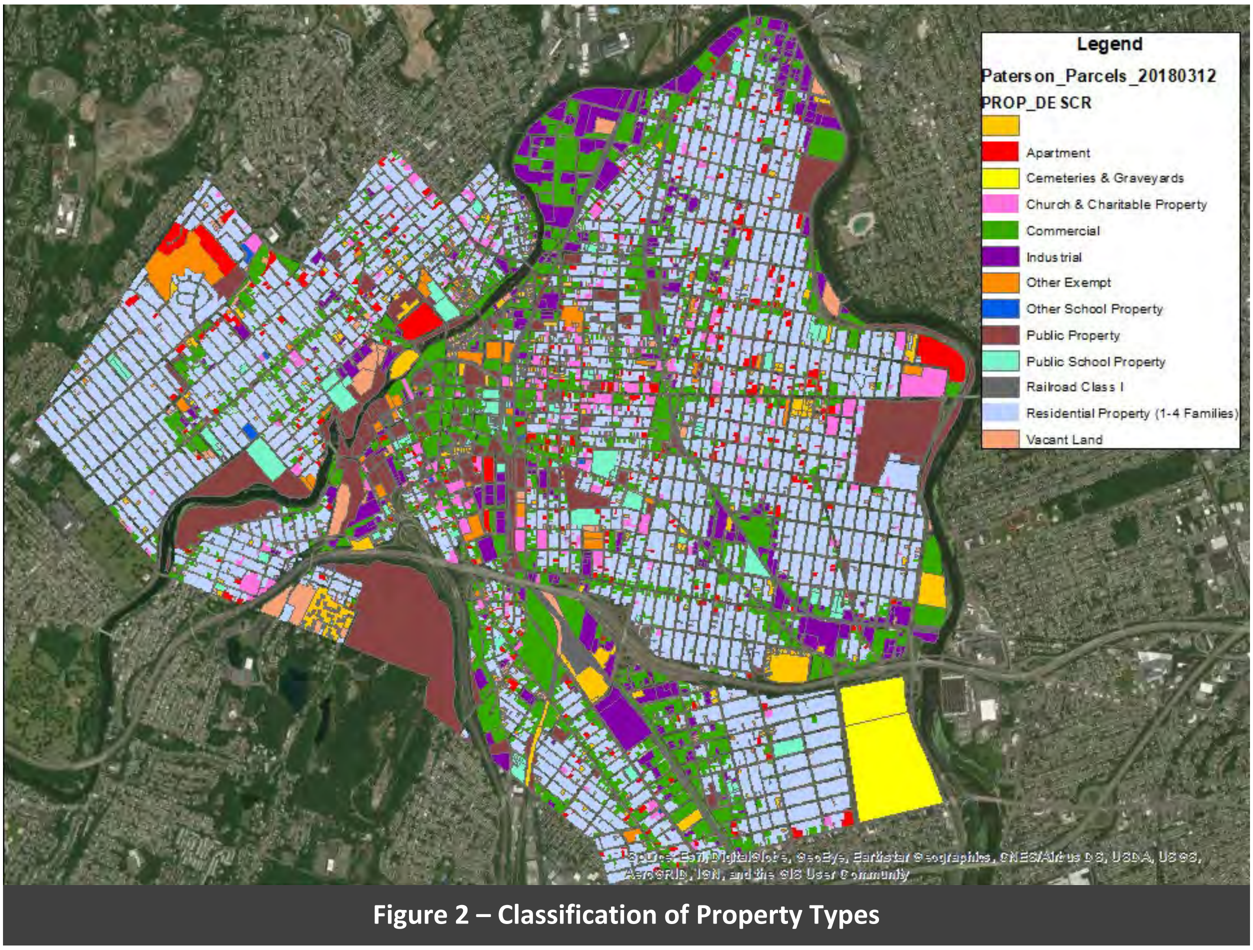
Pumping from	Expected CSO Flow (MGD)*	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maintenance Cost	Present O&M Value (20-yr Lifespan)	**TOTAL 20-yr Lifespan Cost**
025	34.820	$6,801,935	$235,000	$136,039	$5,649,806	$12,451,742
Tank	0.806	$403,664	$235,000	$8,073	$3,701,277	$4,104,941
Tunnel	1.057	$494,833	$0	$9,897	$150,696	$645,529

* Assume 2-day dewatering period for greywater storage.

APPENDIX G

Figures on Green Infrastructure

Figure 1 – Examples of GI Typologies Considered in Analysis



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2 – Classification of Property Types

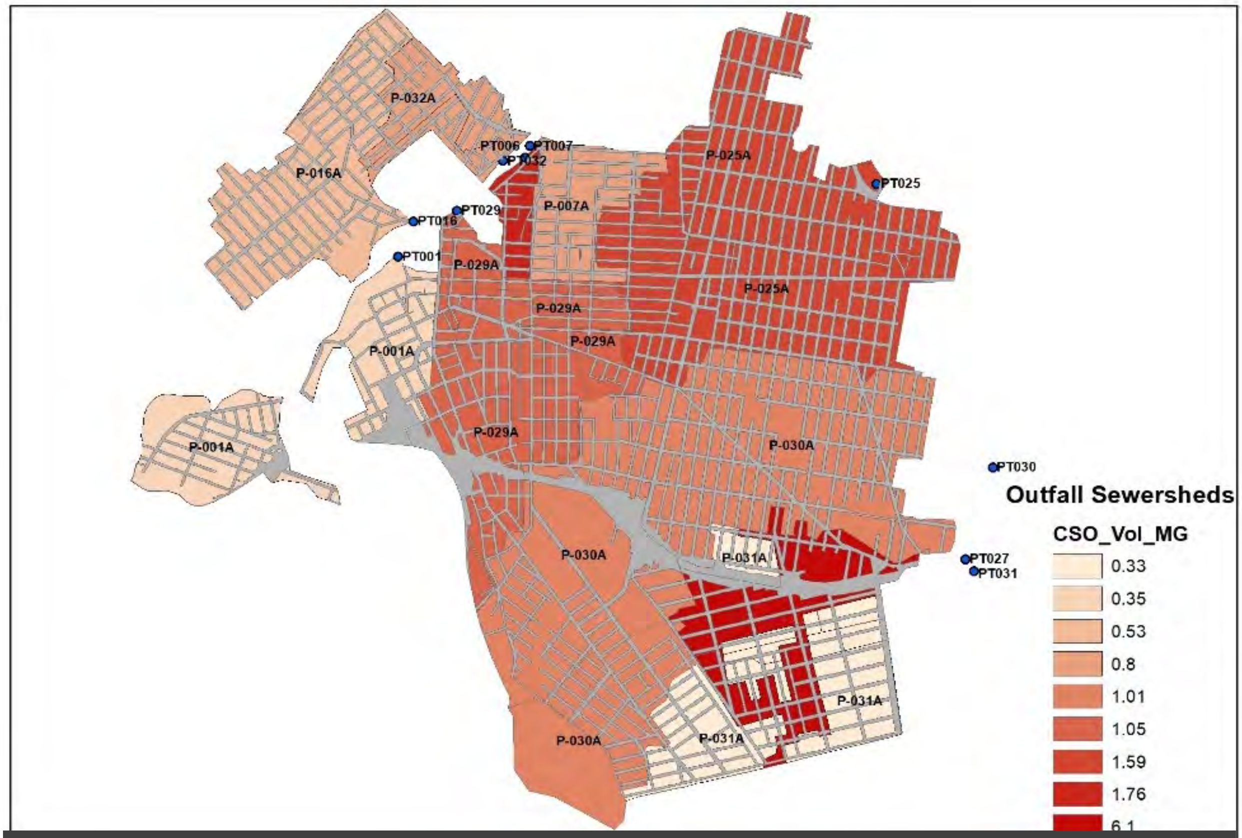


Figure 3 – Right-of-Way GI Opportunities

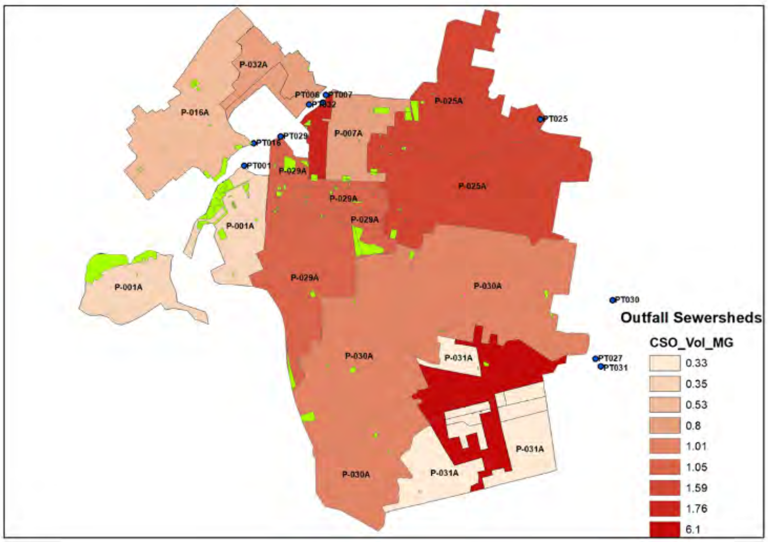


Figure 4 – City-Owned Parcels (Tier 1)

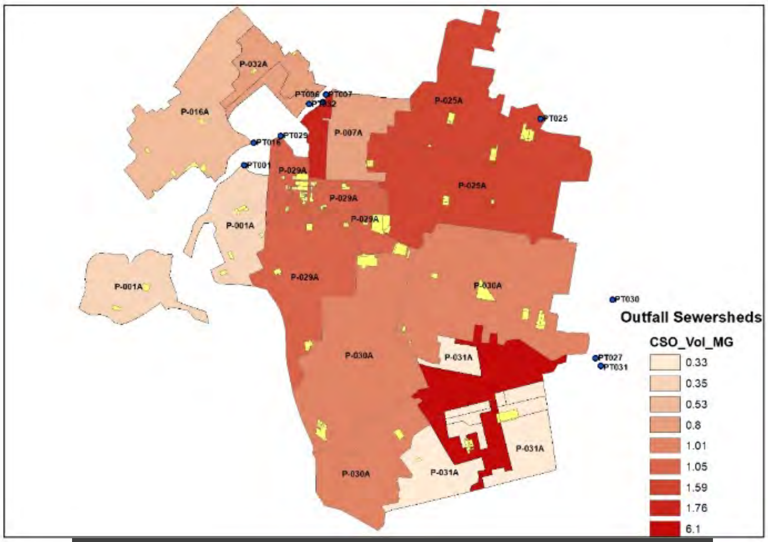


Figure 5 – School District-Owned Parcels (Tier 2)

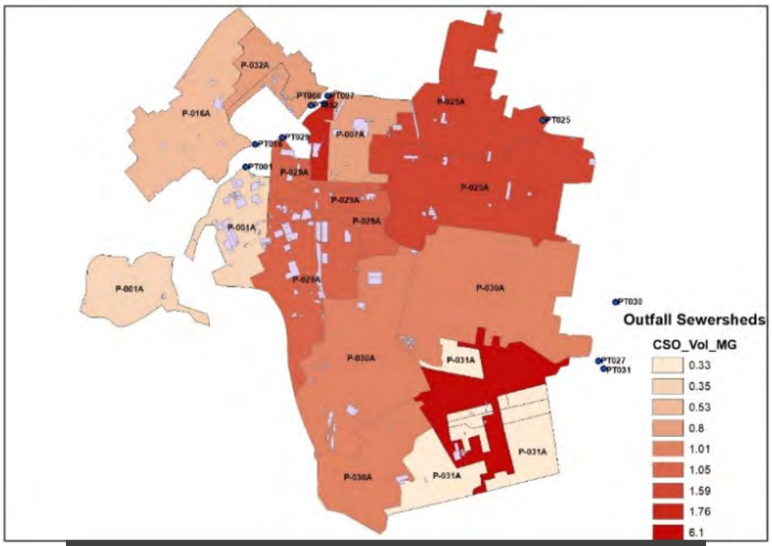


Figure 6 – Other Govt-Owned Parcels (Tier 3)

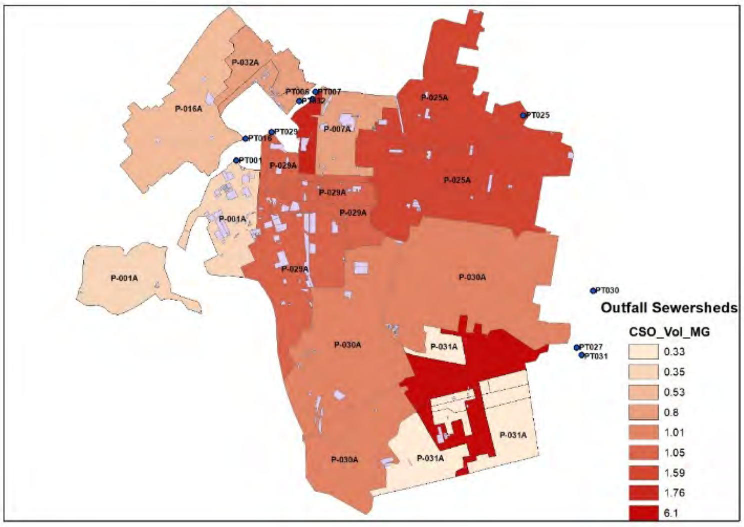


Figure 7 – Tax-Exempt Parcels (Tier 4)

APPENDIX H

CSO Alternatives Summary Tables

CSO Volumes (MG)	Outfall Number / Group									
	001, 003, 029	002	004	005	006	007, 010	012	013	014	015
	D			E	F	G		H	H	B
Baseline	26.405	0.205	0.195	2.299	25.227	38.561	1.647	10.064	0.193	0.575
Alt 1	25.799	0	0	2.126	24.954	38.194	0	10.115	0.180	0.228
Alt 2	25.799	0	0	2.126	24.954	38.194	0	10.115	0.180	0.228
Alt 3	24.787	0	0	2.007	23.918	36.254	0	9.469	0.191	0.228
Alt 4	0	0	0	0	0	0	0	0	0	0
Alt 5	2.758	0	0	0.236	3.337	4.173	0	1.451	0.095	0.159
Alt 6	7.251	0	0	1.092	5.966	7.083	0	4.516	0.105	0.109
Alt 7	9.220	0	0	1.225	12.439	14.272	0	4.543	0.105	0.112
Alt 8	17.890	0	0	1.916	17.356	19.753	0	8.353	0.193	0.187
Alt 9	24.601	0	0	1.957	24.426	36.977	0	10.274	0.193	0.228
	016	017	021, 022, 032	023	024	025	026, 027, 030	028	031	Total
	B	I	J		L	K	C	B	A	
Baseline	12.633	6.858	45.081	9.359	16.490	96.811	52.445	0.091	7.956	**353.093**
Alt 1	12.594	6.755	43.738	9.202	12.553	96.634	52.444	0.084	7.982	**343.582**
Alt 2	12.594	6.755	43.738	0	12.553	96.634	48.954	0.084	7.982	**330.890**
Alt 3	11.862	6.356	41.068	0	11.879	93.309	44.654	0.087	7.557	**313.624**
Alt 4	0	0	0	0	0	0	0	0	0	**0.000**
Alt 5	1.552	0.957	4.732	0	2.201	12.729	5.827	0	0.708	**40.916**
Alt 6	3.304	1.334	5.220	0	3.574	25.632	15.220	0.087	1.388	**81.880**
Alt 7	3.347	2.745	14.043	0	7.627	32.639	15.220	0.087	1.389	**119.013**
Alt 8	7.360	4.439	18.054	0	10.997	54.160	27.156	0.087	3.202	**191.102**
Alt 9	11.857	6.374	41.997	0	13.500	56.621	48.014	0.087	6.094	**283.199**

CSO Frequency	Outfall Number / Group									
	001, 003, 029	002	004	005	006	007, 010	012	013	014	015
	D			E	F	G		H	H	B
Baseline	30	8	9	20	27	32	13	33	5	21
Alt 1	30	0	0	20	27	32	0	33	5	19
Alt 2	30	0	0	20	27	32	0	33	5	19
Alt 3	29	0	0	17	25	28	0	33	5	19
Alt 4	0	0	0	0	0	0	0	0	0	0
Alt 5	3	0	0	3	3	3	0	3	1	1
Alt 6	7	0	0	7	7	7	0	7	3	2
Alt 7	8	0	0	7	11	11	0	7	3	4
Alt 8	15	0	0	14	20	15	0	17	5	10
Alt 9	29	0	0	17	25	28	0	33	5	19
	016	**017**	**021, 022, 032**	**023**	**024**	**025**	**026, 027, 030**	**028**	**031**	**Systemwide***
	B	**I**	**J**		**L**	**K**	**C**	**B**	**A**	
Baseline	32	27	30	24	30	53	37	5	25	**53**
Alt 1	32	27	30	24	29	53	37	5	25	**53**
Alt 2	32	27	30	0	29	53	37	5	25	**53**
Alt 3	29	26	30	0	29	53	34	5	24	**53**
Alt 4	0	0	0	0	0	0	0	0	0	**0**
Alt 5	4	2	2	0	4	4	3	2	1	**4**
Alt 6	7	7	2	0	6	8	7	5	4	**8**
Alt 7	7	11	11	0	11	11	7	5	4	**12**
Alt 8	14	20	13	0	20	19	14	5	10	**20**
Alt 9	29	26	30	0	29	23	34	5	24	**36**

Wet Weather Capture Percentages	Total CSO (MG)	Total Wet Weather DWF (MG)	Total Runoff (MG)	Wet Weather Capture %
Baseline	353.093	1077.8	896.858	**82.1%**
Alt 1	343.582	1077.8	882.355	**82.5%**
Alt 2	330.890	1077.8	871.746	**83.0%**
Alt 3	313.624	1077.8	844.229	**83.7%**
Alt 4	0.000	1077.8	844.229	**100.0%**
Alt 5	40.916	1077.8	844.229	**97.9%**
Alt 6	81.880	1077.8	844.229	**95.7%**
Alt 7	119.013	1077.8	844.229	**93.8%**
Alt 8	191.102	1077.8	844.229	**90.1%**
Alt 9	283.199	1077.8	844.229	**85.3%**

*** Systemwide Frequencies are not necessarily equal to the maximum frequency at an outfall group because different outfalls can overflow on different rain events.**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Storage Option	Storage Option Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
2.396	A	031	Tunnel	$28,029,330		$763,130		$5,990,000	$34,782,460
1.819	B	015, 016, 028	Tunnel + Weirs	$41,326,996	$1,565,448	$9,374,741		$4,547,500	$56,814,684
8.885	C	026, 027, 030	Tunnel	$78,123,666	$1,500,221	$9,969,487		$22,212,500	$111,805,874
4.208	D	001, 003, 029	Tunnel	$42,640,178	$2,556,898	$16,850,162		$10,520,000	$72,567,239
0.325	E	005	Tank @ 005	$9,543,923		$3,738,773		$812,500	$14,095,196
4.289	F	006	Tunnel	$42,640,178		$1,136,149		$10,722,500	$54,498,827
6.561	G	007, 010	Tunnel	$61,425,554		$1,562,531		$16,402,500	$79,390,585
1.676	H	013, 014	Tunnel	$21,767,538		$584,012		$4,190,000	$26,541,550
1.184	I	017	Tunnel	$17,593,010		$453,760		$2,960,000	$21,006,770
6.977	J	021, 022, 032	Tunnel	$63,512,818	$2,335,127	$21,489,884		$17,442,500	$104,780,329
13.890	K	025	Tunnel	$117,781,682		$2,665,664		$34,725,000	$155,172,346
2.659	L	024	Tunnel	$30,116,594		$819,678		$6,647,500	$37,583,772
54.869				$554,501,466	$7,957,694	$69,407,971	$0	$137,172,500	$769,039,631
								Storage by group, 0 overflows:	**$769,039,631**
								Including Alternative 3 System Changes (Alternative 4A):	**$818,039,631**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)

GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Storage Option	Storage Option Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
1.257	A	031	Tunnel	$17,593,010		$453,760		$3,142,500	$21,189,270
0.931	B	015, 016, 028	Tunnel + Weir	$17,203,199	$1,304,540	$5,045,932		$2,327,500	$25,881,171
3.837	C	026, 027	Tunnel	$38,465,650	$1,125,166	$7,799,786		$9,592,500	$56,983,102
2.273	D	001, 003, 029	Tunnel	$28,029,330	$2,556,898	$12,938,201		$5,682,500	$49,206,929
0.229	E	005	Tank @ 005	$8,851,003		$3,714,051		$572,500	$13,137,554
1.760	F	006	Tunnel	$21,767,538		$584,012		$4,400,000	$26,751,550
2.588	G	007, 010	Tunnel	$28,029,330	$525,077	$11,104,139		$6,470,000	$46,128,546
0.909	H	013, 014	Tunnel	$15,505,746		$383,834		$2,272,500	$18,162,080
0.389	I	017	Tank @ 017	$10,670,399	$176,113	$3,764,525	$251,100	$972,500	$15,834,637
2.871	J	021, 022, 032	Tunnel	$30,116,594	$2,335,127	$18,347,114		$7,177,500	$57,976,335
5.624	K	025	Tunnel	$53,076,498		$1,378,528		$14,060,000	$68,515,026
0.954	L	024	Tunnel	$15,505,746		$383,834		$2,385,000	$18,274,580
23.622				$284,814,043	$8,022,921	$65,897,716	$251,100	$59,055,000	$418,040,780
								Storage by group, 4 overflows:	**$418,040,780**
								Including Alternative 3 System Changes (Alternative 5A):	**$467,040,780**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Storage Option	Storage Option Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
0.554	A	031	Tunnel	$13,418,482		$309,342		$1,385,000	$15,112,824
0.648	B	015, 016	Tunnel	$13,418,482	$1,304,540	$4,979,135		$1,620,000	$21,322,157
2.019	C	026, 027	Tunnel	$23,854,802	$1,125,166	$5,553,037		$5,047,500	$35,580,505
1.389	D	001, 003, 029	Tunnel	$19,680,274	$2,556,898	$7,068,070		$3,472,500	$32,777,743
0.089	E	005	Tank @ 005	$7,077,128		$3,641,415		$222,500	$10,941,043
1.262	F	006	Tunnel	$19,680,274		$520,250		$3,155,000	$23,355,524
1.909	G	007, 010	Tunnel	$23,854,802	$525,077	$6,623,709		$4,772,500	$35,776,088
0.387	H	013, 014	Tunnel	$11,331,218		$228,229		$967,500	$12,526,947
0.324	I	017	Tank @ 017	$10,670,399	$176,113	$3,764,525	$251,100	$810,000	$15,672,137
2.627	J	021, 022, 032	Tunnel	$28,029,330	$2,335,127	$14,756,939		$6,567,500	$51,688,895
3.675	K	025	Tunnel	$38,465,650		$1,034,349		$9,187,500	$48,687,499
0.708	L	024	Tunnel	$13,418,482		$309,342		$1,770,000	$15,497,824
15.591				$222,899,324	$8,022,921	$48,788,343	$251,100	$38,977,500	$318,939,188
								Storage by group, 8 overflows:	**$318,939,188**
								Including Alternative 3 System Changes (Alternative 6A):	**$367,939,188**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	**Outfall ID**	**Storage Required for 0 overflow events (MG)**	**Storage Required for 4 overflow events (MG)**	**Storage Required for 8 overflow events (MG)**	**Storage Required for 12 overflow events (MG)**	**Storage Required for 20 overflow events (MG)**	**Storage Required for 85% Capture in Paterson (MG)**
A	**031**	2.396	1.257	0.554	0.553	0.095	
B	**015**	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	**026, 027, 030**	8.885	3.837	2.019	1.986	1.040	
D	**001, 003, 029**	4.208	2.273	1.389	1.124	0.275	
E	**005**	0.325	0.229	0.089	0.071	0.008	
F	**006**	4.289	1.760	1.262	0.629	0.312	
G	**007, 010**	6.561	2.588	1.909	1.185	0.770	
H	**013**	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	**017**	1.184	0.389	0.324	0.185	0.083	
J	**021, 022, 032**	6.977	2.871	2.627	1.514	1.158	
K	**025**	13.890	5.624	3.675	3.020	1.527	1.500
L	**024**	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	**GROUP**	**Active Outfalls in Group**	**Storage Option**	**Storage Option Cost**	**Conveyance Pipe Cost**	**Pump System Cost**	**Acquisition/ Clearing Costs**	**Contaminated Soils**	**TOTAL Alternative Cost**
0.553	**A**	**031**	Tunnel	$13,418,482		$309,342		$1,382,500	$15,110,324
0.642	**B**	**015, 016**	Tunnel	$13,418,482	$1,304,540	$4,971,440		$1,605,000	$21,299,462
1.986	**C**	**026, 027**	Tunnel	$23,854,802	$1,125,166	$5,071,299		$4,965,000	$35,016,267
1.124	**D**	**001, 029**	Tunnel	$17,593,010	$2,556,898	$6,246,264		$2,810,000	$29,206,172
0.071	**E**	**005**	Tank @ 005	$6,867,712		$3,631,201		$177,500	$10,676,414
0.629	**F**	**006**	Tank u/s of 006	$13,761,830		$3,861,533	$200,000	$1,572,500	$19,395,863
1.185	**G**	**007, 010**	Tunnel	$17,593,010	$525,077	$5,547,772		$2,962,500	$26,628,359
0.379	**H**	**013, 014**	Tunnel	$11,331,218		$228,229		$947,500	$12,506,947
0.185	**I**	**017**	Tank @ 017	$8,600,879	$176,113	$3,690,738	$251,100	$462,500	$13,181,330
1.514	**J**	**021, 022, 032**	Tunnel	$19,680,274	$2,335,127	$13,637,672		$3,785,000	$39,438,073
3.020	**K**	**025**	Tunnel	$32,203,858		$874,953		$7,550,000	$40,628,811
0.302	**L**	**024**	Tank u/s of 024	$9,543,923		$3,738,773		$755,000	$14,037,696
11.590				$187,867,480	$8,022,921	$51,809,217	$451,100	$28,975,000	$277,125,718
								Storage by group, 12 overflows:	**$277,125,718**
								Including Alternative 3 System Changes (Alternative 7A):	**$326,125,718**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Storage Option	Storage Option Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
0.095	A	031	Tunnel	$9,243,954		$135,706		$237,500	$9,617,160
0.240	B	015, 016	Tunnel	$9,243,954	$1,304,540	$4,167,341		$600,000	$15,315,835
1.040	C	026, 027	Tunnel	$17,593,010	$1,125,166	$4,394,653		$2,600,000	$25,712,828
0.275	D	001, 029	Tank @ 029	$10,200,034	$2,556,898	$8,131,989	$756,900	$687,500	$22,333,321
0.008	E	005	Tank @ 005	$6,867,712		$3,631,201		$20,000	$10,518,914
0.312	F	006	Tank u/s of 006	$9,835,285		$3,738,773	$200,000	$780,000	$14,554,058
0.770	G	007, 010	Tank u/s of 007	$14,421,248	$525,077	$7,576,459	$10,000	$1,925,000	$24,457,784
0.076	H	013	Tunnel	$9,243,954		$135,706		$190,000	$9,569,660
0.083	I	017	Tank @ 017	$7,430,614	$176,113	$3,640,830	$251,100	$207,500	$11,706,158
1.158	J	021, 022, 032	Tunnel	$17,593,010	$2,335,127	$12,031,525		$2,895,000	$34,854,661
1.527	K	025	Tunnel	$23,854,802		$645,529		$3,817,500	$28,317,831
0.087	L	024	Tank u/s of 024	$7,326,579		$3,652,905		$217,500	$11,196,985
5.671				$142,854,156	$8,022,921	$51,882,618	$1,218,000	$14,177,500	$218,155,195
								Storage by group, 20 overflows:	**$218,155,195**
								Including Alternative 3 System Changes (Alternative 8A):	**$267,155,195**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Alternative Option	Alternative Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
2.396	A	031	PAA Disinfection	$39,615,663					$39,615,663
1.819	B	015, 016, 028	PAA Disinfection	$25,513,075	$1,565,448	$8,790,728			$35,869,251
8.885	C	026, 027, 030	PAA Disinfection	$125,103,936	$1,500,221	$10,869,888			$137,474,044
4.208	D	001, 003, 029	PAA Disinfection	$39,943,960	$2,556,898	$15,714,013			$58,214,872
0.325	E	005	Tank @ 005	$9,543,923		$3,738,773		$812,500	$14,095,196
4.289	F	006	PAA Disinfection	$23,960,071					$23,960,071
6.561	G	007, 010	PAA Disinfection	$39,243,125	$525,077	$15,489,476			$55,257,679
1.676	H	013, 014	PAA Disinfection	$25,881,049					$25,881,049
1.184	I	017	PAA Disinfection	$9,516,032					$9,516,032
6.977	J	021, 022, 032	PAA Disinfection	$24,134,929	$2,335,127	$19,882,494			$46,352,549
13.890	K	025	PAA Disinfection	$125,371,489					$125,371,489
2.659	L	024	PAA Disinfection	$23,716,043					$23,716,043
54.869				$511,543,294	$8,482,771	$74,485,373	$0	$812,500	$595,323,938
								Hybrid Storage/Disinfection, 0 overflows:	**$595,323,938**
								Including Alternative 3 System Changes (Alternative 4B):	**$644,323,938**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Alternative Option	Alternative Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
1.257	A	031	PAA Disinfection	$23,631,423					$23,631,423
0.931	B	015, 016	PAA Disinfection	$23,845,606	$1,304,540	$4,662,098			$29,812,244
3.837	C	026, 027	PAA Disinfection	$24,652,480	$1,125,166	$6,765,437			$32,543,083
2.273	D	001, 003, 029	PAA Disinfection	$24,719,544	$2,556,898	$12,175,071			$39,451,513
0.229	E	005	Tank @ 005	$8,851,003		$3,714,051		$572,500	$13,137,554
1.760	F	006	PAA Disinfection	$23,670,046					$23,670,046
2.588	G	007, 010	PAA Disinfection	$24,315,756	$525,077	$10,341,009			$35,181,842
0.909	H	013, 014	PAA Disinfection	$23,525,033					$23,525,033
0.389	I	017	Tank @ 017	$10,670,399	$176,113	$3,764,525	$251,100	$972,500	$15,834,637
2.871	J	021, 022, 032	PAA Disinfection	$23,741,674	$2,335,127	$17,527,437			$43,604,238
5.624	K	025	PAA Disinfection	$40,487,494					$40,487,494
0.954	L	024	PAA Disinfection	$9,669,472					$9,669,472
23.622				$261,779,929	$8,022,921	$58,949,627	$251,100	$1,545,000	$330,548,577

Hybrid Storage/Disinfection, 4 overflows: **$330,548,577**

Including Alternative 3 System Changes (Alternative 5B): **$379,548,577**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	**Outfall ID**	**Storage Required for 0 overflow events (MG)**	**Storage Required for 4 overflow events (MG)**	**Storage Required for 8 overflow events (MG)**	**Storage Required for 12 overflow events (MG)**	**Storage Required for 20 overflow events (MG)**	**Storage Required for 85% Capture in Paterson (MG)**
A	**031**	2.396	1.257	0.554	0.553	0.095	
B	**015**	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	**026, 027, 030**	8.885	3.837	2.019	1.986	1.040	
D	**001, 003, 029**	4.208	2.273	1.389	1.124	0.275	
E	**005**	0.325	0.229	0.089	0.071	0.008	
F	**006**	4.289	1.760	1.262	0.629	0.312	
G	**007, 010**	6.561	2.588	1.909	1.185	0.770	
H	**013**	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	**017**	1.184	0.389	0.324	0.185	0.083	
J	**021, 022, 032**	6.977	2.871	2.627	1.514	1.158	
K	**025**	13.890	5.624	3.675	3.020	1.527	1.500
L	**024**	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	**GROUP**	**Active Outfalls in Group**	**Alternative Option**	**Alternative Cost**	**Conveyance Pipe Cost**	**Pump System Cost**	**Acquisition/ Clearing Costs**	**Contaminated Soils**	**TOTAL Alternative Cost**
0.554	**A**	**031**	PAA Disinfection	$9,292,720					$9,292,720
0.648	**B**	**015, 016**	PAA Disinfection	$9,560,273	$1,304,540	$4,669,793			$15,534,606
2.019	**C**	**026, 027**	PAA Disinfection	$23,544,345	$1,125,166	$4,907,508			$29,577,018
1.389	**D**	**001, 003, 029**	PAA Disinfection	$9,757,252	$2,556,898	$6,547,820			$18,861,970
0.089	**E**	**005**	Tank @ 005	$7,077,128		$3,641,415		$222,500	$10,941,043
1.262	**F**	**006**	PAA Disinfection	$9,660,694					$9,660,694
1.909	**G**	**007, 010**	PAA Disinfection	$18,202,099	$525,077	$5,978,180			$24,705,355
0.387	**H**	**013, 014**	PAA Disinfection	$6,132,251					$6,132,251
0.324	**I**	**017**	Tank @ 017	$10,670,399	$176,113	$3,764,525	$251,100	$810,000	$15,672,137
2.627	**J**	**021, 022, 032**	PAA Disinfection	$9,663,151	$2,335,127	$13,993,809			$25,992,087
3.675	**K**	**025**	PAA Disinfection	$25,068,908					$25,068,908
0.708	**L**	**024**	PAA Disinfection	$9,423,336					$9,423,336
15.591				$148,052,556	$8,022,921	$43,503,049	$251,100	$1,032,500	$200,862,127
								Hybrid Storage/Disinfection, 8 overflows:	**$200,862,127**
								Including Alternative 3 System Changes (Alternative 6B):	**$249,862,127**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	**Outfall ID**	**Storage Required for 0 overflow events (MG)**	**Storage Required for 4 overflow events (MG)**	**Storage Required for 8 overflow events (MG)**	**Storage Required for 12 overflow events (MG)**	**Storage Required for 20 overflow events (MG)**	**Storage Required for 85% Capture in Paterson (MG)**
A	**031**	2.396	1.257	0.554	0.553	0.095	
B	**015**	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	**026, 027, 030**	8.885	3.837	2.019	1.986	1.040	
D	**001, 003, 029**	4.208	2.273	1.389	1.124	0.275	
E	**005**	0.325	0.229	0.089	0.071	0.008	
F	**006**	4.289	1.760	1.262	0.629	0.312	
G	**007, 010**	6.561	2.588	1.909	1.185	0.770	
H	**013**	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	**017**	1.184	0.389	0.324	0.185	0.083	
J	**021, 022, 032**	6.977	2.871	2.627	1.514	1.158	
K	**025**	13.890	5.624	3.675	3.020	1.527	1.500
L	**024**	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	**GROUP**	**Active Outfalls in Group**	**Alternative Option**	**Alternative Cost**	**Conveyance Pipe Cost**	**Pump System Cost**	**Acquisition/ Clearing Costs**	**Contaminated Soils**	**TOTAL Alternative Cost**
0.553	**A**	**031**	PAA Disinfection	$6,061,676					$6,061,676
0.642	**B**	**015, 016**	PAA Disinfection	$9,350,304	$1,304,540	$4,662,098			$15,316,941
1.986	**C**	**026, 027**	PAA Disinfection	$9,770,243	$1,125,166	$4,425,770			$15,321,178
1.124	**D**	**001, 029**	PAA Disinfection	$9,623,826	$2,556,898	$5,792,504			$17,973,228
0.071	**E**	**005**	Tank @ 005	$6,867,712		$3,631,201		$177,500	$10,676,414
0.629	**F**	**006**	Tank u/s of 006	$13,761,830		$3,861,533	$200,000	$1,572,500	$19,395,863
1.185	**G**	**007, 010**	PAA Disinfection	$9,599,248	$525,077	$5,094,012			$15,218,337
0.379	**H**	**013, 014**	PAA Disinfection	$6,112,588					$6,112,588
0.185	**I**	**017**	Tank @ 017	$8,600,879	$176,113	$3,690,738	$251,100	$462,500	$13,181,330
1.514	**J**	**021, 022, 032**	PAA Disinfection	$9,534,993	$2,335,127	$13,117,422			$24,987,541
3.020	**K**	**025**	PAA Disinfection	$24,596,301					$24,596,301
0.302	**L**	**024**	Tank u/s of 024	$9,543,923		$3,738,773		$755,000	$14,037,696
11.590				$123,423,522	$8,022,921	$48,014,051	$451,100	$2,967,500	$182,879,094
								Hybrid Storage/Disinfection, 12 overflows:	**$182,879,094**
								Including Alternative 3 System Changes (Alternative 7B):	**$231,879,094**

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	**031**	2.396	1.257	0.554	0.553	0.095	
B	**015**	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	**026, 027, 030**	8.885	3.837	2.019	1.986	1.040	
D	**001, 003, 029**	4.208	2.273	1.389	1.124	0.275	
E	**005**	0.325	0.229	0.089	0.071	0.008	
F	**006**	4.289	1.760	1.262	0.629	0.312	
G	**007, 010**	6.561	2.588	1.909	1.185	0.770	
H	**013**	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	**017**	1.184	0.389	0.324	0.185	0.083	
J	**021, 022, 032**	6.977	2.871	2.627	1.514	1.158	
K	**025**	13.890	5.624	3.675	3.020	1.527	1.500
L	**024**	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Alternative Option	Alternative Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
0.095	A	**031**	PAA Disinfection	$4,388,486					$4,388,486
0.240	B	**015, 016**	PAA Disinfection	$5,993,559	$1,304,540	$4,031,635			$11,329,734
1.040	C	**026, 027**	PAA Disinfection	$9,434,923	$1,125,166	$3,940,893			$14,500,982
0.275	D	**001, 029**	Tank @ 029	$10,200,034	$2,556,898	$8,131,989	$756,900	$687,500	$22,333,321
0.008	E	**005**	Tank @ 005	$6,867,712		$3,631,201		$20,000	$10,518,914
0.312	F	**006**	Tank u/s of 006	$9,835,285		$3,738,773	$200,000	$780,000	$14,554,058
0.770	G	**007, 010**	Tank u/s of 007	$14,421,248	$525,077	$7,576,459	$10,000	$1,925,000	$24,457,784
0.076	H	**013**	PAA Disinfection	$5,973,896					$5,973,896
0.083	I	**017**	Tank @ 017	$7,430,614	$176,113	$3,640,830	$251,100	$207,500	$11,706,158
1.158	J	**021, 022, 032**	PAA Disinfection	$9,332,748	$2,335,127	$11,577,765			$23,245,639
1.527	K	**025**	PAA Disinfection	$23,654,597					$23,654,597
0.087	L	**024**	Tank u/s of 024	$7,326,579		$3,652,905		$217,500	$11,196,985
5.671				$114,859,681	$8,022,921	$49,922,451	$1,218,000	$3,837,500	$177,860,553
								Hybrid Storage/Disinfection, 20 overflows:	**$177,860,553**
								Including Alternative 3 System Changes (Alternative 8B):	**$226,860,553**

PERACETIC ACID (PAA) DISINFECTION

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION & EQUIPMENT COST	ANNUAL O&M COST
5	$370,000	$10,000
25	$550,000	$100,000
100	$935,000	$208,000
250	$1,230,000	$450,000

Source: PVSC TGM 2018

Avg. Wet Events /yr	70

Source: Boomi Env.

TYP. DOSAGE (ppm)		
Secondary Effluent	0.5	1
Enhanced Primary	5	10
Raw Wastewater	10	20
PAA Cost **/lb**	$0.50	$0.70
PAA Cost **/gal** (if $0.60/lb)	$5.50	

Source: CH2M Hill, PNCWA 2009

	(ppm = mg/L)	(ppm = mg/L)	
	TSS in effluent	PAA Demand	
target TSS after disinfect	70	0.10	
level flow TSS	110	0.17	
	150	0.25	
first flush range	200	0.37	
first flush range	300	0.60	<--- ***conservatively use this dosage***
	500	1.00	
	700	1.40	
	950	2.00	
	1700	4.00	
	1850	4.40	

Source: PERAGreen Solutions, 2014

Peracetic Acid (PAA) Dosage & Costs

Active Outfalls in Group	Group	Peak 5-min CSO Flow (MGD)	Dosage (ppm = mg/L)	Required PAA (gal/day)	Cost ($/day)	Annual Dosage Cost ($/year)	Initial Capital Construction & Equip. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr PAA Lifespan Cost	Contingency for Primary Treatment*
031	**A**	113.37	0.60	516.967	$2,843.32	$199,032.37	$1,230,000	$6,852,000	$12,062,647	$27,553,016
015, 016, 028	**B**	87.75	0.60	400.140	$2,200.77	$154,053.90	$935,000	$3,167,000	$7,183,078	$18,329,997
026, 027, 030	**C**	225.66	0.60	1029.010	$5,659.55	$396,168.70	$1,230,000	$6,852,000	$16,005,374	$109,098,562
001, 003, 029	**D**	122.72	0.60	559.603	$3,077.82	$215,447.23	$1,230,000	$6,852,000	$12,390,945	$27,553,016
005	**E**	9.28	0.60	42.317	$232.74	$16,291.97	$550,000	$1,523,000	$2,398,839	$3,711,291
006	**F**	43.52	0.60	198.451	$1,091.48	$76,403.71	$935,000	$3,167,000	$5,630,074	$18,329,997
007, 010	**G**	102.76	0.60	468.586	$2,577.22	$180,405.46	$1,230,000	$6,852,000	$11,690,109	$27,553,016
013, 014	**H**	98.23	0.60	447.929	$2,463.61	$172,452.59	$935,000	$3,167,000	$7,551,052	$18,329,997
017	**I**	17.71	0.60	80.758	$444.17	$31,091.68	$550,000	$1,523,000	$2,694,834	$6,821,199
021, 022, 032	**J**	48.50	0.60	221.160	$1,216.38	$85,146.60	$935,000	$3,167,000	$5,804,932	$18,329,997
025	**K**	233.28	0.60	1063.757	$5,850.66	$409,546.37	$1,230,000	$6,852,000	$16,272,927	$109,098,562
024	**L**	36.57	0.60	166.759	$917.18	$64,202.29	$935,000	$3,167,000	$5,386,046	$18,329,997
									$105,070,857	**$403,038,645** +

*If needed, Primary Treatment costs assume construction of a FlexFilter unit and corresponding 20-yr O&M.

Conveyance Pipe Costs

Pipe Diam. (in)	Conveyance Pipe Needed (LF)	Conv. Pipe Construction Cost	Annual Conv. Pipe Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
30	2400	$1,200,000	$24,000	$365,448	$1,565,448
36	2000	$1,150,000	$23,000	$350,221	$1,500,221
72	1600	$1,960,000	$39,200	$596,898	$2,556,898
36	700	$402,500	$8,050	$122,577	$525,077
48	1000	$750,000	$15,000	$228,405	$978,405
42	1600	$1,040,000	$20,800	$316,722	$1,356,722
					$8,482,771 +

Pump System Costs

Expected CSO Flow (MGD)	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
17.13	$3,995,572	$235,000	$79,911	$4,795,156	$8,790,728
26.80	$5,589,359	$235,000	$111,787	$5,280,528	$10,869,888
52.86	$9,302,642	$235,000	$186,053	$6,411,372	$15,714,013
51.56	$9,130,522	$235,000	$182,610	$6,358,954	$15,489,476
17.23	$4,013,053	$235,000	$80,261	$4,800,480	$8,813,533
27.78	$5,741,959	$235,000	$114,839	$5,327,001	$11,068,961
					$70,746,599

Disinfection by group, 0 overflows: $587,338,873

Including Alternative 3 System Changes (Alternative 4C): $636,338,873

PRIMARY TREATMENT (FlexFilter)

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION	ANNU. O&M
10	$3,325,500	$25,336
25	$6,313,500	$33,342
30	$12,586,500	$37,973
100	$17,239,500	$71,616
200	$25,798,500	$115,224
450	$105,583,500	$230,844

Source: PVSC TGM 2018

Peracetic Acid (PAA) Dosage & Costs

Active Outfalls in Group	Group	Peak 5-min CSO Flow (MGD)	Dosage (ppm = mg/L)	Required PAA (gal/day)	Cost ($/day)	Annual Dosage Cost ($/year)	Initial Capital Construction & Equip. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr PAA Lifespan Cost	Contingency for Primary Treatment*
031	**A**	34.16	0.60	155.770	$856.73	$59,971.30	$935,000	$3,167,000	$5,301,426	$18,329,997
015, 016, ~~028~~	**B**	40.26	0.60	183.586	$1,009.72	$70,680.46	$935,000	$3,167,000	$5,515,609	$18,329,997
026, 027, ~~030~~	**C**	63.24	0.60	288.374	$1,586.06	$111,024.14	$935,000	$3,167,000	$6,322,483	$18,329,997
001, 003, 029	**D**	65.15	0.60	297.084	$1,633.96	$114,377.34	$935,000	$3,167,000	$6,389,547	$18,329,997
005	**E**	6.20	0.60	28.272	$155.50	$10,884.72	$550,000	$1,523,000	$2,290,694	$3,711,291
006	**F**	35.26	0.60	160.786	$884.32	$61,902.46	$935,000	$3,167,000	$5,340,049	$18,329,997
007, 010	**G**	53.65	0.60	244.644	$1,345.54	$94,187.94	$935,000	$3,167,000	$5,985,759	$18,329,997
013, 014	**H**	31.13	0.60	141.953	$780.74	$54,651.83	$935,000	$3,167,000	$5,195,037	$18,329,997
017	**I**	8.38	0.60	38.213	$210.17	$14,711.93	$550,000	$1,523,000	$2,367,239	$3,711,291
021, 022, 032	**J**	37.30	0.60	170.088	$935.48	$65,483.88	$935,000	$3,167,000	$5,411,678	$18,329,997
025	**K**	138.20	0.60	630.192	$3,466.06	$242,623.92	$1,230,000	$6,852,000	$12,934,478	$27,553,016
024	**L**	22.08	0.60	100.685	$553.77	$38,763.65	$550,000	$1,523,000	$2,848,273	$6,821,199
									$65,902,271	**$188,436,772** +

*If needed, Primary Treatment costs assume construction of a FlexFilter unit and corresponding 20-yr O&M.

Conveyance Pipe Costs

Pipe Diam. (in)	Conveyance Pipe Needed (LF)	Conv. Pipe Construction Cost	Annual Conv. Pipe Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
30	2000	$1,000,000	$20,000	$304,540	$1,304,540
36	1500	$862,500	$17,250	$262,666	$1,125,166
72	1600	$1,960,000	$39,200	$596,898	$2,556,898
36	700	$402,500	$8,050	$122,577	$525,077
48	1000	$750,000	$15,000	$228,405	$978,405
42	1600	$1,040,000	$20,800	$316,722	$1,356,722
					$7,846,808 +

Pump System Costs

Expected CSO Flow (MGD)	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
2.11	$830,755	$235,000	$16,615	$3,831,343	$4,662,098
8.89	$2,443,078	$235,000	$48,862	$4,322,360	$6,765,437
33.38	$6,589,852	$235,000	$131,797	$5,585,219	$12,175,071
24.24	$5,183,945	$235,000	$103,679	$5,157,064	$10,341,009
11.64	$2,990,375	$235,000	$59,808	$4,489,034	$7,479,409
22.85	$4,959,359	$235,000	$99,187	$5,088,668	$10,048,028
					$51,471,051

Disinfection by group, 4 overflows: $313,656,902

Including Alternative 3 System Changes (Alternative 5C): $362,656,902

PERACETIC ACID (PAA) DISINFECTION

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION & EQUIPMENT COST	ANNUAL O&M COST
5	$370,000	$10,000
25	$550,000	$100,000
100	$935,000	$208,000
250	$1,230,000	$450,000

Source: PVSC TGM 2018

Avg. Wet Events /yr	70

Source: Boomi Env.

TYP. DOSAGE (ppm)		
Secondary Effluent	0.5	1
Enhanced Primary	5	10
Raw Wastewater	10	20
PAA Cost **/lb**	$0.50	$0.70
PAA Cost **/gal** (if $0.60/lb)	$5.50	

Source: CH2M Hill, PNCWA 2009

	(ppm = mg/L)	(ppm = mg/L)	
	TSS in effluent	PAA Demand	
target TSS after disinfect	70	0.10	
level flow TSS	110	0.17	
	150	0.25	
first flush range	200	0.37	
first flush range	300	0.60	*<--- conservatively use this dosage*
	500	1.00	
	700	1.40	
	950	2.00	
	1700	4.00	
	1850	4.40	

Source: PERAGreen Solutions, 2014

Peracetic Acid (PAA) Dosage & Costs

Active Outfalls in Group	Group	Peak 5-min CSO Flow (MGD)	Dosage (ppm = mg/L)	Required PAA (gal/day)	Cost ($/day)	Annual Dosage Cost ($/year)	Initial Capital Construction & Equip. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr PAA Lifespan Cost	Contingency for Primary Treatment*
031	A	11.35	0.60	51.756	$284.66	$19,926.06	$550,000	$1,523,000	$2,471,521	$6,821,199
015, 016, ~~028~~	B	18.97	0.60	86.503	$475.77	$33,303.73	$550,000	$1,523,000	$2,739,075	$6,821,199
026, 027, ~~030~~	C	31.68	0.60	144.461	$794.53	$55,617.41	$935,000	$3,167,000	$5,214,348	$18,329,997
001, 003, 029	D	24.58	0.60	112.085	$616.47	$43,152.65	$550,000	$1,523,000	$2,936,053	$6,821,199
005	E	3.34	0.60	15.230	$83.77	$5,863.70	$370,000	$152,000	$639,274	$3,711,291
006	F	21.83	0.60	99.545	$547.50	$38,324.75	$550,000	$1,523,000	$2,839,495	$6,821,199
007, 010	G	26.64	0.60	121.478	$668.13	$46,769.18	$935,000	$3,167,000	$5,037,384	$13,164,715
013, ~~014~~	H	9.91	0.60	45.190	$248.54	$17,398.00	$550,000	$1,523,000	$2,420,960	$3,711,291
017	I	5.55	0.60	25.308	$139.19	$9,743.58	$550,000	$1,523,000	$2,267,872	$3,711,291
021, 022, 032	J	21.90	0.60	99.864	$549.25	$38,447.64	$550,000	$1,523,000	$2,841,953	$6,821,199
025	K	75.10	0.60	342.456	$1,883.51	$131,845.56	$935,000	$3,167,000	$6,738,911	$18,329,997
024	L	15.07	0.60	68.719	$377.96	$26,456.89	$550,000	$1,523,000	$2,602,138	$6,821,199
									$38,748,983	**$101,885,774** +

*If needed, Primary Treatment costs assume construction of a FlexFilter unit and corresponding 20-yr O&M.

Conveyance Pipe Costs

Pipe Diam. (in)	Conveyance Pipe Needed (LF)	Conv. Pipe Construction Cost	Annual Conv. Pipe Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
30	2000	$1,000,000	$20,000	$304,540	$1,304,540
36	1500	$862,500	$17,250	$262,666	$1,125,166
72	1600	$1,960,000	$39,200	$596,898	$2,556,898
36	700	$402,500	$8,050	$122,577	$525,077
48	1000	$750,000	$15,000	$228,405	$978,405
42	1600	$1,040,000	$20,800	$316,722	$1,356,722
					$7,846,808 +

Pump System Costs

Expected CSO Flow (MGD)	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
2.13	$836,653	$235,000	$16,733	$3,833,139	$4,669,793
2.77	$1,018,875	$235,000	$20,377	$3,888,633	$4,907,508
8.09	$2,276,262	$235,000	$45,525	$4,271,558	$6,547,820
6.09	$1,839,602	$235,000	$36,792	$4,138,577	$5,978,180
7.86	$2,227,552	$235,000	$44,551	$4,256,724	$6,484,276
11.76	$3,013,467	$235,000	$60,269	$4,496,066	$7,509,533
					$36,097,109

Disinfection by group, 8 overflows:	**$184,578,674**
Including Alternative 3 System Changes (Alternative 6C):	**$233,578,674**

PRIMARY TREATMENT (FlexFilter)

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION	ANNU. O&M
10	$3,325,500	$25,336
25	$6,313,500	$33,342
30	$12,586,500	$37,973
100	$17,239,500	$71,616
200	$25,798,500	$115,224
450	$105,583,500	$230,844

Source: PVSC TGM 2018

Peracetic Acid (PAA) Dosage & Costs

Active Outfalls in Group	Group	Peak 5-min CSO Flow (MGD)	Dosage (ppm = mg/L)	Required PAA (gal/day)	Cost ($/day)	Annual Dosage Cost ($/year)	Initial Capital Construction & Equip. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr PAA Lifespan Cost	Contingency for Primary Treatment*
031	A	7.90	0.60	36.024	$198.13	$13,869.24	$550,000	$1,523,000	$2,350,385	$3,711,291
015, 016, ~~028~~	B	12.99	0.60	59.234	$325.79	$22,805.24	$550,000	$1,523,000	$2,529,105	$6,821,199
026, 027, ~~030~~	C	24.95	0.60	113.772	$625.75	$43,802.22	$550,000	$1,523,000	$2,949,044	$6,821,199
001, 003, 029	D	20.78	0.60	94.757	$521.16	$36,481.37	$550,000	$1,523,000	$2,802,627	$6,821,199
005	E	2.61	0.60	11.902	$65.46	$4,582.12	$370,000	$152,000	$613,642	$3,711,291
006	F	18.58	0.60	84.725	$465.99	$32,619.05	$550,000	$1,523,000	$2,725,381	$6,821,199
007, 010	G	20.08	0.60	91.565	$503.61	$35,252.45	$550,000	$1,523,000	$2,778,049	$6,821,199
013, ~~014~~	H	9.35	0.60	42.636	$234.50	$16,414.86	$550,000	$1,523,000	$2,401,297	$3,711,291
017	I	4.36	0.60	19.882	$109.35	$7,654.42	$370,000	$152,000	$675,088	$3,711,291
021, 022, 032	J	18.25	0.60	83.220	$457.71	$32,039.70	$550,000	$1,523,000	$2,713,794	$6,821,199
025	K	61.64	0.60	281.078	$1,545.93	$108,215.18	$935,000	$3,167,000	$6,266,304	$18,329,997
024	L	10.01	0.60	45.646	$251.05	$17,573.56	$550,000	$1,523,000	$2,424,471	$6,821,199
									$31,229,188	**$80,923,552** +

*If needed, Primary Treatment costs assume construction of a FlexFilter unit and corresponding 20-yr O&M.

Conveyance Pipe Costs

Pipe Diam. (in)	Conveyance Pipe Needed (LF)	Conv. Pipe Construction Cost	Annual Conv. Pipe Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
30	2000	$1,000,000	$20,000	$304,540	$1,304,540
36	1500	$862,500	$17,250	$262,666	$1,125,166
72	1600	$1,960,000	$39,200	$596,898	$2,556,898
36	700	$402,500	$8,050	$122,577	$525,077
48	1000	$750,000	$15,000	$228,405	$978,405
42	1600	$1,040,000	$20,800	$316,722	$1,356,722
					$7,846,808 +

Pump System Costs

Expected CSO Flow (MGD)	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
2.11	$830,755	$235,000	$16,615	$3,831,343	$4,662,098
1.52	$649,596	$235,000	$12,992	$3,776,173	$4,425,770
5.47	$1,697,272	$235,000	$33,945	$4,095,232	$5,792,504
3.30	$1,161,840	$235,000	$23,237	$3,932,172	$5,094,012
6.46	$1,922,805	$235,000	$38,456	$4,163,916	$6,086,721
9.89	$2,646,416	$235,000	$52,928	$4,384,285	$7,030,701
					$33,091,805

Disinfection by group, 12 overflows:	**$153,091,354**
Including Alternative 3 System Changes (Alternative 7C):	**$202,091,354**

PERACETIC ACID (PAA) DISINFECTION

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION & EQUIPMENT COST	ANNUAL O&M COST
5	$370,000	$10,000
25	$550,000	$100,000
100	$935,000	$208,000
250	$1,230,000	$450,000

Source: PVSC TGM 2018

Avg. Wet Events /yr	70

Source: Boomi Env.

TYP. DOSAGE (ppm)		
Secondary Effluent	0.5	1
Enhanced Primary	5	10
Raw Wastewater	10	20
PAA Cost **/lb**	$0.50	$0.70
PAA Cost **/gal** (if $0.60/lb)	$5.50	

Source: CH2M Hill, PNCWA 2009

	(ppm = mg/L)	(ppm = mg/L)	
	TSS in effluent	PAA Demand	
target TSS after disinfect	70	0.10	
level flow TSS	110	0.17	
	150	0.25	
first flush range	200	0.37	
first flush range	300	0.60	*<--- conservatively use this dosage*
	500	1.00	
	700	1.40	
	950	2.00	
	1700	4.00	
	1850	4.40	

Source: PERAGreen Solutions, 2014

Peracetic Acid (PAA) Dosage & Costs

Active Outfalls in Group	Group	Peak 5-min CSO Flow (MGD)	Dosage (ppm = mg/L)	Required PAA (gal/day)	Cost ($/day)	Annual Dosage Cost ($/year)	Initial Capital Construction & Equip. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr PAA Lifespan Cost	Contingency for Primary Treatment*
031	A	4.42	0.60	20.155	$110.85	$7,759.75	$370,000	$152,000	$677,195	$3,711,291
015, 016, ~~028~~	B	5.96	0.60	27.178	$149.48	$10,463.38	$550,000	$1,523,000	$2,282,268	$3,711,291
026, 027, ~~030~~	C	15.40	0.60	70.224	$386.23	$27,036.24	$550,000	$1,523,000	$2,613,725	$6,821,199
001, 003, 029	D	8.24	0.60	37.574	$206.66	$14,466.14	$550,000	$1,523,000	$2,362,323	$3,711,291
~~005~~	E	0.00	0.00	0.000	$0.00	$0.00	$0	$0	$0	$0
006	F	9.14	0.60	41.678	$229.23	$16,046.18	$550,000	$1,523,000	$2,393,924	$3,711,291
007, 010	G	9.81	0.60	44.734	$246.03	$17,222.44	$550,000	$1,523,000	$2,417,449	$3,711,291
013, ~~014~~	H	5.40	0.60	24.624	$135.43	$9,480.24	$550,000	$1,523,000	$2,262,605	$3,711,291
017	I	2.44	0.60	11.126	$61.20	$4,283.66	$370,000	$152,000	$607,673	$3,711,291
021, 022, 032	J	12.49	0.60	56.954	$313.25	$21,927.44	$550,000	$1,523,000	$2,511,549	$6,821,199
025	K	34.82	0.60	158.779	$873.29	$61,129.99	$935,000	$3,167,000	$5,324,600	$18,329,997
024	L	6.52	0.60	29.731	$163.52	$11,446.51	$550,000	$1,523,000	$2,301,930	$3,711,291
*If needed, Primary Treatment costs assume construction of a FlexFilter unit and corresponding 20-yr O&M.									**$25,755,240**	**$61,662,724** +

Conveyance Pipe Costs

Pipe Diam. (in)	Conveyance Pipe Needed (LF)	Conv. Pipe Construction Cost	Annual Conv. Pipe Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
30	2000	$1,000,000	$20,000	$304,540	$1,304,540
36	1500	$862,500	$17,250	$262,666	$1,125,166
72	1600	$1,960,000	$39,200	$596,898	$2,556,898
36	700	$402,500	$8,050	$122,577	$525,077
48	1000	$750,000	$15,000	$228,405	$978,405
42	1600	$1,040,000	$20,800	$316,722	$1,356,722
					$7,846,808 +

Pump System Costs

Expected CSO Flow (MGD)	Pump Station Construction Cost	Annual Pump Sta. Operation Cost	Annual Pump Sta. Maint. Cost	Present O&M Value (20-yr Life)	TOTAL 20-yr Lifespan Cost
0.66	$347,471	$235,000	$6,949	$3,684,164	$4,031,635
0.49	$277,912	$235,000	$5,558	$3,662,980	$3,940,893
1.48	$636,733	$235,000	$12,735	$3,772,256	$4,408,988
0.10	$84,384	$235,000	$1,688	$3,604,043	$3,688,428
5.17	$1,626,967	$235,000	$32,539	$4,073,822	$5,700,789
5.75	$1,762,024	$235,000	$35,240	$4,114,952	$5,876,976
					$27,647,709

Disinfection by group, 20 overflows:	**$122,912,481**
Including Alternative 3 System Changes (Alternative 8C):	**$171,912,481**

PRIMARY TREATMENT (FlexFilter)

PRELIM. CONSTRUCTION

FLOW (MGD)	CONSTRUCTION	ANNU. O&M
10	$3,325,500	$25,336
25	$6,313,500	$33,342
30	$12,586,500	$37,973
100	$17,239,500	$71,616
200	$25,798,500	$115,224
450	$105,583,500	$230,844

Source: PVSC TGM 2018

Volume Not Captured after Alternative 3 (including Sewer Separation, Relief Sewer + GI)							
GROUP	Outfall ID	Storage Required for 0 overflow events (MG)	Storage Required for 4 overflow events (MG)	Storage Required for 8 overflow events (MG)	Storage Required for 12 overflow events (MG)	Storage Required for 20 overflow events (MG)	Storage Required for 85% Capture in Paterson (MG)
A	031	2.396	1.257	0.554	0.553	0.095	
B	015	0.111	0.026	0.017	0.016	0.003	
	016	1.628	0.905	0.631	0.626	0.237	
	028	0.080					
C	026, 027, 030	8.885	3.837	2.019	1.986	1.040	
D	001, 003, 029	4.208	2.273	1.389	1.124	0.275	
E	005	0.325	0.229	0.089	0.071	0.008	
F	006	4.289	1.760	1.262	0.629	0.312	
G	007, 010	6.561	2.588	1.909	1.185	0.770	
H	013	1.562	0.884	0.369	0.361	0.076	
	014	0.114	0.025	0.018	0.018		
I	017	1.184	0.389	0.324	0.185	0.083	
J	021, 022, 032	6.977	2.871	2.627	1.514	1.158	
K	025	13.890	5.624	3.675	3.020	1.527	1.500
L	024	2.659	0.954	0.708	0.302	0.087	
	Systemwide	**54.869**	**23.622**	**15.591**	**11.590**	**5.671**	**1.500**

Storage Required (MG)	GROUP	Active Outfalls in Group	Storage Option	Storage Option Cost	Conveyance Pipe Cost	Pump System Cost	Acquisition/ Clearing Costs	Contaminated Soils	TOTAL Alternative Cost
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	I								
	J								
1.500	K	025	Tunnel	$23,854,802		$645,529		$3,750,000	$28,250,331
	L								
1.500				$23,854,802	$0	$645,529	$0	$3,750,000	$28,250,331
								Storage by group, 85% capture:	**$28,250,331**
								Including Alternative 3 System Changes (Alternative 9):	**$77,250,331**

APPENDIX I

Quarterly CSO Construction Related Activities

City of Paterson, 4th Quarter 2015 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects**
    - **CSO-029A Screening Facility, Memorial Drive at Paterson Street**
        - **Contractor has mobilized and commenced activities at the site**

- **In-House Major Projects**
    - **East 27th Street (19th Avenue - Market Street) – Replace 590 L.F. of 8" concrete sewer with 590 L.F. of 8" PVC sewer. (Complete)**
    - **Union Avenue (Ryerson Avenue to Manchester Avenue) - Replace 268 L.F. of 18" concrete sewer with 268 L.F. of 18" PVC sewer and 40 L.F. of 15" concrete branch sewer with 40 L.F. of 15" PVC sewer. (Complete)**
    - **Summer Street (Montgomery Street - Lawrence Street) - Replace 369 L.F. of 18" concrete sewer with 369 L.F. of 18" PVC sewer and rehabilitate 257 L.F. of 18" concrete sewer with 257 L.F. of CIPP liner. (Complete)**
    - **6th Avenue (East 7th Street - Wait Street) – Spot repairs of 12" concrete pipe using 12" PVC sewer followed by installation of 684 L.F. of 12" CIPP liner. (Complete)**
    - **Market Street (East 31st Street - East 32nd Street) - Replace 195 L.F. of 12" concrete sewer with 195 L.F. of 12" PVC sewer, spot repairs of 12" concrete pipe using 12" PVC sewer followed by installation of 350 L.F. of 12" CIPP liner. (Complete)**
    - **Trenton Avenue, (Alabama Avenue - Maryland Avenue) – Replace 13 L.F. of 15" concrete sewer with 15 L.F. of 15" PVC sewer and rehabilitate 236 L.F. of 15" concrete sewer with 236 L.F. of CIPP liner. (Complete)**
    - **East 30th Street (20th Avenue – 19th Avenue beneath NYS&W RR) - Spot repairs of 27"x18" Egg-Shaped concrete pipe followed by installation of 690 L.F. 27"x18" Egg-Shaped CIPP liner. (In Progress)**
    - **East 19th Street (20th Avenue - Cedar Street) - Spot repairs of lateral connection to an 18" x 24" Brick Egg-Shaped sewer followed by installation of 528 L.F. of 18" x 24" CIPP liner. (In Progress)**
    - **East 5th Street (5th Avenue - Branch Street) Replace 102 L.F. of 24" VCP sewer with 102 L.F. of 24" PVC sewer and rehabilitate 346 L.F. of 18" and 24" VCP sewer with 346 L.F. of CIPP liner. (In Progress)**

City of Paterson, 1st Quarter 2016 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects**
  - **CSO-029A Screening Facility, Memorial Drive at Paterson Street**
    - **Contractor has mobilized and commenced activities at the site**
- **In-House Major Projects**
  - **Lyon Street (North York Street – Van Blarcom Street) – Replace 118 L.F. of 18" concrete sewer with 118 L.F. of 18" PVC sewer. (Complete)**
  - **Putnam Street (East of Intersection of Rosa Parks Avenue) - Abandon 270 L.F. of 18" concrete sewer redirecting flow into parallel 36" sewer. (Complete)**
  - **East 5th Street (5th Avenue - Branch Street) Rehabilitate 194 L.F. of 18" VCP and 154 L.F. of 24" VCP with CIPP liner. (Complete)**
  - **East 30th Street (20th Avenue – 19th Avenue beneath NYS&W RR) - Spot repairs of 27"x18" Egg-Shaped concrete pipe followed by installation of 685 L.F. 27"x18" Egg-Shaped CIPP liner. (Complete)**
  - **East 19th Street (20th Avenue - Cedar Street) - Spot repairs of lateral connection to an 18" x 24" Brick Egg-Shaped sewer followed by installation of 527 L.F. of 18" x 27" CIPP liner. (Complete)**
  - **21st Avenue, (Madison Avenue – Lewis Street) – Rehabilitate 290 L.F. of 12" concrete sewer and 118 L.F. of 18" Concrete and VCP sewer main with CIPP liner. (Complete)**
  - **Renewal or replacement of 14 service laterals from main to curb.**

City of Paterson, 2nd Quarter 2016 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
  - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
    - **Contractor has mobilized and commenced activities at the site**
    - **Closed sheeting has been installed preparatory to excavation work**
- **In-House Managed Main and Lateral Repair Projects**
  - **Buffalo Avenue (Multiple spot repairs of main and laterals to mitigate against main surcharging) – Replace 127 L.F. of 8" VCP sewer with PVC sewer and repair 17 lateral points of connection with tees and 84 L.F. of 6" PVC sewer lateral. (Complete)**
  - **New storm water inlets (2) constructed at East 20th Street and 22nd Avenue to receive excess flow from onsite stormwater retention system at New School 16. (Complete)**
  - **Three defective storm water inlets replaced at the following locations, (Complete);**
    - **Intersection of Jefferson Street and Garfield Street**
    - **599 East 30th Street**
    - **Levine Street at intersection of Sussex Street**
  - **New City Yard, Easement to Jelsma Street, redirect Lawrence to Montgomery to remove flow in main from under privately owned building by constructing 298 LF of 12" PVC sewer, included replacement of 4 defective inlets. (Complete)**
  - **Wayne Avenue (Union Avenue - James Street) – Replace 269 L.F. of 15" concrete sewer with 269 L.F. of 15" PVC sewer, included the replacement of 1 defective inlet. (Complete)**
  - **Renewal or replacement of 9 service laterals. (Complete)**
  - **River Street (4th Avenue – 5th Avenue) – Replace or renew 405 L.F. of 12" and 15" concrete sewer including CIPP where appropriate. (In Progress)**
  - **Lower Main Street (Memorial Drive – Passaic River Bridge) – Replace or renew 125 L.F. of 24" storm sewer including separation of stormwater inlets from combined sewer system and lateral repairs. (In Progress)**
  - **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer. (In Progress)**

City of Paterson, 2nd Quarter 2016 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

- **In-House Managed Projects, Other;**
  - **Factory rehabilitation of V2-1, V1-8 and V1-9 Mechanical Screen Rake Arms. (In Progress)**
    - **Rake arms removed and sent to manufacturer for factory rehabilitation.**
    - **Arms have been returned and await reinstallation by contractor.**

City of Paterson, 3rd Quarter 2016 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Contractor has mobilized and commenced activities at the site**
        - **Closed sheeting has been installed preparatory to excavation work**
        - **Excavation work has commenced**

- **In-House Managed Main and Lateral Repair Projects**
    - **Straight Street, between 16th Avenue and Pearl Street, Replace 160 LF of 18” sewer main. Multiple spot repairs of branch basin laterals and manhole replacement. (Complete)**
    - **Three defective storm water inlets replaced and basin laterals renewed at the following locations, (Complete);**
        - **(2) at 114 North Main Street 599 East 30th Street**
        - **(1) at 11 John Street**
    - **Renewal or replacement of 7 service laterals. (Complete)**
    - **River Street (4th Avenue – 5th Avenue) – Replace or renew 405 L.F. of 12” and 15” concrete sewer including CIPP where appropriate. (Complete)**
    - **Lower Main Street (Memorial Drive – Passaic River Bridge) – Replace or renew 125 L.F. of 24” storm sewer including separation of stormwater inlets from combined sewer system and lateral repairs. (Complete)**
    - **River Street, between Bridge Street & Tyler Street Replace – Slip line 537 L.F. of defective 30” brick main with 16” HDPE pipe. Replace collapsed and defective manholes and the replacement of 1 defective inlet. (Complete)**
    - **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80” outfall sewer by means of slip lining. (In Progress)**
    - **A-1 Trunk Sewer from Totowa Avenue to Passaic River Crossing in Westside Park - Replace approximately 937 L.F. of 30” and 36” sewer main. (In Progress)**
    - **Wayne Avenue (Totowa Avenue – Liberty Street) – Replace approximately 386 L.F. of 15” concrete sewer with 386 L.F. of 8” PVC sewer and 390 L.F. of 18” stormwater main including the replacement of 6 defective inlets and basin laterals. (In Progress)**
    - **East 23rd Street, between Market Street and 20th Avenue – Replace or renewal by means of CIPP lining 665 L.F. of 18” concrete sewer main, including the replacement of 1 defective inlet and basin lateral. (In Progress)**

City of Paterson, 3rd Quarter 2016 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

- **In-House Managed Projects, Other;**
    - **Factory rehabilitation of V2-1, V1-8 and V1-9 Mechanical Screen Rake Arms. (Complete)**

City of Paterson, 4th Quarter 2016 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Excavation work has been completed.**
        - **Form work and reinforcing steel being placed.**
- **In-House Managed Main and Lateral Repair Projects**
    - **Madison Avenue, between Market Street and 19th Avenue, - Replace approximately 103 L.F. of 15" sewer main, construct a receiver manhole and repair/reconnect defective stormwater laterals. (Complete)**
    - **Renewal or replacement of 4 service laterals. (Complete)**
    - **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)**
    - **A-1 Trunk Sewer from Totowa Avenue to Passaic River Crossing in Westside Park - Replace approximately 937 L.F. of 30" and 36" sewer main. (In Progress)**
    - **Wayne Avenue (Totowa Avenue – Liberty Street) – Replace approximately 386 L.F. of 15" concrete sewer with 386 L.F. of 8" PVC sewer and 390 L.F. of 18" stormwater main including the replacement of 6 defective inlets and basin laterals. (Complete)**
    - **East 23rd Street, between Market Street and 20th Avenue – Replace or renewal by means of CIPP lining 665 L.F. of 18" concrete sewer main, including the replacement of 1 defective inlet and basin lateral. Pipe laying operations are complete, final reach to 19th Avenue interceptor awaits CIPP lining. (In Progress)**
- **In-House Managed Projects, Other;**
    - **Rehabilitation of CSO-016 Mechanical Screening System in design.**

Combined Sewer Overflow (CSO) Construction Related Activities Reported to PVSC for the 1st Quarter 2017

Paterson – as reported by the City of Paterson

- Solids and Floatables Control Projects, Outside Consultant
  - Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)
    - Excavation work has been completed.
    - Form work and reinforcing steel being placed.
    - Below grade cast in place structure has been poured.
    - Work on precast diversion tunnels has begun

- In-House Managed Main and Lateral Repair Projects
  - Renewal or replacement of 7 service laterals. (Complete)
  - CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)
  - A-1 Trunk Sewer from Totowa Avenue to Passaic River Crossing in Westside Park - Replace approximately 937 L.F. of 30" and 36" sewer main. (Completed)
  - East 23rd Street, between Market Street and 20th Avenue – Replace or renewal by means of CIPP lining 665 L.F. of 18" concrete sewer main, including the replacement of 1 defective inlet and basin lateral. Pipe laying operations are complete, final reach to 19th Avenue interceptor awaits CIPP lining. (In Progress)
  - Rehabilitation of 20 manholes by means of epoxy lining on River Street and Straight Street (in Progress)

- In-House Managed Projects, Other;
  - Rehabilitation of CSO-016 Mechanical Screening System in design.

Combined Sewer Overflow (CSO) Construction Related Activities Reported to PVSC for the 2nd Quarter 2017

Paterson – as reported by the City of Paterson

- Solids and Floatables Control Projects, Outside Consultant
    - Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)
        - Excavation work has been completed.
        - Below grade cast in place structure is complete.
        - Precast diversion tunnels have been completed.
        - Awaiting delivery of mechanical screening equipment and controls.

- In-House Managed Main and Lateral Repair Projects
    - Renewal or replacement of 8 service laterals. (Completed)
    - CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)
    - 16th Avenue from Straight Street to Madison Avenue, project is as follows:
        - Completed 98 spot repairs of various size sewer mains, (8" thru 18"), totaling 105 LF of main and including replacement of 4 defective manholes.
        - A total of 48 point of connection lateral repairs to prepare the main line for CIPP lining.
        - Renewal of 4 laterals from main to curb with new cleanouts.
        - Replacement of 4 collapsed inlets
        - Replacement of 187 LF of inlet laterals, (8" and 10"), 14 inlet lateral repairs in total.
        - CIPP lining of approximately 3225 LF of mainline sewer is scheduled for completion by September 1.
    - East 23rd Street, between Market Street and 20th Avenue – Replace or renewal by means of CIPP lining 665 L.F. of 18" concrete sewer main, including the replacement of 1 defective inlet and basin lateral. Pipe laying operations are complete, final reach to 19th Avenue interceptor CIPP lining. (Completed)

  - Rehabilitation of 20 manholes by means of epoxy lining on River Street and Straight Street (Completed)
  - Jersey Street replacement of 2 inlets and inlet laterals. (Completed)
  - Replacement of 2 defective manhole frames and covers. (Completed)
  - East 42nd Street between 18th and 19th Avenue, replacement of 134 LF of 12" defective sewer main and 33 LF of defective 10" storm drain. (Completed)
  - Replacement of 5 LF of defective 8" sewer main and a defective manhole at Redwood Avenue. (Completed)

- In-House Managed Projects, Other;
  - Rehabilitation of CSO-016 Mechanical Screening System in design. (In Progress)

City of Paterson, 3rd Quarter 2017 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

City of Paterson:

- Solids and Floatables Control Projects, Outside Consultant
  - Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)
    - Excavation work has been completed.
    - Below grade cast in place structure is complete.
    - Precast diversion tunnels have been completed.
    - Mechanical screening equipment and controls have been received and are presently being installed.
- In-House Managed Main and Lateral Repair Projects
  - Renewal or replacement of 11 service laterals. (Completed)
  - Installation of approximately 120 LF of 12" stormwater main to relieve a drainage issue at 129 Temple Street (Completed)
  - 23rd Avenue between East 24th and East 25th Street, replacement of 204 LF of defective 8" sewer main. (Completed)
  - Paterson Avenue between Union Avenue and James Street, replacement of 250 LF of defective 12" sewer main. (Completed)
  - 16th Avenue from Straight Street to Madison Avenue, project is as follows:
    - CIPP lining of approximately 2677 LF of mainline sewer. (Completed)
    - Repairs to existing manholes. (Completed)
    - Epoxy coating of manholes is scheduled for completion by December 1st. (In Progress)
  - East 12th Street between 5th Avenue and Dead End, replacement of 406 LF of defective 12" sewer main. (In Progress)
  - East 24th Street between 18th Avenue and 19th Avenue, spot repairs and renewal or replacement service laterals in advance of installation of approximately 642 LF of 12" CIPP. (In Progress)
  - Straight Street between Park Avenue and Essex Street, spot repairs and renewal or replacement service laterals in advance of installation of approximately 800 LF of 12" & 18" CIPP. (In Progress)
  - CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)
- In-House Managed Projects, Other;
  - Rehabilitation of CSO-016 Mechanical Screening System in design. (In Progress)

City of Paterson, 4th Quarter 2017 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Excavation work has been completed.**
        - **Below grade cast in place structure is complete.**
        - **Precast diversion tunnels have been completed.**
        - **Mechanical screening equipment and controls have been received and are presently being installed.**
        - **Project has been delayed by unresolved utility conflicts. Engineer is addressing possible change orders.**
- **In-House Managed Main and Lateral Repair Projects**
    - **Renewal or replacement of 4 service laterals. (Completed)**
    - **Linwood Avenue at the intersection of Union Avenue**
        - **Replaced 49 LF of defective 18" sewer main.**
        - **Replaced 15 LF of defective 15" basin lateral.**
    - **16th Avenue from Straight Street to Madison Avenue, project is as follows:**
        - **Epoxy coating of manholes is scheduled for completion by December 1st. (Completed)**
    - **Eagle Avenue at Knickerbocker Avenue**
        - **Excavate and spot repair of manhole and approaching inlet piping followed by full manhole rehabilitation from the interior including epoxy coating.**
    - **Carbon Street between North 9th Street & Burhans Avenue**
        - **Replace collapsed manhole and reinstate approach piping, renew a collapsed lateral and install a cleanout**
    - **Presidential Blvd. between Piercy Street and Hudson Street**
        - **Spot repair of 12 LF of 8" collapsed main.**
    - **East 19th Street between Market Street and Park Avenue. (Completed)**
        - **Replace 815 LF of 15" sewer main**
    - **East 24th Street between 18th Avenue and 19th Avenue**
        - **Spot repairs of defective main, repair or replacement of defective manholes and repair or replacement of 25 concrete laterals, including 17 cleanouts, in preparation for CIPP lining of approximately 600 LF of 12" concrete sewer main. (Completed).**
        - **CIPP scheduled for 2018.**

City of Paterson, 4th Quarter 2017 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson: Continued

- **East 38th St. between Market Street and 21st Avenue**
    - **Replace 97 LF of defective 15" sewer main.**
    - **Renew two service laterals.**

Park Avenue at the Intersection of East 21st Street

- **Replacement of collapsed mainline tee and lateral.**

- **Straight Street between Park Avenue and Essex Street, spot repairs and renewal or replacement service laterals in advance of installation of approximately 800 LF of 12" & 18" CIPP. (In Progress, project will be completed in Spring)**

- **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)**

- **In-House Managed Projects, Other;**
    - **Rehabilitation of CSO-016 Mechanical Screening System in design. (In Progress)**

City of Paterson, 1st Quarter 2018 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **The City has issued an Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals are due on May 8, 2018.**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Excavation work has been completed.**
        - **Below grade cast in place structure is complete.**
        - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
        - **Mechanical screening equipment and controls have been received and are presently being installed.**
        - **Project is progressing but has been slowed by utility conflicts and contaminated soils. Engineer is addressing a proposed change order to resolve the utility conflicts to move the project to completion.**

- **In-House Managed Main and Lateral Repair Projects**
    - **Renewal or replacement of 4 service laterals. (Completed)**
    - **Linwood Avenue between Union Avenue and Molly Ann's Brook (In Progress)**
        - **Spot repairs of 890 LF of 15" sewer main in advance of CIPP lining.**
    - **Broadway between Curtis Place and West Broadway (In Progress)**
        - **Replaced 12 LF of defective 8". 10" & 12" sewer main.**
        - **Replaced 2 defective manholes.**
    - **River Street between 3rd and 4th Avenues (Completed)**
        - **Replaced 668 LF of defective 15" sewer main.**
        - **Replaced 7.5 LF of defective 8" sewer main.**
        - **Replaced 4 defective manholes.**
        - **Replaced 33 LF of defective 8" basin lateral.**
        - **Replaced 20 LF of defective 6" service laterals.**
        - **Replaced one collapsed stormwater inlet.**
    - **Prince Street between Slater Street and Green Street (In Progress)**
        - **Began replacement of 208 LF of defective 18" sewer main.**
        - **Three (3) defective manholes.**
        - **Prepped for CIPP lining of 190 LF of defective 18" sewer main for CIPP. Scheduled for 2nd quarter.**
    - **Cumberland Avenue, between Union Avenue and Totowa Border (In Progress)**
        - **Replaced approximately 2360 LF of defective 8" and 10" sewer main.**

  - **Straight Street between Park Avenue and Essex Street, spot repairs and renewal or replacement service laterals in advance of installation of approximately 800 LF of 12" & 18" CIPP. (In Progress, project will restart in April)**

  - **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. (In Progress)**

- **In-House Managed Projects, Other;**

  - **Rehabilitation of CSO-016 Mechanical Screening System in design. (In Progress)**
  - **Repairs to the V1-4 and V1-7 Internal Regulators and Screening Facilities (In Progress)**

City of Paterson, 2nd Quarter 2018 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
  - **The City issued a Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals were received on May 8, 2018. Contract documents are being finalized to award the redesign to Mott McDonald.**
  - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
    - **Excavation work has been completed.**
    - **Below grade cast in place structure is complete.**
    - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
    - **Mechanical screening equipment and controls have been received and are presently being installed.**
    - **Project is progressing but has been slowed by utility conflicts and contaminated soils. Engineer is addressing a proposed change order to resolve the utility conflicts to move the project to completion. A redesign is being finalized and the work should move forward during the 3rd Quarter.**

- **In-House Managed Main and Lateral Repair Projects**
  - **Renewal or replacement of 8 service laterals. (Completed)**
  - **Linwood Avenue between Union Avenue and Molly Ann's Brook (Project Completed)**
    - **Spot repairs of 15 LF of 12" sewer main.**
  - **Broadway between Curtis Place and West Broadway (Project Completed)**
    - **Replaced 12 LF of defective 8". 10" & 12" sewer main.**
    - **Replaced 2 defective manholes.**
  - **Prince Street between Slater Street and Green Street (Project Completed)**
    - **Completed replacement of 208 LF of defective 18" sewer main.**
    - **Completed replacement of three (3) defective manholes.**
    - **Completed CIPP lining of 190 LF of defective 18" sewer main for CIPP.**
  - **Cumberland Avenue, between Union Avenue and Totowa Border (Project Completed)**
    - **Replaced 2293 LF of defective 8" sewer main.**
    - **Replaced 6 defective manholes.**
    - **Reconnected 39 service laterals.**
    - **Replaced one storm water inlet.**
  - **Burlington Avenue, Chamberlain to Chatham**
    - **Replacement of 413 LF of 18" Storm Sewer.**
    - **Replacement of 65 LF of 12" basin lateral and 5 catch basins.**
    - **Replacement of 165 LF of 12" sanitary sewer.**
    - **CIPP lining of approximately 1600 LF of 10" and 12" sanitary sewer.**

City of Paterson, 2nd Quarter 2018 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

- **Straight Street between Park Avenue and Essex Street, spot repairs and renewal or replacement service laterals in advance of installation of approximately 800 LF of 12" & 18" CIPP. (In Progress, project will restart in April)**

- **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. Pipe scheduled for delivery the week of July 23rd. (In Progress)**

- **In-House Managed Projects, Other;**
  - **Rehabilitation of CSO-016 Mechanical Screening System in design. (In Progress)**
  - **Repairs to the V1-4 and V1-7 Internal Regulators and Screening Facilities (In Progress)**

City of Paterson, 3rd Quarter 2018 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
  - **The City issued a Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals were received on May 8, 2018. The contract was awarded for the redesign to Mott McDonald. Design work has commenced and the City is currently in the process of resolving easement issues.**
  - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
    - **Below grade cast in place structure is complete.**
    - **Mechanical screening equipment and controls have been received and are presently being installed.**
    - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
    - **Project is progressing but has been slowed by utility conflicts and excessive quantities of contaminated soils. Engineer has completed the modifications to one of the chambers required due to utility conflicts. The Contractor is preparing a change order to construct the modified chamber and address the contaminated soil disposal. This will be processed through the municipal council when received and move the project to completion.**

- **In-House Managed Main and Lateral Repair Projects**
  - **Burlington Avenue, Chamberlain to Chatham (Project Completed)**
    - **Replacement of 413 LF of 18" Storm Sewer.**
    - **Replacement of 65 LF of 12" basin lateral and 5 catch basins.**
    - **Replacement of 165 LF of 12" sanitary sewer.**
    - **CIPP lining of approximately 1600 LF of 10" and 12" sanitary sewer.**
  - **Renewal or replacement of 14 service laterals. (Completed)**
  - **Danforth between McBride and Nagle (Project Completed)**
    - **Replaced 18.33 LF of 8" sewer main.**
  - **Frame and Cover Replacements (Projects Completed)**
    - **103 North Main Street**
    - **Main and Lee Streets**
    - **Governor and Straight Streets**
  - **186 Jackson Street; replace collapsed basin and lateral (Projects Completed)**
  - **4th Avenue at East 16th Street (Projects Completed)**
    - **Rehabilitation of a brick manhole over a brick main.**
    - **Manhole lining**
  - **Paterson Ave Between Crosby and Molly Ann Brook (Project Completed)**
    - **Spot repairs of 14.43 LF of defective 8" sewer main.**
    - **Replaced 19.5 LF of 6" laterals. City of Paterson, 2nd Quarter 2018 Report - Continued**

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

- **In-House Managed Main and Lateral Repair Projects Continued**
    - **East 18th Street between Ellison Street and Pearl Street (Project Completed)**
        - **Completed replacement of 11.50 LF of defective 15" sewer main.**
    - **Paterson Ave Between Chamberlain Avenue and Molly Ann Brook (Project Completed)**
        - **Replacement of 128 LF of defective 12" sewer main.**
        - **Replaced 19.5 LF of 6" laterals.**
    - **Paterson Ave at Molly Ann Brook Crossing (Project Completed)**
        - **Rehabilitation and relining of syphon chambers and approach manholes.**
    - **10th Avenue between East 26th Street and East 27th Street (Project Completed)**
        - **Replaced 8.5 LF of defective 8" sewer main.**
        - **Replaced 4.17 LF of 6" laterals.**
    - **Straight Street between Park Avenue and Essex Street (Project Completed)**
        - **Spot repairs of 662 LF of 12" and 18".**
        - **CIPP lining of 723 LF of 12" and 18" combined sewer.**
        - **Rehabilitation of all manholes**
    - **East 18th Street between Ellison Street and Pearl Street (Project Completed)**
        - **Spot repairs of 662 LF of 12" and 18".**
        - **CIPP lining of 723 LF of 12" and 18" combined sewer.**
    - **East 12th Street between 4th and 5th Avenues (In Progress)**
        - **Replace approximately 500 LF of 12" concrete sewer main**
    - **Linwood Avenue, between Molly Ann Brook and Totowa Avenue, work includes renewal of the 18" Brook crossing, (In Progress)**
        - **Replace approximately 175 LF of defective 18" sewer main**
        - **CIPP lining of the brook crossing and rehabilitation of the associated manholes**
    - **Totowa Avenue, between Ryerson Avenue and Sheraton Avenue (In Progress)**
        - **Replace approximately 450 LF of defective 8" sewer main**
        - **CIPP lining of approximately 475 LF of defective 8" sewer main**
    - **CSO-027 Outfall (PVSC Market Street Regulating Chamber – Passaic River) – Rehabilitate 325 L.F. of defective 80" outfall sewer by means of slip lining. Pipe has been received and is scheduled for installation the week of October 22, 2018. (In Progress)**

City of Paterson, 1st Quarter 2019 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **The City issued a Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals were received on May 8, 2018. The contract was awarded for the redesign to Mott McDonald. Design work has commenced and the City is currently in the process of resolving easement issues.**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Below grade cast in place structure is complete.**
        - **Mechanical screening equipment and controls have been received and are presently being installed.**
        - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
        - **Project is progressing but has been slowed by utility conflicts and excessive quantities of contaminated soils. Engineer has completed the modifications to one of the chambers required due to utility conflicts. The Contractor has prepared a change order to construct the modified chamber and address the contaminated soil disposal. This proposal is being processed through the municipal council and should move forward during the 2nd Quarter.**

- **In-House Managed Main and Lateral Repair Projects**
    - **Holsman Avenue, between Jefferson Street and Stout Street, Sewer Main Repair (In Progress)**
        - **Replaced 55 LF of defective 12" & 8" sewer main**
        - **Replacement of 1 Defective Manhole**
        - **Repair and reconnect three building laterals**
    - **Renewal or replacement of 6 service laterals. (Completed)**
    - **Beech Street between 20th & 21st Avenues, replace defective manhole (Project Completed)**
        - **Replaced 8 LF of 12" sewer main.**
        - **Replacement of 1 Defective Manhole**
        - **Repair and reconnect two building laterals**

City of Paterson, 2nd Quarter 2019 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **The City issued a Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals were received on May 8, 2018. The contract was awarded for the redesign to Mott McDonald. Design work has commenced and the City is currently in the process of resolving easement issues.**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Below grade cast in place structure is complete.**
        - **Mechanical screening equipment and controls have been received and are presently being installed.**
        - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
        - **Project is progressing but has been slowed by utility conflicts and excessive quantities of contaminated soils. Engineer has completed the modifications to one of the chambers required due to utility conflicts. The Contractor has prepared a change order to construct the modified chamber and address the contaminated soil disposal. This proposal has been approved by the municipal council and we are working with the State to address the funding. The project should move forward during the 3rd Quarter.**

- **In-House Managed Main and Lateral Repair Projects**
    - **Finalized repairs to the Jefferson Street Sewer Main**
    - **Ryerson Avenue, between Union Avenue and James Street, Sewer Main Repair (Project Completed)**
        - **Replaced 114 LF of 8" sewer main.**
        - **Repair and reconnect four building laterals**
    - **First Avenue at the Intersection of River Street, replace defective main (Project Completed)**
        - **Replaced 99 LF of defective 8" sewer main**
        - **Replaced 2 LF of defective 12" sewer main**
        - **Replaced 86 LF of defective 18" sewer main**
        - **Replaced 6 LF of defective 24" sewer main**
        - **Replaced 31 LF of defective 8" basin lateral**
        - **Replacement of 1 building lateral, main to curb**
    - **Renewal or replacement of 4 service laterals. (Completed)**
    - **North Main Street (Completed)**
        - **Replace defective MH frame and cover and two defective stormwater inlet frames and grates.**
    - **6th Avenue at East 11th Street**
        - **Repair defective manhole**
        - **Replace 10 LF of 10" basin lateral.**

City of Paterson, 3rd Quarter 2019 Report

NJPDES Number: NJ0108880

Summary of construction related activities in this municipal system

ATTACHMENT A

City of Paterson, Outsourced Construction Projects:

- **Solids and Floatables Control Projects, Outside Consultant**
    - **The City issued a Request for Proposals for the redesign and permitting of CSO-025A Screening Facility. Proposals were received on May 8, 2018. The contract was awarded for the redesign to Mott McDonald. Design work has commenced and the City is currently in the process of resolving easement issues.**
    - **Construction of new CSO-029A Screening Facility, Memorial Drive at Paterson Street (In Progress)**
        - **Below grade cast in place structure is complete.**
        - **Mechanical screening equipment and controls have been received and are presently being installed.**
        - **Precast diversion tunnels have been completed, except inlet tunnel that requires modifications to accommodate conflicting utilities.**
        - **Project is progressing but has been slowed by utility conflicts and excessive quantities of contaminated soils. Engineer has completed the modifications to one of the chambers required due to utility conflicts. The Contractor has prepared a change order to construct the modified chamber and address the contaminated soil disposal. This proposal has been approved by the municipal council. We have successfully coordinated with the NJDEP and the NJIB to secure the required funding and approvals; and the contractor remobilized to the site on October 15, 2019. Completion is expected within the next 4-6 months.**

- **In-House Managed Main and Lateral Repair Projects**
    - **Governor Street between Rosa Parks & Carroll Street, Sewer Main Repair (Project Completed)**
        - **Replaced 117 LF of 12" sewer main.**
        - **Replaced 1 defective manhole.**
        - **Repair and reconnect 2 building laterals**
    - **Summer Street at the Intersection of Montgomery Street, replace defective main (Project Completed)**
        - **Replaced 97 LF of defective 18" sewer main**
        - **Replaced 1 defective manhole.**
        - **Repair and reconnect 3 building laterals.**
        - **Replaced 27 LF of 12" basin laterals.**
        - **Replaced 2 stormwater basins.**
    - **Renewal or replacement of 12 service laterals. (Completed)**
    - **Summer Street Intersection of Essex Street (Completed)**
        - **Spot-repair replace 2 LF of 12" main.**
    - **Replace 2 defective MH frames and covers.**

City of Paterson, 3rd Quarter 2019 Report
NJPDES Number: NJ0108880
Summary of construction related activities in this municipal system
ATTACHMENT A

- **Lewis Street, between Cedar Street & Oak Street, Sewer Main Repair (Project Completed)**
  - **Replaced 174 LF of 12" sewer main.**
  - **Repair and reconnect 6 building laterals**

- **East 20th Street, near house number 84**
  - **Replace 1 defective basin.**
  - **Replaced 10 LF of 12" basin lateral.**

- **East 16th Street between 4th Avenue and River Street, Sewer Main Repair (Project Completed)**
  - **Replaced 386 LF of 10" sewer main.**
  - **Replaced 86 LF of 12" sewer main.**
  - **Replaced 78 LF of 15" sewer main.**
  - **Replaced 4 defective manholes.**
  - **Repair and reconnect 10 building laterals**
- **Madison Street, near house number 76**
  - **Replace 1 defective basin.**
  - **Replaced 4 LF of 10" basin lateral.**

- **Beckwith Avenue between State Street & Chestnut Street, Sewer Main Repair (Project Completed)**
  - **Replaced 105 LF of 12" sewer main.**
  - **Replaced 1 defective manhole.**
  - **Repair and reconnect 1 building laterals**

- **Sherwood Avenue between Totowa Avenue Parks & Chamberlain Avenue, Sewer Main Repair (In Progress)**
  - **Replaced 1,301 LF of 30" sewer main.**
  - **Repair and reconnect 5 building laterals**

APPENDIX J

PVSC Updated Technical Guidance Manual

By Greeley and Hansen & CDM Smith

Dated: January 2018

Updated: November 2019

Passaic Valley Sewerage Commissioners

CSO Long Term Control Plan

Updated Technical Guidance Manual

January 2018

(Revised November 2019)

GREELEY AND HANSEN

CDM Smith

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Section 1

Introduction

The combined sewer systems (CSS) in the State of New Jersey are owned by a mix of municipal governments and authorities that are responsible for the State's 210 permitted outfalls. These collection systems are serviced by nine publicly owned treatment works (POTW) wastewater treatment facilities. The New Jersey Department of Environmental Protection has issued NJPDES permits to each of the CSS owners and POTWs requiring that the nine hydraulically connected systems develop and submit a Long Term Control Plan (LTCP) for reducing the impact of combined sewer overflow (CSO) to their receiving waters.

The Passaic Valley Sewerage Commission (PVSC) is one of the nine permitted POTW facilities and is coordinating the LTCP for its eight combined sewer communities: Bayonne, East Newark, Harrison, Jersey City, Kearny, Newark, North Bergen, and Paterson. The North Bergen Municipal Utility Authority also operates one of the nine permitted POTW facilities with its Woodcliff Wastewater Treatment plant, which services parts of North Bergen and Guttenberg. While a separate LTCP will be developed for that system, PVSC and NBMUA have agreed that PVSC would coordinate that LTCP development process as well.

The LTCP development process requires that the permittees each evaluate a variety of CSO control alternatives and submit an Evaluation of Alternatives Report. Although the PVSC and NBMUA hydraulically connected communities will submit system-wide LTCPs, each permittee will be responsible for evaluating the alternatives within their community.

To assist in the communities in performing their alternatives evaluations, PVSC has updated this Technical Guidance Manual (TGM) that was originally developed in 2007.

1.1 Background

In 2004, the NJDEP issued a General Permit (GP) for combined sewer systems that, in part, required combined sewer system owners to initiate the CSO LTCP development process and undergo a Cost and Performance Analysis for Combined Sewer Overflow Point Operation. That analysis required the permittees to evaluate alternatives at each CSO point that would provide continuous disinfection prior to discharge. To assist their communities in performing the analysis, PVSC developed a Technical Guidance Manual that provides an overview of various screening, pretreatment, disinfection, and storage technologies along with guidance on costs. The original TGM was released in 2007.

The New Jersey Pollutant Discharge Elimination System (NJPDES) permits issued in 2015 require the permittees to continue the CSO LTCP development process and perform a complete CSO control alternatives evaluation that will lead to a selected alternative and eventual implementation. While much of the information in the original TGM is still viable, a decade has passed since it was developed. To assist their permittees with the current permit, PVSC has updated the TGM to reflect new information, updated costs, and new permit requirements such as the evaluation of green infrastructure.

1.2 Purpose of the Technical Guidance Manual

The Technical Guidance Manual is intended as a guidance document to assist the individual permittees in performing their LTCP alternatives evaluations. The information and costs provided throughout the document are for planning purposes only, and the individual permittees should verify all of the assumptions and information contained herein.

Section 2

Treatment Technology

Treatment technologies are intended to reduce the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the environment. Specific technologies can address different pollutant constituents, such as settleable solids, floatables, or bacteria. To satisfy CSO treatment objectives, treatment technologies for each unit processes of screenings/ pretreatment/ disinfection alternatives have been evaluated, including the following:

- Screenings - mechanical bar screens, fine screens, band and belt screens, and drum screens.
- Pretreatment - vortex/swirl Separation (Storm King® Vortex Separator, HYDROVEX® Fluidsep Vortex Separator, and SANSEP Process), ballasted flocculation (ACTIFLO® Ballasted Flocculation Process and DensaDeg Ballasted Flocculation), and compressible media filtration (FlexFilter Process)
- Disinfection – chlorination, peracetic acid, ozonation, and, UV disinfection.

CSOs are intermittent in nature and are characterized by highly variable flow rates relative to base sewage flow. Bacterial and organic loadings from the collection system also vary greatly, both within and between storm events. The screenings/pretreatment/disinfection system must be able to handle variable pollutant loadings and large fluctuations in flow that can change drastically. Where treatment facilities are to be considered, provisions for the handling, treatment, and ultimate disposal of sludge and other treatment residuals shall also be included.

2.1 Treatment Technology Evaluation Criteria

In the evaluation of each treatment technology as included in subsequent sections, the following description outlines the process used to evaluate each technology:

1. **Description of Process**: includes a verbal and graphical description of the treatment process and pertinent components.
2. **Applicability**: evaluates the applicability of technology for CSO control. Equipment manufacturers/vendors have been contacted to gather information on installation list for CSO applications, technology evaluation and case study. If determined not applicable for CSO control, no further evaluation will be performed.
3. **Performance**: Each process has been evaluated on a preliminary basis for its performance under similar conditions to CSO, particularly where flow and loading rates varied significantly. Individual processes have a different ability to handle varying loading rates and still maintain a reasonably consistent removal rate, or disinfection rate. The inability to maintain a required level of performance over varying hydraulic loadings may eliminate the process, or require that limitations to its use be considered.

4. **Hydraulics**: The screenings/ pre-treatment/ disinfection alternatives will need to be physically located between the CSO control facility and the receiving waters. In many locations, there may be limited difference in elevation between the water surface level in the regulator and the receiving water level. This will be particularly true wherein the receiving water elevations are affected by tides. Head loss within an individual control process will vary from negligible to as much as 8 feet. The total head loss for a treatment train consisting of screenings, pre-treatment, and disinfection may be as much as 10 feet. For this reason, the evaluation will identify the need for intermediate pumping. Screw pumps, which are capable of efficiently handling large flows under low head conditions, can be utilized for this purpose.

5. **Generation of Waste Streams:** Most if not all screening and pretreatment processes produce waste streams that must be contained and disposed of; however, none of the disinfection processes produce appreciable waste streams. Waste streams for the screening processes consist of the storing and/or disposal of collected screening materials. For the pre-treatment process, the waste streams are more varied. The vortex units produce underflow containing the solids removed by the process, which can be as much as 10% of the design flow of the vortex unit. Ballasted flocculation units produce waste sludge as part of the process. In addition, there is a startup period (approximately 20 minutes) for the ballasted flocculation system during which time the process effluent is of poor quality, and filtration processes produce filter backwash water. When these processes are located at a WWTP or along an interceptor sewer with available capacity, the waste streams can be discharged and treated. However, in remote locations, such as those envisioned for CSO treatment facilities, there is typically no place to dispose of the waste stream. While the permittees that own and operate the CSO conveyance systems will be evaluating the feasibility of increasing wet weather flows to the WWTP, most interceptor sewers during wet weather events are currently at capacity or surcharged. As a result, ancillary tankage must be provided to store the volume of the waste stream produced until such time that it can either be introduced into the process, or discharged to the interceptor sewer for treatment at the WWTP. Where applicable, the need for ancillary tanks must be included in the evaluation of the process.

6. **Complexity**: This portion of the evaluation will identify the level of complexity of the process, whether it is capable of functioning unmanned in a remote setting, and the level of instrumentation that would be needed to operate the system during the overflow events.

7. **Limitations**: Different processes can have limitations on the hydraulic and pollutant loading conditions that it can operate within, which can include both lower and upper limits. Any such limitation must be considered when determining the configuration of unit sizes for that process as needed to handle the variable flow/pollutant loading conditions. Limitations for each process are discussed in subsequent sections and have been considered in development of the evaluation process.

8. **Construction Costs**: This portion of the evaluation will provide preliminary report level construction cost estimates, which includes budgetary equipment costs as provided by the manufacturer, installation costs, building costs, and contingency for design flow ranging from 10 MGD to 450 MGD.

9. **Operation and Maintenance Costs**: Information on the operation and routine maintenance requirements was obtained from each of the equipment manufacturers and included in this section. Annual operation costs have been prepared based on power requirements for operation of the equipment, the estimated cost of power, and the estimated annual hours of operation of the equipment. In addition, annual maintenance costs reflecting those recommended by the equipment manufacturer, as well as the manpower required for anticipated post-overflow event clean up and service has been included.

10. **Space Requirements**: Due to the proximity of the regulators to the receiving water body, in most cases it is unlikely that there will be sufficient existing open land available to construct the screenings/pre-treatment/disinfection facilities. Therefore, it will likely be necessary for the Permittee to purchase land. The evaluation of the respective process shall include an evaluation of the space needed for the process. This area is not limited to the process or tank area but includes a small buffer for roadways and access base.

In the process of preparing this TGM, technology users were contacted to gather information on their experience with using the technology for CSO treatment.

2.1.1 Bayonne Wet Weather Demonstration Project

The Bayonne Wet Weather Flow Treatment and Disinfection Demonstration Project (Bayonne MUA Pilot Study) was conducted over a two-year period at the Oak Street facility in Bayonne, NJ which receives the CSO from Bayonne City. The project was sponsored by the Bayonne Municipal Utilities Authority (BMUA), with grants and collaboration from New Jersey Department of Environmental Protection (NJDEP) and the United States Environmental Protection Agency (USEPA). The primary focus of the Bayonne MUA Pilot Study was to verify the performance of selected technologies to treat CSO discharges for solids removal and disinfection under field conditions as suitable for remote satellite locations.

The treatment technologies evaluated included high rate solids removal (i.e., vortex and plate settler units) and enhanced high rate solids treatment (i.e., a compressed media filter). Three types of disinfection units were also included, namely chemical disinfection (i.e., Peracetic acid, PAA), and ultraviolet (UV) disinfection (low and medium pressure units). The evaluation results of the pilot study are discussed in the corresponding sections of the TGM.

2.2 Screenings

Screening technologies can either represent minimal treatment of a CSO before disinfection or can be used to remove larger particles upstream of vortex/swirl separation, ballasted flocculation, or compressed media filtration before high rate disinfection processes. The screening technologies and their related clearances, reviewed for this Technical Guidance Manual, are as follows:

- Mechanical Bar Screens 0.25" to 2" (6-50 mm) bar spacing
- Fine Screens 0.125" to 0.5" (3-13 mm) bar spacing
- Band and Belt Screens 0.08" to 0.4" (2-10 mm) openings
- Drum screens 0.0004" (0.01 mm) openings

As indicated above, screening technology will remove large material or particles as small as 0.0004" from the waste stream. The choice of a particular screening technology is a function of the general purpose of the screen, and what additional treatment process or equipment lies downstream. Screens with smaller openings, such as belt and micro screens, typically require pretreatment with a mechanical bar screen to prevent damage from large objects. Screenings equipment which are not continuously cleaned, such as manually cleaned bar screens, were eliminated from this evaluation due to the potential for backup and surcharging of the collection system. In general, screening systems are very effective in removing floatable and visible solids, but do not remove a significant amount of TSS, fecal coliform, enterococci, BOD, COD, NH3, TKN, total phosphorous, and total nitrogen.

The following sections describe the types of screens and equipment, as well as its capability to remove the various pollutants of concern. At the end of the section a summary of performance, operation, and environmental impacts will be presented. Based upon this summary some of the screening technologies will be eliminated from further consideration.

2.2.1 Mechanical Bar Screens

Description of Equipment

The three most common types of mechanically cleaned bar screens are: (1) chain driven, (2) climber type rake, and (3) catenary. Chain driven mechanical raking systems consist of a series of bar rakes connected to chains on each side of the bar rack. During the cleaning cycle, the rakes travel continuously from the bottom to the top of the bar rack, removing material retained on the bars and discharging them at the top of the rack. A disadvantage of chain-driven systems is that the lower bearings and sprockets are submerged in the flow and are susceptible to blockage and damage from grit and other materials. Climber-type systems employ a single rake mechanism mounted on a gear driven rack and pinion system. The gear drive turns cog wheels that move along a pin rack mounted on each side of the bar rack. During the cleaning cycle, the rake mechanism travels up and down the bar rack to remove materials retained on the bars. Screenings are typically discharged from the bars at the top of the rack. This type of bar screen has no submerged bearings or sprockets and is less susceptible to blockages, damage and corrosion. Catenary systems also employ chain drive rake mechanisms, but all sprockets, bearings, and shafts are located above the flow level in the screen channel. This in turn reduces the potential for damage and corrosion and facilitates routine maintenance. During the cleaning cycle, the rakes travel continuously from the bottom to the top of the bar rack to remove materials retained on the bars. Screenings are typically discharged from the bars at the top of the rack. The cleaning rake is held against the bars by the weight of its chains, allowing the rake to be pulled over large objects that are lodged in the bars and that might otherwise jam the rake mechanism.

Bar screens will remove essentially 100% of all rigid objects of which the minimum dimension is more than the spacing between the bars. Removing screenings from CSOs essentially does not remove any dissolved solids, or nutrients such as TKN, total nitrogen and total phosphorous. Screenings removed from overflows can however contain some larger rigid materials that reflect a BOD loading. Solids, such as fecal material, can also be contained within screenings collected on the bar screen, however the velocity between the bars increases with increasing flow, thus this material can be broken up and pass through the bars. Therefore, it is difficult to quantify on a consistent basis any BOD loading, fecal coliform and enterococci count, and TSS concentrations removed by the screening technologies. Nevertheless, some removal estimates, as provided by the manufacturer, have been included within the analysis procedure for further consideration.

For the purposes of the Technical Guidance Manual, the mechanical bar screen evaluation is based on the use of Climber Screens® since these have been found to be more reliable and significantly lower in operation and maintenance requirements than others. Figure 2-1 shows photos of typical climber screens. The Technical Guidance Manual analysis is based on mechanical bar screens with a maximum velocity between the bars of 4.5 feet per second (fps) and a peak velocity of approach of 3.0 fps. These are the standard criteria for designing bar screens for use in wastewater treatment plants, where flow is continuous and the diurnal patterns more predictable. Since CSOs are intermittent, with widely varying flow rates, these standards are more likely to be violated for short periods of time. The mechanical bar screen selections are also based upon an anticipated head loss of less than one foot, a peak flow level of six feet under peak flow conditions, with an operating floor located twelve feet above the water surface. For CSO applications where heavy debris loadings are likely, the minimum bar spacing should be approximately 1 inch.

Figure 2-1 - Photos of Typical Climber Screens

TYPICAL 60 MGD CLIMBER SCREEN

TYPICAL 120 MGD CLIMBER SCREEN

(Source: Infilco Degremont, Inc.)

Applicability to The Project

Mechanical bar screens have proven to be a relatively simple and inexpensive means of removing floatables and visible solids. They are typically the screen of choice in treatment facilities, and are used at a many CSO treatment facilities. There have been hundreds of Climber Screens® installed in CSO applications across the US. A list is provided in Appendix A focused on Type IIS and IIIAS installations in NJ, NY, and PA since 2000.

Performance Under Similar Conditions

As stated above, mechanical bar screens are already installed in many CSO facilities and operate successfully to remove floatables and visible solids over the fluctuations in flow rates seen in CSOs. Slight removal of TSS, total phosphorous, and total nitrogen (typically 5%, 3%, and 2%, respectively) can be achieved with the solids removal.

Hydraulics

Hydraulic losses through bar screens are a function of approach velocity, and the velocity through the bars. The head loss across the bar screen increases as the bar screen becomes clogged, or blinded. Instrumentation provided with mechanically cleaned screens is typically configured to send a signal to the cleaning mechanism so the head loss across the screen is limited to 6 inches.

Generation of Waste Streams

As screenings are removed from the CSO flows they generate a waste stream for disposal. Studies have found that the average CSO screenings loads vary from approximately 0.5 to 11 cubic feet per million gallons, with peaking factors based upon hourly flows ranging from 2:1 to greater than 20:1. These screenings must be either transferred to the interceptor sewer for ultimate disposal at the WWTP, or removed and stored in a container for onsite removal at a convenient time. The collection of screenings can be performed using conveyors, screenings compactors, or pumps. Any enclosure around the screenings equipment should provide space for a container and odor control.

Complexity

Mechanical bar screens are able to function intermittently, at remote locations with a minimum level of instrumentation. A level detector is needed to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer can be utilized to periodically exercise the screen, so it is ready for use.

Limitations

When mechanical bar screens are installed in a WWTP, the flows vary within an anticipated range which is predetermined so the screens can be sized for the necessary peak flows, and redundant units can be provided. In CSO installations there are wide variations in flow rates that can pass through the screens, but the high flow rates are usually of short duration. Due to the intermittent nature of CSOs, it is not considered cost effective, nor necessary to provide redundancy. Nevertheless, providing multiple units in separate channels is a means of handling equipment out of service. The quickness with which CSO flows can increase however can lead to problems in getting units in other channels into operation quickly enough given the operating speeds of motor operated sluice gates. A review of the pollutant removal rates as reported by the manufacturer indicates that only about 5% of the TSS is removed by the screen. While screening of solids may be adequate for the lower treatment objects (50%, 85%, and 95% removals) where TSS levels are not as critical, the literature does not indicate that screening alone will remove adequate solids to provide for consistent and reliable disinfection at higher treatment objectives.

Construction Costs

Table 2-1 presents the preliminary planning level construction cost estimates of Climber Screens® for design flows ranging from 10 MGD to approximately 450 MGD. It includes equipment cost, installation cost, general contractor (GC) field general conditions, GC overhead & profit (OH&P), and contingency. This cost estimates assume that the Climber Screens® will be installed in existing CSO channels. If the existing CSO channel does not provide adequate channel width to maintain velocities below 3 fps, a new or modified chamber will be required at an additional cost. The installation cost is assumed at 50% of the equipment cost based on the complexity of the installation. Budgetary equipment pricing information for Climber Screens® was gathered from equipment manufacturer Suez, formerly Infilco Degremont, Inc. The estimated total construction costs for the Climber Screens® are plotted against flowrates from 10 MGD to approximately 450 MGD in Figure 2-2.

Climber Screens® pricing is primarily determined by channel size which is dictated by the flow and plant specific parameters or design. Therefore, the Type IIS is suitable for channels up to 7’-0” wide. Pricing provided by the manufacturer is based on assumed channel dimensions of 5’-0” wide by 10’-6” deep. A single unit of this model of Climber Screen® would be suitable for up to 50 MGD or larger depending on channel dimensions. The Type IIIAS is suitable-for channels 6’-6” to 12’-0” wide. The pricing provided by the manufacturer is accurate up to the 8’-0” wide and 10’-6” deep dimensions. For the large 450MGD flow, multiple units each designed for a peak flow of 112 MGD are recommended. Capacity can be adjusted based on channel dimensions, bar rack clear spacing, and number of units desired.

Operation and Maintenance

Costs associated with operation include the electrical cost for operating the motor(s) on the mechanical bar screens. Regular maintenance requires visits to the site after each storm to inspect the screens for damage, remove any large material in the channels, clean up any screenings on the floor or equipment, and general wash down of the area. Regular maintenance also includes routine lubrication and maintenance of the tracks, racks, drives, and gear boxes. It is important to keep the pin racks and carriage bearings greased and oiled. It is also important to inspect the bearings for excessive wear. The Type IIS and IIIAS carriage assemblies utilize self-greasing/oiling canisters which are easily replaced at the recommended intervals. The follower shaft bearings and carriage drive bearings are replaced utilizing access points built into the side frames (i.e. carriage does not need to be removed). It is recommended to perform periodic visual inspections to ensure proper operation, lubrication and bearing wear.

Estimated annual operation costs for the Climber Screen® are presented on Table 2-2 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-3.

Space Requirements

The space required for mechanical bar screens consists of the building and area on the exterior of the building for access to remove the screenings container.

Case Study

New York City utilized TypeIIIAS Climber Screens® at their Manhattan and Bronx Grit Chambers from 1986 until 2016. These chambers deliver combined sewage to the Wards Island WWTP, which has a total plant flow of approximately 500 MGD. After the first 6 years of using the Climber Screens®, the shaft bearings were beyond their useable life. Although initially designed for 5HP per motor based on the average weight of debris, it was later found that 7.5 HP was required to handle the harsher conditions imposed by the combined sewage.

Table 2-1 - Preliminary Construction Cost Estimates for Climber Screens

Flow Range	System	Width x Depth	Budgetary Equipment Price	Install Cost[1]	GC General Conditions [2]	GC OH&P[3]	Contingency[4]	Total
10 MGD to 50 MGD	(1) Type IIS	5’-0” x 10’-6”	$305,000	$152,500	$45,750	$45,750	$274,500	$823,500
50 MGD to 112 MGD	(1) Type IIIAS	8’-0” x 10’-6”	$465,000	$232,500	$69,750	$69,750	$418,500	$1,255,500
112 MGD to 224 MGD	(2) Type IIIAS	8’-0” x 10’-6”	$465,000	$232,500	$69,750	$69,750	$418,500	$1,255,500
224 MGD to 336 MGD	(3) Type IIIAS	8’-0” x 10’-6”	$1,900,000	$950,000	$285,000	$285,000	$1,710,000	$5,130,000
336 MGD to 448 MGD	(4) Type IIIAS	8’-0” x 10’-6”	$1,900,000	$950,000	$285,000	$285,000	$1,710,000	$5,130,000

Notes:
(1) Installation cost is assumed at 50% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-2 - Total Estimated Construction Cost of Climber Screens

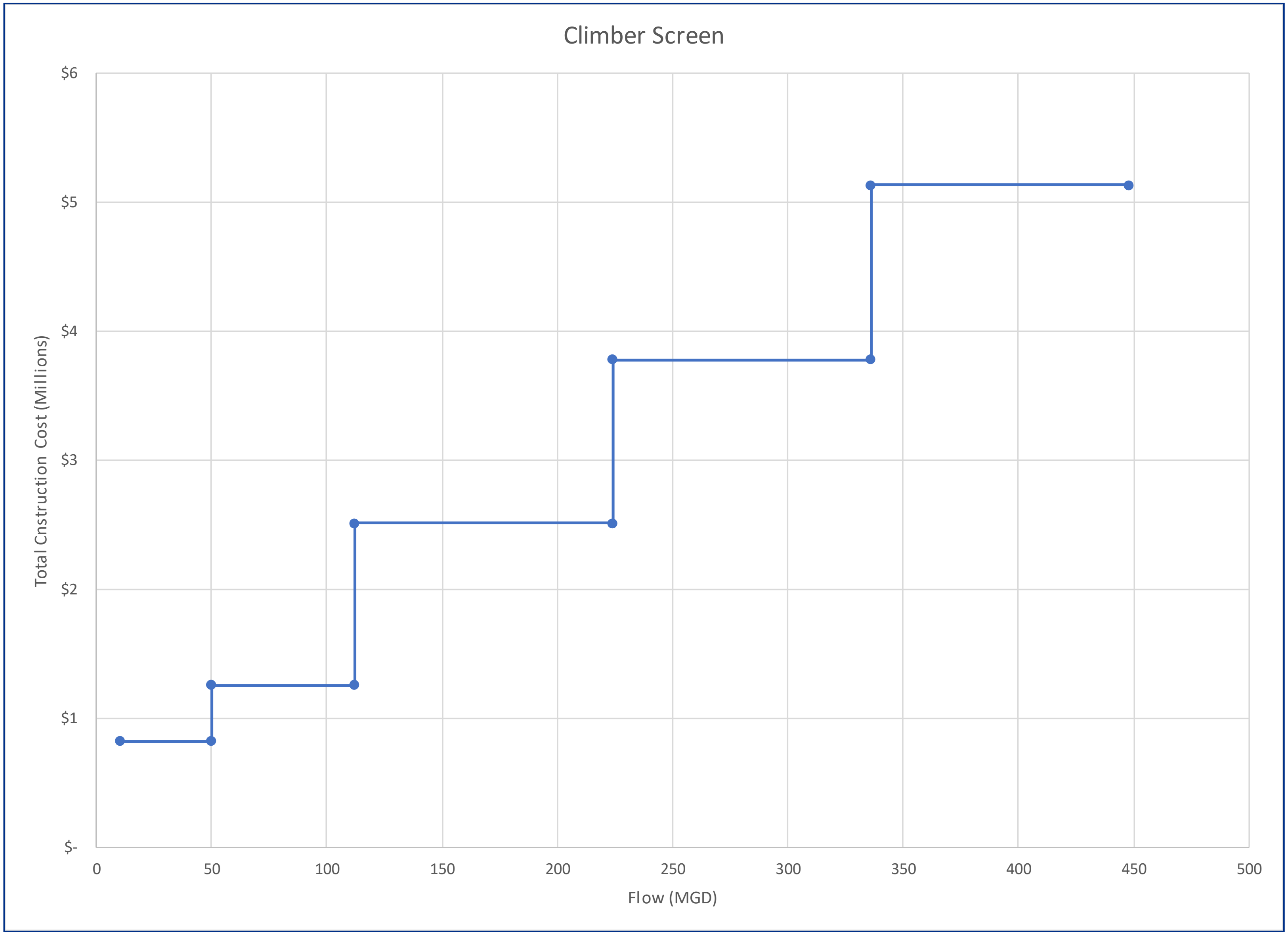


Table 2-2 - Annual Operation Costs of Climber Screens

Flow Range	System	Total Horsepower (HP)	Total Power (kW)$^{(1)}$	Annual Energy Usage (kW-hr)$^{(2)}$	Annual Cost$^{(3)}$
10 MGD to 50 MGD	(1) Type IIS	3	2	1,119	$157
50 MGD to 112 MGD	(1) Type IIIAS	5	4	1,864	$261
112 MGD to 224 MGD	(2) Type IIIAS	10	7	3,729	$522
224 MGD to 336 MGD	(3) Type IIIAS	15	11	5,593	$783
336 MGD to 448 MGD	(4) Type IIIAS	20	15	7,457	$1,044

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-3 - Annual Maintenance Labor Costs of Climber Screens

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost$^{(1)(2)}$
Monthly	Cam Tracks and Pin Racks	Grease and inspection	0.5	$900
Bi-annually	Automatic Lubricators	Grease	0.5	$150
Annually	Automatic Lubricators	Oil	0.5	$75
2-3 years	Carriage Drive Shaft Bearing	Replace	1	$75
3-5 years	Follower Shaft Bearing	Inspect - replace as necessary	2	$100
5 years	Gear Box	Change fluid	2	$60
After Each CSO Event	Screens	Inspection and cleanup	2	$30,000
Total Annual Maintenance Labor Cost				$31,360

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

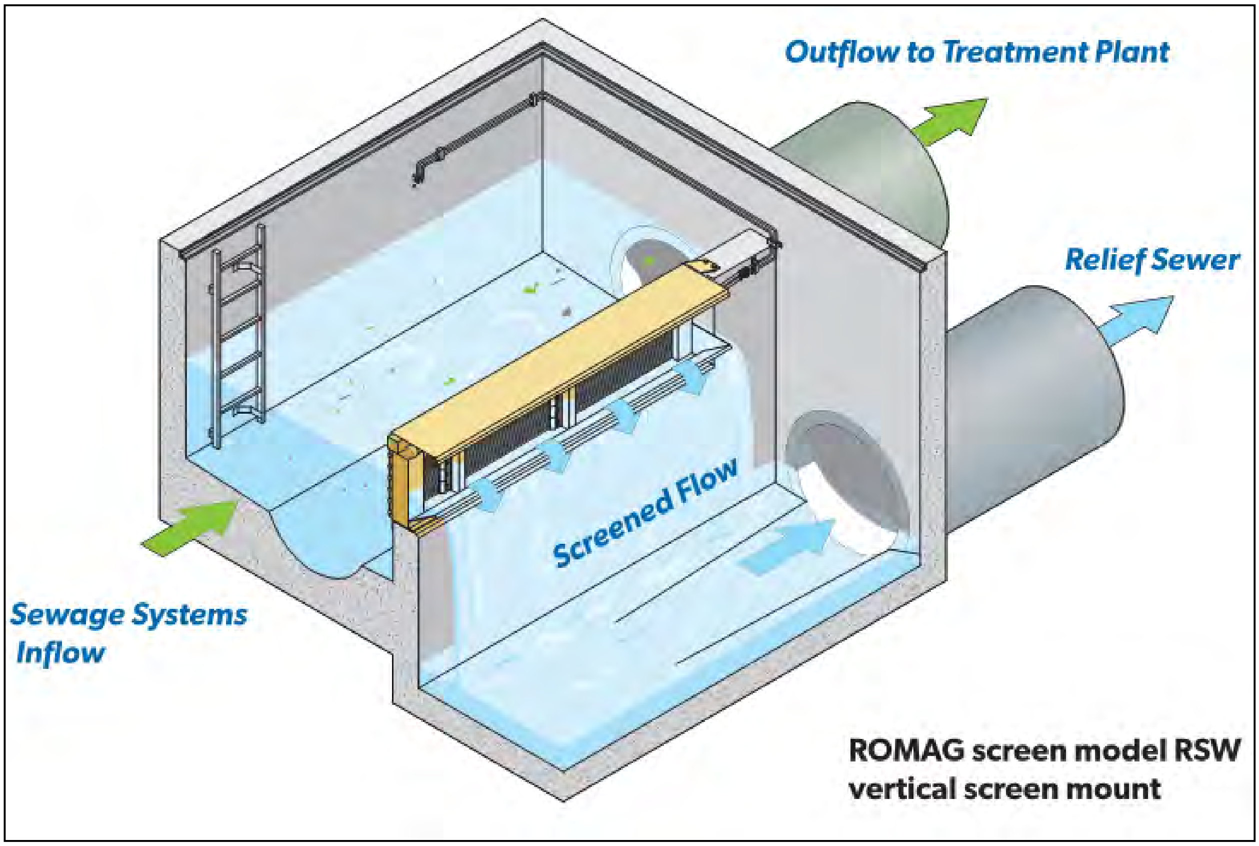
2.2.2 Fine Screens

Description of Process

These screens have openings ranging from 1/8" to 1/2", and will capture suspended and floatable material with smaller dimensions. The equipment evaluated under this category of screenings technology includes ROMAG™ Screens as manufactured by WesTech Engineering, Inc.

The ROMAG™ Screens consist of parallel bars similar to a bar screen, with spacing varying from 0.16" to 0.47". The screens are cleaned by combs, which extend through the rack and are attached to a hydraulically driven mechanism on the downstream side of the screen. The hydraulic unit is located above grade in an enclosure. The material collected on the upstream side of the screen is cleaned off the face of the screen by the combs and kept in the flow in the interceptor. They are not removed or collected, but continue toward the wastewater treatment plant for removal. As the flow increases beyond the capacity of the screens, the upstream water surface rises and overflows a baffle that is part of the screen assembly, discharging directly to the outfall. All the fine screens of this category are located such that the solids are retained on one side of the screen and transported to the interceptor or other facility for ultimate disposal. **Figure 2-3** shows the cross section of vertical mount ROMAG™ Screens.

Figure 2-3 - Cross Section of ROMAG Screens



(Source: WesTech Engineering, Inc.)

Applicability to the Project

Fine screens have proven to be a relatively simple and inexpensive means of removing floatables and visible solids where the overflow is controlled by a weir. They are typically constructed in the regulator, sometimes requiring modifications to the regulator, such as moving the weirs, and extending the weir lengths. The required screening capabilities for the maximum flow rate would need to be provided, since flows exceeding the capacities of the screens will continue to overflow unscreened. See Appendix B for a list of installation of ROMAG™ Screens for CSO application.

Performance Under Similar Conditions

As stated above, fine screens are typically installed in CSO regulators and operate successfully to remove floatables and visible solids over the fluctuations in flow rates seen in CSOs. Slight removal of TSS, total phosphorous, and total nitrogen (typically 10%, 8%, and 5%, respectively) can be achieved with the solids removal.

Hydraulics

The typical head loss reported through the unit is 4 inches, while additional freeboard from the maximum flow through the screens to the baffle height is typically 2 inches. The total head loss through the screen is typically about 6 inches at the design flow.

Flows exceeding the capacity of the screens would overflow the baffle and by-pass the screen. Usually additional weir length is needed so that the existing upstream water surface elevations are maintained after the screen is installed

Generation of Waste Streams

Fine screens are located in the regulator with flow passing up and through the screen, overflowing the weir and going out the outfall. Since the flow direction is up through the screen, the screened material is kept on the interceptor side of the screen, and remains in the interceptor when the cleaning mechanism cleans the face of the screen. Since the screenings remain in the interceptor, there is no collection at the screen and therefore no waste stream. Nevertheless, the limitation is that there be adequate flow and solids transport within the interceptor sewer system. The additional screening material that remains in the interceptor will find its way to any downstream regulators, and eventually to the WWTP.

Complexity

Fine screens can function intermittently, at remote locations with the minimum of instrumentation. A level detector is needed to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer can be utilized to periodically exercise the screen, so it is ready for use.

Limitations

Fine screens would need to be installed on regulators with side overflow weirs. Other types of regulators would require the construction of a weir, at which point the use of a mechanical bar screen may be preferable. Also, any regulators where the fine screens would be installed would need to be accessible for routine inspection and maintenance of the screens. A review of the pollutant removal rates as reported by the manufacturer indicates that only about 10% of the TSS is removed by the screen. While screening of solids may be adequate for the lower treatment objectives (50%, 85%, and 95% removals) where TSS levels are not as critical, the literature does not indicate that screening alone will remove adequate solids to provide for consistent and reliable disinfection at higher treatment objectives. The higher TSS removal rates of fine screens versus mechanical bar screens (10% vs 5% respectively) may result in TSS levels acceptable for disinfection at lower treatment objectives.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-4 for ROMAG™ Screens of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. This cost estimates assume that the ROMAG™ Screens will be installed in existing regulators. The costs for modifying a side overflow regulator to accommodate the installation of the screen is included in the installation cost. If the existing regulator cannot be modified to accommodate the ROMAG Screen and side overflow, a new and larger regulating chamber will be required at an additional cost. The installation cost is assumed at 50% of the equipment cost based on the complexity of the installation. Budgetary equipment pricing information for ROMAG™ Screen was gathered from equipment manufacturer WesTech Engineering, Inc. Based on vendor provided information, the largest individual screen can potentially handle up to 100 MGD, and in the case of higher demand multiple screens would be applied side by side. Velocities should be restricted to 5 ft/s. The equipment cost includes the controls, hydraulic power pack and everything needed to operate.

The estimated total construction costs for the ROMAG™ Screens are plotted against flowrate from 10 MGD to 450 MGD in

Figure 2-4.

Operation and Maintenance Costs

The operating costs include the electrical cost for operating the hydraulic power pack and an in-tank (hydraulic fluid) heater (700W-120V). The hydraulic pack operates the cleaning comb action across the screen. Each single ROMAG™ Screen has a hydraulic power pack that consists of a 5HP motor to drive the hydraulic pump. An 1HP in-tank heater for each screen is used to keep the hydraulic fluid at right temperature. Routine maintenance of the ROMAG™ Screens includes visits to the site after each storm to inspect the screens for damage, remove any large material in the channels, and cleanup of any screenings on the floor or equipment, and general wash-down of the area. Routine maintenance also includes the monthly maintenance of the screen such as replacing combs, repairing leaks in the hydraulic lines, maintaining the oil level in the hydraulic drive, and cleaning any level sensors, etc.

Estimated annual operation costs for the ROMAGTM Screens are presented on Table 2-5 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-6.

Table 2-6Space Requirements

Since the fine screens would be installed in the regulators, which would probably be located in the street or existing easement, it is anticipated that there would be no additional space requirements for the fine screens.

Case Studies

Chattanooga, Tennessee utilizes ROMAG™ Screens at their downtown CSO treatment facility. Two RSW 8x7 screens were installed in 2000 and are still in use treating approximately 180 MGD. The maintenance of the screens was reported as minimum, and the automatic cleaning function had been working well with the exception of one instance where the screens became stuck.

The City of Binghamton, NY, has been using CSO screens for floatable control at four CSO locations since 2003. According to conversations with the site supervisor, the screens have been trouble-free. Both sides of the screens can be observed without entering the channel, and weekly inspection takes approximately 5 minutes. Typically, operators hose down the screens to remove residual debris after a storm event. Binghamton operators check the tension of the bars annually, and change hydraulic oil and filters per the Operations and Maintenance manual. No parts have required replacement to date.

Chattanooga, Tennessee utilizes ROMAG™ Screens at their downtown CSO treatment facility. Two RSW 8x7 screens were installed in 2000 and are still in use treating approximately 180 MGD. The maintenance of the screens was reported as minimum, and the automatic cleaning function had been working well with the exception of one instance where the screens became stuck.

Table 2-4 - Preliminary Construction Cost Estimates for ROMAG Screens

Flow	System	Length x Depth	Budgetary Equipment Price	Install Cost(1)	GC General Conditions(2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) Model RSW 4x3/4	9’-10” x 1’-9”	$252,000	$126,000	$37,800	$37,800	$226,800	$680,400
25 MGD	(1) Model RSW 7x4/4	13’-2” x 2’-8”	$305,000	$152,500	$45,750	$45,750	$274,500	$823,500
50 MGD	(1) Model RSW 12x4/4	13’-2” x 4’-3”	$393,000	$196,500	$58,950	$58,950	$353,700	$1,061,100
75 MGD	(1) Model RSW 14x5/4	16’-5” x 4’-11”	$450,000	$225,000	$67,500	$67,500	$405,000	$1,215,000
100 MGD	(1) Model RSW 14x6/4	19’-8” x 5’-1”	$475,000	$237,500	$71,250	$71,250	$427,500	$1,282,500
450 MGD	(6) Model RSW 14x5/4	98’-5” x 4’-11”	$2,700,000	$1,350,000	$405,000	$405,000	$2,430,000	$7,290,000

Notes:

Note:
(1) Installation cost is assumed at 50% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-4 - Total Estimated Construction Cost of ROMAG Screens

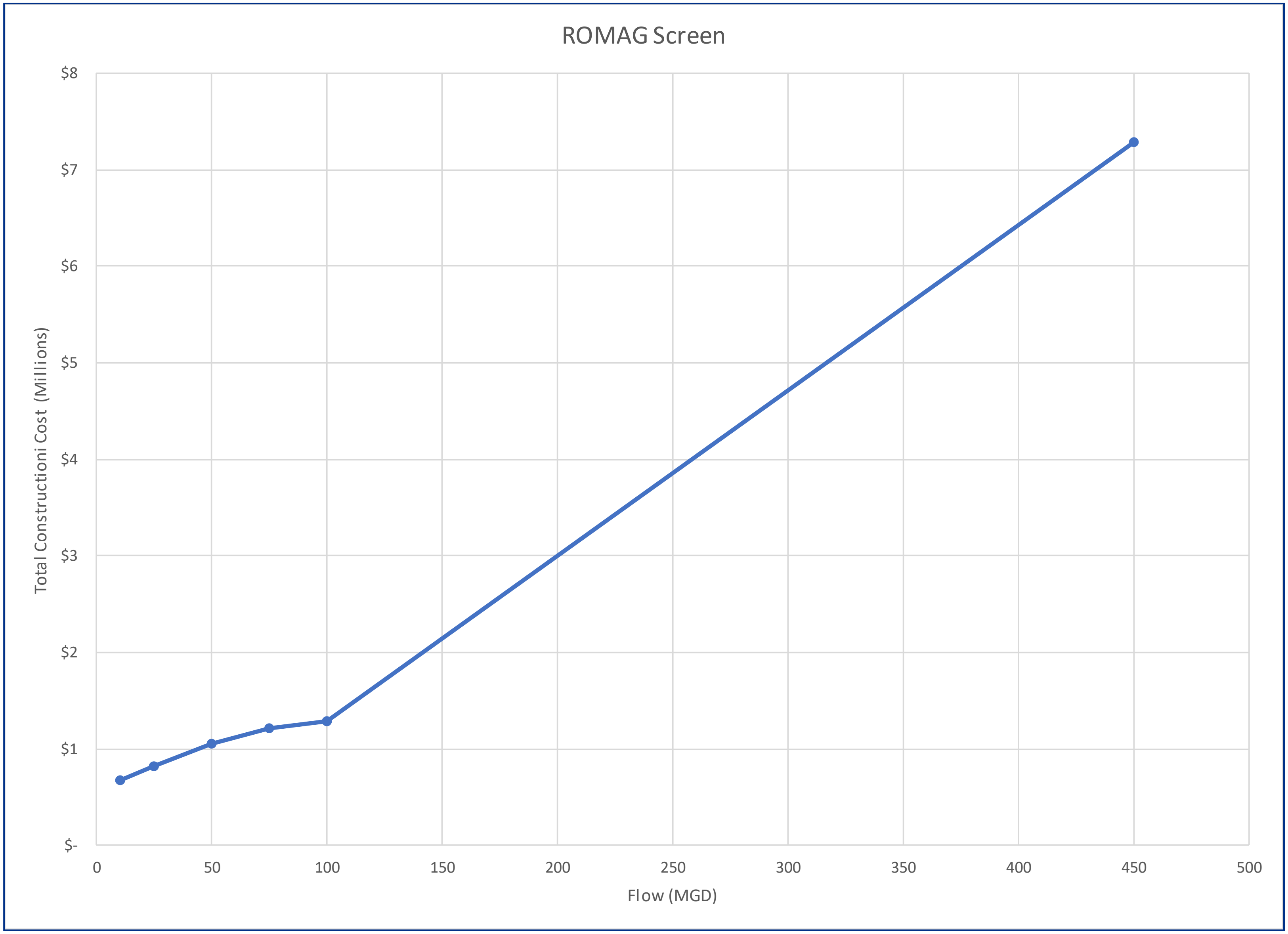


Table 2-5 - Annual Operation Costs of ROMAG Screens

Flow	System	Total Horsepower (HP)	Total Power (kW)$^{(1)}$	Annual Energy Usage (kW-hr)$^{(2)}$	Annual Cost$^{(3)}$
10 MGD	(1) Model RSW 4x3/4	6	4	2,237	$313
25 MGD	(1) Model RSW 7x4/4	6	4	2,237	$313
50 MGD	(1) Model RSW 12x4/4	6	4	2,237	$313
75 MGD	(1) Model RSW 14x5/4	6	4	2,237	$313
100 MGD	(1) Model RSW 14x6/4	6	4	2,237	$313
450 MGD	(6) Model RSW 14x5/4	30	22	11,186	$1,566

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-6 - Annual Maintenance Labor Costs of ROMAG Screens

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost$^{(1)(2)}$
Every 100 Operational Hours	Fasteners	Check for tightness	0.5	$375
Monthly	Screen bars	Check for clogging	0.5	$900
Monthly	Cleaning carriage	Check for proper operation	0.25	$450
Monthly	Piston rod locking nut	Check for tightness	0.25	$450
Monthly	Power pack oil level	Check for proper level and Check lines and piston rod for major fluid loss	0.5	$900
Monthly	Oil filter	Replace filter if necessary	0.25	$450
Annually	Screen Bars	Confirm tension with torque wrench	0.5	$75
Annually	Oil Temperature Probe	Check for proper operation and send sample to oil supplier; replace if required	0.5	$75
Annually	Motor	Lubricate	0.5	$75
After Each CSO Event	General Visual Inspection	Check for proper operation	1	$15,000
Total Annual Maintenance Cost				$18,750

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.2.3 Band and Belt Screens

Description of Process

The common characteristic of these screens is that they contain stainless steel perforated elements forming a continuous band traveling either parallel or perpendicular to the flow stream. In the case where the band is parallel to the channel, flow enters the center of the screen, turns 90 degrees and passes through the sieve elements, exiting through the sides of the unit. Where the band is perpendicular to the channel flow passes through the screen, with the screened flow continuing down the channel.

Figure 2-5 shows a photo of Finescreen Monster, manufactured by JWC Environmental. These screens utilize either stainless steel, or UHMW sheets with perforations between 0.08" to 0.4" mm in diameter.

Figure 2-5 - Photo of Finescreen Monster

(Source: JWC Environmental)

Applicability for the Project

These screens are typically used for polishing wastewater treatment flows. Their perforated panels are very prone to clogging from fibrous materials and are not easily cleaned. To protect these screens from larger objects that could damage or clog them, the manufacturers recommend installing ¾ inch screens upstream of them. However, that ¾ inch screen upstream of the belt and band screen would have the same pollutant removal efficiency and thus the belt and band screen would be ineffective. Accordingly, it does not appear to be practical to utilize these types of screens in a CSO application. There currently are no known installations on CSO discharges.

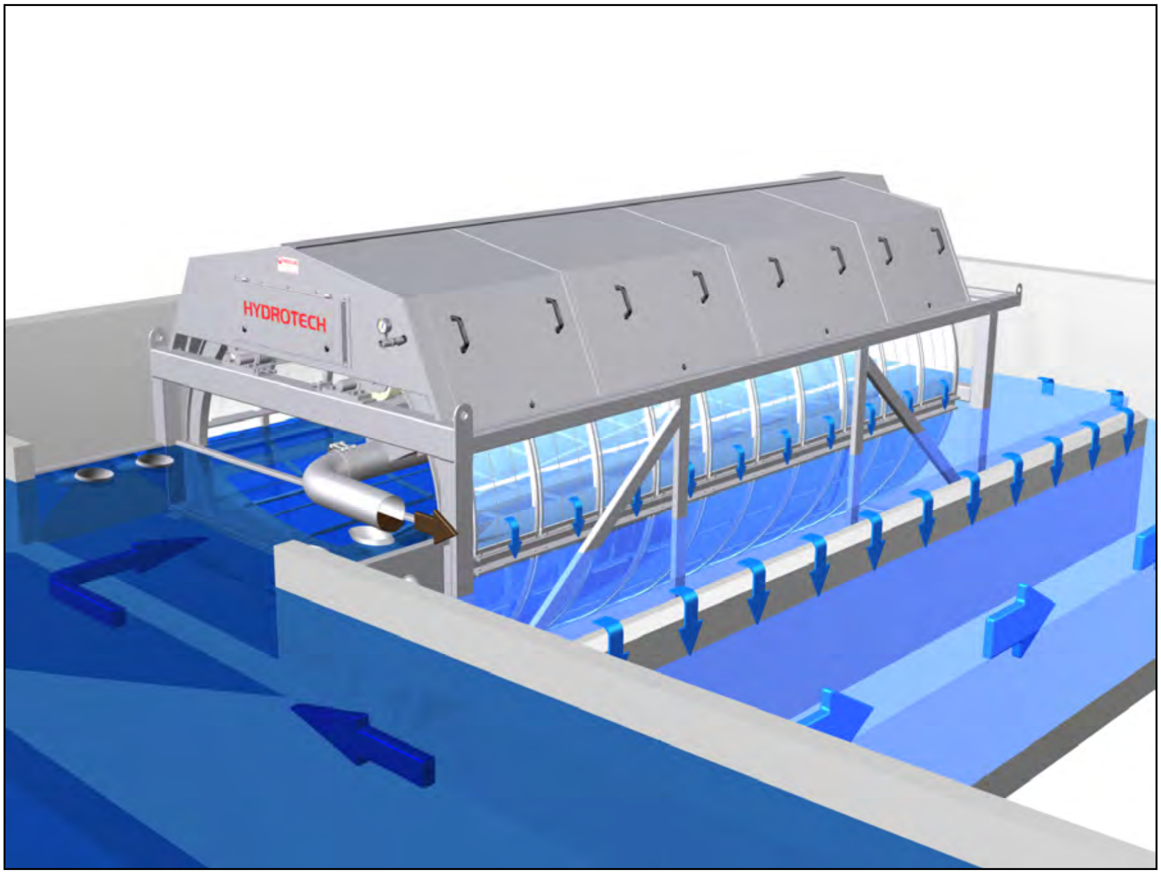
These screens are not considered applicable for CSO treatment and not further evaluated.

2.2.4 Drum Screens

Description of Process

A drum screen is a fine filter with openings from 10 to 1000 microns. The filter cloth is made of acid proof steel or polyester. Three, four, or five filter elements are placed in sections over a rotating drum, depending upon the drum diameter. The drum rotates in a tank. The liquid is filtered through the periphery of the slowly rotating drum. Assisted by the filter elements special cell structure, the particles are carefully separated from the liquid. Separated solids are rinsed off the filter cloth into the solids collection tray and discharged. The operation of the drum can be continuous or automatically controlled. The unit evaluated for this application was the HydroTech Drumfilter by Veolia Water Technologies. Figure 2-6 shows a cross section HydroTech Drumfilter.

Figure 2-6 - Cross Section of HydroTech Drumfilter



(Source: Veolia Water Technologies)

Applicability for the Project

Drum filters are currently used as a polishing unit at WWTPs. The disc media is polyethylene and the size openings are 10 microns for wastewater. The hydraulic loading for drum filters is 50 to 100 gpm/ft^2, based upon an influent TSS concentration of 20 mg/L. The manufacturer expects an influent TSS concentration of 10 to 100 mg/L upstream of the unit. Accordingly, significant TSS removal equipment would be needed upstream of the screen. There currently are no known installations on CSO discharges.

These screens are not considered applicable for CSO treatment and not further evaluated.

2.2.5 Evaluation of Screening Technology

The above sections evaluated each of the screening processes considered for pretreatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the most effective, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each screening unit in relationship to each category and subcategory. The results of the evaluation are illustrated on Table 2-7.

Based upon the evaluation results in Table 2-7, fine screens received the highest results followed by mechanical bar screens, band and belt screens, and drum screen. requirements, which is reflected in their rating. Fine screens and mechanical bar screens should be considered as part of this TGM. Drum screens and band and belt screens were not considered applicable, and did not undergo further consideration.

Table 2-7 - Evaluation of Screening Technology

Criteria	**Mechanical Bar Screens**	**Fine Screens**	**Band and Belt Screens**	**Drum Screens**
Applicability	5	5	1	1
Performance				
TSS	1	3	4	4
Solids and Floatables	1	2	4	4
Hydraulics	4	4	1	1
Waste streams	3	5	1	1
Complexity	5	5	1	1
Limitations	2	2	1	1
Construction Cost	4	2	1	1
Operations	4	4	1	1
Maintenance	4	3	1	1
Space Requirements	3	2	1	1
Total	31	32	16	16

2.3 Pretreatment Technology

Pretreatment technology is used to remove floatable and total suspended solids (TSS) prior to high rate disinfection in CSO applications. The pretreatment technology evaluated for the TGM includes vortex/swirl separation technology, ballasted flocculation, and compressed media filtration.

The choice of a pretreatment technology is a function of construction costs, space requirements, and type of disinfection treatment process downstream. In general, pretreatment is very effective in removing floatable and TSS. It can also remove certain amount of fecal coliform, enterococci, BOD, COD, NH3, TKN, total phosphorous, and total nitrogen, which is attached to the TSS.

The following sections describe the types of pretreatment technology, as well as its capability to remove the various pollutants of concern. At the end of the section a summary of performance, operation, and environmental impacts will be presented.

2.3.1 Vortex/Swirl Separation Technology

Vortex/swirl separation technology utilizes naturally occurring forces to remove solids and floatable material. Flow enters a circular tank tangentially causing the contents to rotate slowly about the vertical axis. The flow spirals down the perimeter allowing the solids to settle out. This process is aided by rotary forces, shear forces, and drag forces at the boundary layer on the wall and base of the vessel. The internal components direct the main flow away from the perimeter and back up the middle of the vessel as a broad spiraling column, rotating at a slower velocity than the outer downward flow. Per manufacturer claims, by the time the flow reaches the top of the vessel it is virtually free of settleable solids and is discharged to the outlet channel. The collected solids are then discharged by gravity or pumped out from the base of the unit to the interceptor sewer or auxiliary storage tank if interceptor capacity is not available.

Conventional vortex separators such as Storm King®, manufactured by Hydro International, and the HYDROVEX® FluidSep manufactured by John Meunier were reviewed for this Technical Guidance Manual. A variation of the typical vortex/swirl separation process - the SanSep equipment from PWTech is evaluated as well.

The following provides a discussion of each of the above referenced unit processes, as well as its reported capability to remove the various pollutants of concern. A summary of performance, operation, and limitations or constraints, is provided at the end of this section.

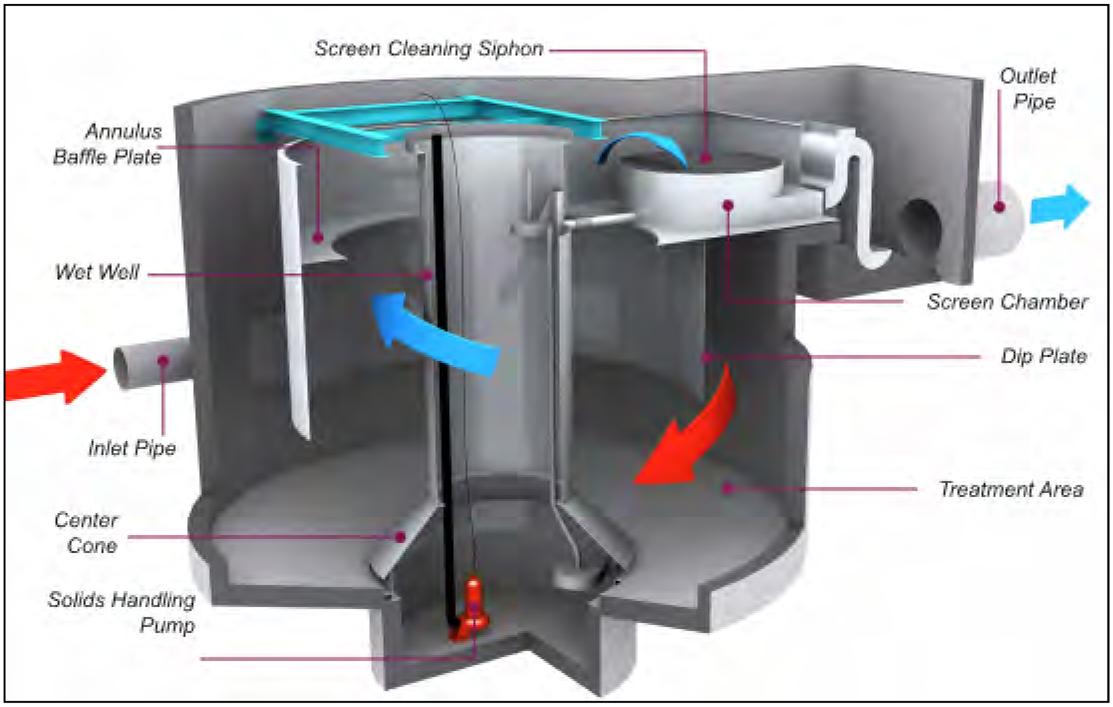
2.3.1.1 Storm King® Vortex Separator

Description of Process

Flow is introduced tangentially into the side of the Storm King®, causing the contents to rotate slowly about the vertical axis. The flow spirals down the perimeter allowing the solids to settle out. This process is aided by rotary forces, shear forces, and drag forces at the boundary layer on the wall and base of the vessel. The internal component directs the main flow away from the perimeter and back up the middle of the vessel as a broad spiraling column, rotating at a slower velocity than the outer downward flow. A dip plate locates the shear zone, the interface between the outer downward circulation and the inner upward circulation, where a marked difference in velocity encourages further solids separation. Settled solids are directed to the helical channel located under the center cone and are conveyed out of the main chamber through the underflow outlet. The flow passes down through the Swirl Cleanse screen which captures floatables and neutrally buoyant material greater than 4mm in diameter. The air regulated siphon provides an effective backwash mechanism to prevent the screen from blinding. Screened effluent is discharged into a receiving watercourse, a storage facility, or continues on to receive further treatment. The collected solids are then discharged by gravity or pumped out from the base of the unit to the sanitary sewer.

Typical design loading rates are from 7 to 44 gpm/sf. This loading rate is based on the flow coming in and the horizontal surface area of the circular vortex unit. Cross section of a Storm King® Vortex Separator in full operation is provided in Figure 2-7.

Figure 2-7 - Cross Section of Storm King Vortex Separator



(Source: Hydro International)

Applicability to the Project

Based on manufacturer publications, Storm King® units have been used for floatables control, primary treatment equivalency of CSOs and wet weather induced flows. The first installation of Storm King® units for CSO application was in mid-1995 in Hartford CT. See Appendix C for a list of Storm King® installation in the US for CSO application.

The units have been installed in remote locations, away from treatment plants and reportedly performed well. There are no moving parts within the vortex unit itself. Underflow from the unit can be discharged by gravity to sewers or continuously pumped to an ancillary tank where it would be stored until there is capacity in the interceptor sewer system. Underflows from the unit run approximately 10% of the design flow and thus the volume from the underflow can be significant.

Performance

The Storm King® vortex separator is most effective in removing heavier settleable solids, floatable material, and inorganic solids. The performance information provided by the manufacturer indicates that the percent removal of TSS, BOD and COD drops off as the hydraulic loading rate increases. TSS removal ranges from 35-50%, and BOD removal is typically 15-25%. Vortex units achieve removal by two means: the consolidation of solids material; and flow separation, which is accomplished by the underflow removal. When the vortex unit operates under low hydraulic loading rates, and there is a significant amount of settleable solids, both removal mechanisms are operating. As the hydraulic loading rate increases, or the settleable solids concentration decreases, there is less consolidation and the vortex unit functions more as a flow separator. At the highest hydraulic loading rates recommended, the unit functions strictly as a flow separator. The vortex units, the Storm King included, usually have an underflow that is 10% of the design capacity of the unit. So even under the worst conditions, when there is no consolidation of solids taking place, they would theoretically remove 10% of the pollutants. While this would hold true for the soluble portion of pollutants, in the case where the pollutant was associated with fine particles, the removal would be less. The reason for this decrease is that since fine particles weigh less, more of these particles would be carried out in the effluent especially at higher hydraulic loading rates. Some of the removals associated with these units are for lower volume storms when the volume associated with the unit acts as a storage system.

In the Bayonne MUA Pilot Study, the Storm King® units experienced operating issues due to their screens clogging with materials that appeared to be primarily toilet paper. Performance issues of less than 10% TSS removals were experienced when Volatile Suspended Solids (VSS) accounted for a high percent of the influent TSS. The TSS removal efficiencies improved when evaluating the inorganic component of TSS, or Fixed Suspended Solids (FSS). The FSS removal efficiencies for Storm King® units averaged around 17%, with the maximum removal efficiencies of 45.2%. The low removal of VSS (or inorganic) fraction of TSS indicated that the Storm King® units will be ineffective on their own with UV disinfection due to low ultraviolet light transmittance of the effluent.

Hydraulics

Vortex units are hydraulically efficient. The head loss through the unit consists of the losses through the inlet to the unit, and the head loss over the effluent weir. The losses in the lower hydraulic loading rates will be limited to less than six inches. At higher hydraulic loading rates, the losses will increase significantly, possibly up to a couple of feet, unless diverted upstream.

Generation of Waste Streams

As discussed under the description of the process and the performance: 10% of the design flow must continuously be removed as underflow. In many cases this flow will need to be pumped from the vortex unit due to the depth of the underflow pipe. While permittees with conveyance facilities must evaluate means of increasing conveyance to the WWTP, it is doubtful that the underflow can be consistently and constantly transported to the interceptor. In locations where interceptor capacity is not available during the overflow, the underflow must be stored in ancillary tanks. The capacity of these ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process, especially since there are no moving parts within the unit. Removals are achieved using natural forces and no adjustment of equipment is necessary. The only controls that are needed are in the flow coming to the unit to ensure that the unit operates within its hydraulic loading rates. This can be accomplished using sluice gates or overflow weirs. The other area requiring instrumentation would be the control of the underflow sump where underflow is pumped out. The control of the pumping units would be by floats, bubblers, or ultrasonic level sensors.

Limitations

As previously indicated, the hydraulic loading rate is key to the performance of the vortex/swirl separator. Therefore, the limitation to this process occurs for the more stringent treatment objectives. Since a required and consistent effluent TSS must be achieved for the disinfection process to be effective, the variations in flows, particularly above the required hydraulic loading rate, result in a reduced removal of TSS and a corresponding decrease in the efficiency of the disinfection process. If the excess flows are by-passed around the vortex unit, going directly to disinfection, as required by the NJPDES requirement for complete disinfection, the higher TSS concentrations will again result in decreased disinfection efficiency. This represents a limitation on the process for the higher treatment objectives.

Construction Costs

Budgetary equipment pricing information for Storm King® vortex separator was obtained from equipment manufacturer Hydro International, Inc. Table 2-8 presents preliminary planning level construction cost estimates for flows ranging from 10 MGD to 450 MGD. It includes equipment cost, concrete cost associated with the construction of the tank containing the vortex structure, cost for ancillary tank for underflow storage, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing provided by the equipment manufacturer Hydro International includes only the fabricated stainless-steel vortex structures inside. Cost for outside concrete tank enclosure were estimated based on the sizes of the vortex units. Construction costs for excavation, sitework, soil support, and dewatering, as well as the underflow wet well and the pumps are included in the installation costs. The estimated total construction costs for the Storm King® Vortex Separator are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-8.

Operation and Maintenance

The operating costs for the Storm King® vortex separator are associated with the power of the underflow pump. The horsepower of the pumps required increases as the size of the vortex separator, and corresponding underflow, increases. Regular maintenance required for the Storm King® unit includes inspection of the vortex separator after each rainfall event, replacement of the underflow pumps every 6 months for overhaul and sharpening of the cutter blades, and vacuuming out the floatable material that will accumulate in the underflow wet well.

Estimated annual operation costs for the Storm King® vortex separator are presented on Table 2-9 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-10.

Space Requirements

The space requirements of the Storm King® vortex separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Studies

According to literature obtained from Hydro International, Bucksport, ME, has been using Storm King® since 2008 as a solution to CSO related flooding caused by the nearby Penobscot River. The installation of satellite treatment within the collection system saved the city from expanding the capacity of their wastewater treatment plant. Solids which settle out from the Storm King® are fed via gravity from the base of the unit to the sewage treatment plant. Additionally, the system is used as a chlorine contact and mixing chamber for the reduction of fecal coliforms before effluent is discharged into the Penobscot River. Since the system was commissioned, all rain events the system has handled have been treated in accordance with regulatory requirements

The 18’ (5.5 m) diameter Storm King® system was constructed in a park and is housed within a building which may resemble a restaurant. Residents are impressed with the installation. Bucksport has designed the facility such that a Swirl-Cleanse screening component may be added in the future which will allow capture of all floatables and neutrally buoyant material greater than 4 millimeters in diameter.

According to literature obtained from Hydro International, Saco, ME, has been using a 22-ft diameter Storm King® since November 2006. Sedimentation and screening are followed by disinfection using sodium hypochlorite (NaClO) in the flow tank. A Swirl-Cleanse screen is installed in this system which captures all floatables and neutrally buoyant material greater than 4 millimeters in diameter. Influent Total Suspended Solids (TSS) levels are in the range of 300 mg/L. Treated effluent TSS is typically 60mg/L or lower. Treated effluent is discharged directly into the Saco River, while the collected screenings and settleable solids are pumped back to the wastewater treatment plant for processing.

Engineers who worked on the Saco Sewer Project have been impressed with the performance of the Storm King® even in storms much larger than the set design criteria. The system requires maintenance crews to perform a quick wash down the tank after a storm. Additional maintenance is minimal.

Table 2-8- Preliminary Construction Cost Estimates for Storm King Vortex Separator

Flow	System	Diameter	Budgetary Equipment Price	Concrete Structure Cost	Auxiliary Tank Cost(1)	Install Cost(2)	GC General Conditions (3)	GC OH&P(4)	Contingency(5)	Total
10 MGD	(1) StormKing 10 MGD	28’	$739,000	$82,000	$871,200	$1,269,150	$296,135	$296,135	$1,776,810	$5,330,430
25 MGD	(1) StormKing 25 MGD	38’	$1,403,000	$181,000	$1,573,000	$2,367,750	$552,475	$552,475	$3,314,850	$9,944,550
50 MGD	(2) StormKing 25 MGD	38’	$2,797,000	$291,500	$2,300,000	$4,041,375	$942,988	$942,988	$5,657,925	$16,973,775
75 MGD	(2) StormKing 37 MGD	42’	$3,831,000	$291,500	$3,040,000	$5,371,875	$1,253,438	$1,253,438	$7,520,625	$22,561,875
100 MGD	(3) StormKing 35 MGD	42’	$5,733,000	$359,000	$3,720,000	$7,359,000	$1,717,100	$1,717,100	$10,302,600	$30,907,800
450 MGD	(10) StormKing 45 MGD	44’	$23,463,000	$718,000	$10,890,000	$26,303,250	$6,137,425	$6,137,425	$36,824,550	$110,473,650

Notes:
(1) Auxiliary Tank costs derived from quotation from Mid Atlantic Storage System on Aquastore Glass Fused to Steel Storage Tank of 150,000 gal
(2) Installation cost is assumed at 75% of the equipment cost.
(3) GC general conditions are estimated at 10% of the total direct cost.
(4) GC OH&P are estimated at 10% of the total direct cost.
(5) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-8 - Total Estimated Construction Cost of Storm King Vortex Separator

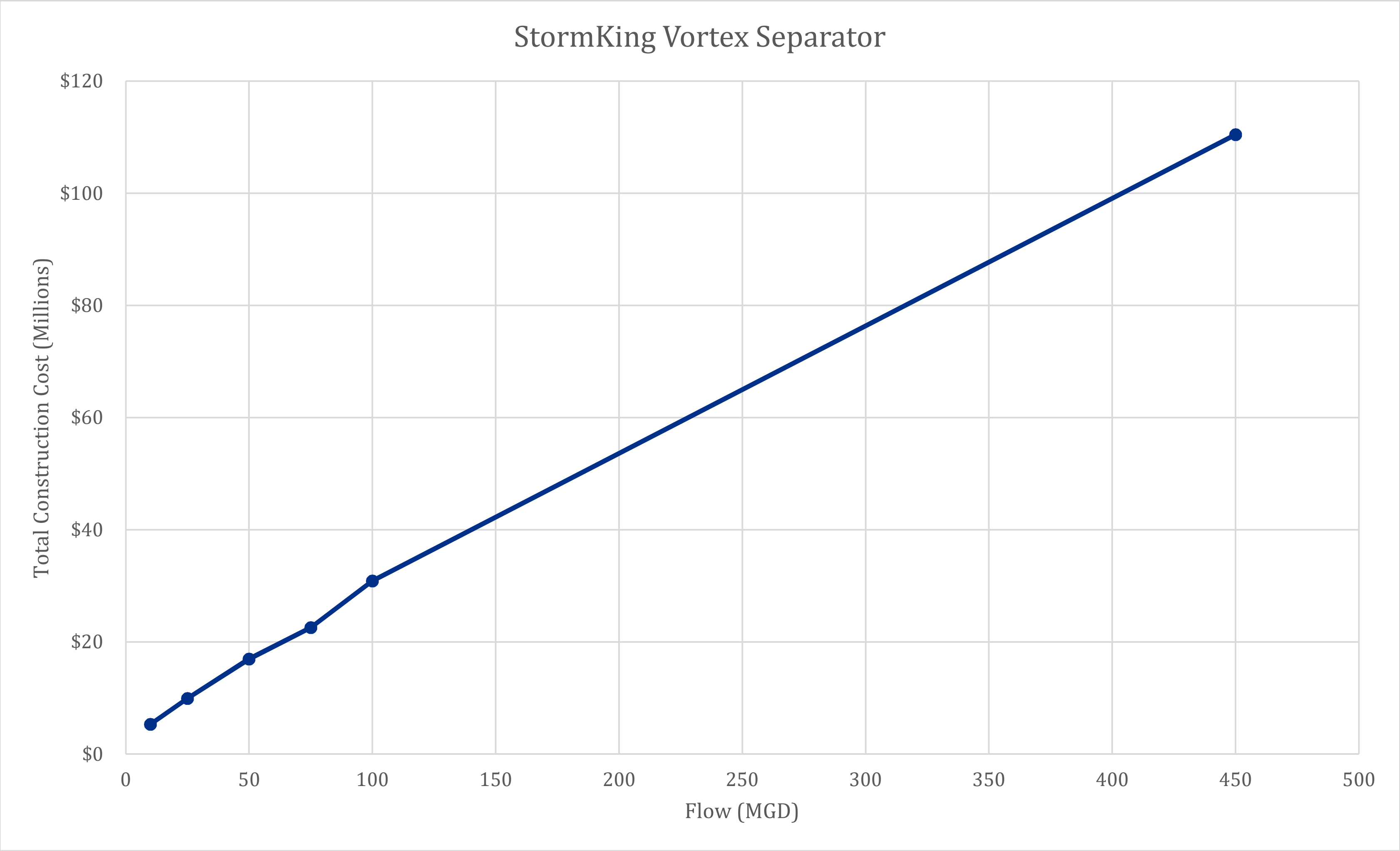


Table 2-9 - Annual Operation Costs of Storm King Vortex Separator

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) StormKing 10 MGD	14	10	1	$731
25 MGD	(1) StormKing 25 MGD	35	26	4	$1,827
50 MGD	(2) StormKing 25 MGD	70	52	7	$3,654
75 MGD	(2) StormKing 37 MGD	104	78	11	$5,429
100 MGD	(3) StormKing 35 MGD	139	104	15	$7,256
450 MGD	(10) StormKing 45 MGD	625	466	65	$32,624

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-10 - Annual Maintenance Labor Costs of Storm King Vortex Separator

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)
Biannually	Valve inlet and outlet	Visual check and removal of coarse debris	1	300
Biannually	Underflow pumps	Visual check	1	300
Every three years	Underflow pumps	Replacement of underflow pumps	8	400
Total Annual Maintenance Cost				$1,000

Notes:

(1) Assumes labor rate of $150/hour

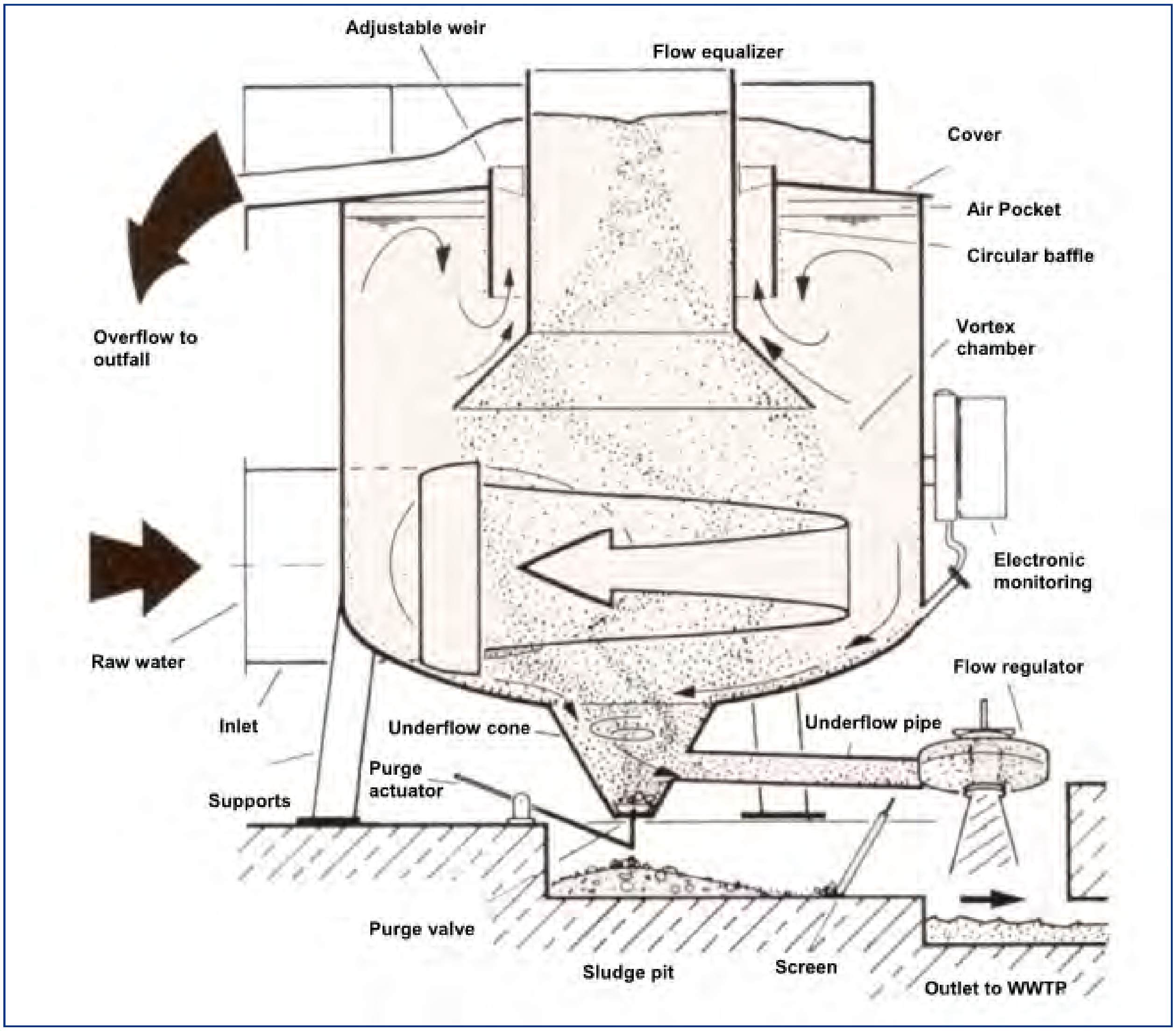
2.3.1.2 HYDROVEX® FluidSep Vortex Separator

Description of Process

In CSO installations, the dry weather flow that enters the HYDROVEX® FluidSep Vortex Separator passes by freely on the sloped bottom towards the central cone of evacuation and then through a flow regulator. During a storm event, the incoming flow becomes greater than the regulated outflow. This will effectively start the filling of the vortex separator. Many minor events can be fully intercepted and contained inside the vortex separator volume without actual overflow. For more intense or more durable storm events, the HYDROVEX® FluidSep Vortex Separator starts overflowing through its central annular overflow weir. This weir is made of two plunging cylindrical treatment baffles providing a double crown arrangement. The overflow water is evacuated through the ring-shaped opening formed by these two treatment baffles. The overflow is fixed in the circular opening of the top cover of the vortex separator structure. The overflowed water falls from the weir on the upper chamber of the separator and is then evacuated, either towards an additional treatment system or directly to the outfall. Due to its tangential inlet port, the incoming water brings the mass of retained water into a rotational movement inside the tank. The resulting flow pattern is non-turbulent and very favorable to the separation of suspended solids. These particles can readily settle and are furthermore pulled by the centrifugal currents towards the wall of the separator. Once the particles are caught on the limit layer along the walls, they fall to the structure bottom and are finally brought to the unit's evacuation cone. From there, they are carried out with the underflow water through the regulator. When the HYDROVEX® FluidSep Vortex Separator is filled, an air pocket is formed under the unit's cover, imprisoned by the baffle partition arrangement. The floatables entering the separator will be caught there and will simply circulate around until the unit progressively gets back to dry time flow conditions. The lower surface of the cover always remains free of water, due to the captured air pocket.

The proper selection of the HYDROVEX® FluidSep implies that the unit operating size is efficient for all flows up to the design flow. When flows higher than the design flow are received, the unit will operate at a lesser efficiency level. The collected solids are then discharged by gravity or pumped out from the base of the unit to the sanitary sewer. Loading rates vary from 3 gpm/sf to 21 gpm/sf. Cross section of a HYDROVEX® FluidSep Vortex Separator in full operation is shown in Figure 2-9.

Figure 2-9 - Cross Section of a HYDROVEX® FluidSep Vortex Separator



(Source: John Meunier, Inc.)

Applicability

The HYDROVEX® FluidSep Vortex Separator was developed in 1985 by a German firm, Umwelt-und Fluid-Technik (UFT) as a tool in the treatment of CSO and stormwater. The first HYDROVEX® Fluidsep unit was installed in 1987 in the City of Tengen near Schaffhausen in Germany. The units are still operating successfully. A special research program that ended in the summer of 1990 supplied evidence of CSO treatment efficiency of the HYDROVEX® FluidSep (H. Brombach, *et al.*, 1993). The program was based on the qualitative evaluation of sampling campaigns performed at the installation.

HYDROVEX® FluidSep is currently in full operation in Germany, France, Canada, and the United States of America. John Meunier Inc./Veolia Water Technologies designs and manufactures HYDROVEX® FluidSep units for the North America under license from UFT. See Appendix D for an installation list of HYDROVEX® FluidSep units in the North America. All the installations included on the list are for CSO applications. HYDROVEX® FluidSep Vortex Separator are most effective on removing settleable solids and floatable material. The units have been installed in remote locations, away from treatment plants and have performed well. There are no moving parts within the vortex unit itself. Underflow from the unit can be discharged by gravity to sewers or continuously pumped to an ancillary tank where it would be stored until there is capacity in the interceptor sewer system.

Performance

The performance of HYDROVEX® FluidSep Vortex Separator is similar to that described above for the Storm King® Vortex Separator in terms of contaminants removal since they use similar mechanism for solids removal.

Hydraulics

Vortex units are hydraulically efficient. The head loss is comparable to that described above for the Storm King**®** Vortex Separator.

Generation of Waste Streams

As discussed under the description of the process and the performance, 10% of the design flow will continuously be removed as underflow. This flow must be pumped from the vortex unit, and since the interceptor is full, no capacity will exist in the interceptor during an overflow event. Therefore, the underflow must be stored in ancillary tanks. The capacity of the ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process. Hydraulic loading rates can be controlled using sluice gates or overflow weirs. Floats, bubblers, or ultrasonic level sensors would be used to control the underflow sump similar to the Storm King® Vortex Separator.

Limitations

The limitations of the HYDROVEX® FluidSep Vortex Separator are similar to those described above for the Storm King**®** Vortex Separator.

Construction Costs

Table 2-11 presents preliminary planning level construction cost estimates for flows ranging from 10 MGD to 450 MGD. It includes equipment cost, concrete cost associated with the construction of the tank containing the vortex structure, cost for ancillary tank for underflow storage, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing provided by the equipment manufacturer Veolia Water Technologies includes only the fabricated stainless-steel vortex structures inside. Cost for outside concrete tank enclosure were estimated based on the sizes of the vortex units. Construction cost for excavation, sitework, soil support, and dewatering, as well as the underflow wet well and the pumps are included in the installation costs. The estimated total construction costs for the HYDROVEX® FluidSep Vortex Separator are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-8.

Operation and Maintenance

The operating costs for the HYDROVEX® FluidSep Vortex Separator are the power costs for the underflow pump. The horsepower of the pumps increases as the size of the vortex separator, and correspondingly the underflow, increase. Maintenance costs for the HYDROVEX® FluidSep unit include inspection of the vortex separator and removal of coarse debris (if any) after first heavy rainfall event and then every six months. Once every year, a full inspection of the unit is recommended, including cleaning of the area, visual inspection for abnormalities, like leaks, cracks in the unit's tank and pipe works. Perform visual inspection of all anchors and bolted assemblies. During visual inspection, all normal safety procedures are recommended to be used to prevent any kind of injury. Underflow pumps are recommended to be replaced every six months for overhaul and sharpening of the cutter blades.

Estimated annual operation costs for the HYDROVEX® FluidSep Vortex Separator are presented on Table 2-12 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-13.

Space Requirements

The space requirements of the HYDROVEX® FluidSep Vortex Separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Study

In 2016, Mattoon, IL installed a HYDROVEX® FluidSep Vortex Separator at their Riley Creek satellite CSO treatment facility. As of September 2017, the unit has not been in service yet. The Riley Creek facility is in a remote location and designed for 15 MGD. The application required a 12" gravity underflow line (at 2 ft/s flow) for 3 or 4 MGD of underflow, which will get pumped back to the wastewater treatment plant. This large amount of underflow requires having almost one pump dedicated to pumping it back to the WWTP.

Table 2-11 - Preliminary Construction Cost Estimates for HYDROVEX Fluidsep Vortex Separator

Flow	System	Diameter x Depth	Budgetary Equipment Price	Concrete Structure Cost	Auxiliary Tank Cost(1)	Install Cost(2)	GC General Conditions (3)	GC OH&P(4)	Contingency(5)	Total
10 MGD	(1) Type 1	20’-0” x 20’-0”	$60,000	$82,000	$871,200	$759,900	$177,310	$177,310	$1,063,860	$3,191,580
25 MGD	(1) Type 2	35’-0” x 19’-6”	$81,000	$181,000	$1,573,000	$1,376,250	$321,125	$321,125	$1,926,750	$5,780,250
50 MGD	(1) Type 2	45’-0” x 24’-6”	$85,700	$291,500	$2,300,000	$2,007,900	$468,510	$468,510	$2,811,060	$8,433,180
75 MGD	(1) Type 2	45’-0” x 24’-5”	$85,700	$291,500	$3,040,000	$2,562,900	$598,010	$598,010	$3,588,060	$10,764,180
100 MGD	(1) Type 2	50’-0” x 27’-5”	$113,900	$359,000	$3,720,000	$3,144,675	$733,758	$733,758	$4,402,545	$13,207,635
450 MGD	(4) Type 2	50’-0” x 27’-5”	$455,600	$718,000	$10,890,000	$9,047,700	$2,111,130	$2,111,130	$12,666,780	$38,000,340

Notes:
(1) Auxiliary Tank costs derived from quotation from Mid Atlantic Storage System on Aquastore Glass Fused to Steel Storage Tank of 150,000 gal
(2) Installation cost is assumed at 75% of the equipment cost.
(3) GC general conditions are estimated at 10% of the total direct cost.
(4) GC OH&P are estimated at 10% of the total direct cost.
(5) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-10 - Total Estimated Construction Cost of HYDROVEX FluidSep Vortex Separator

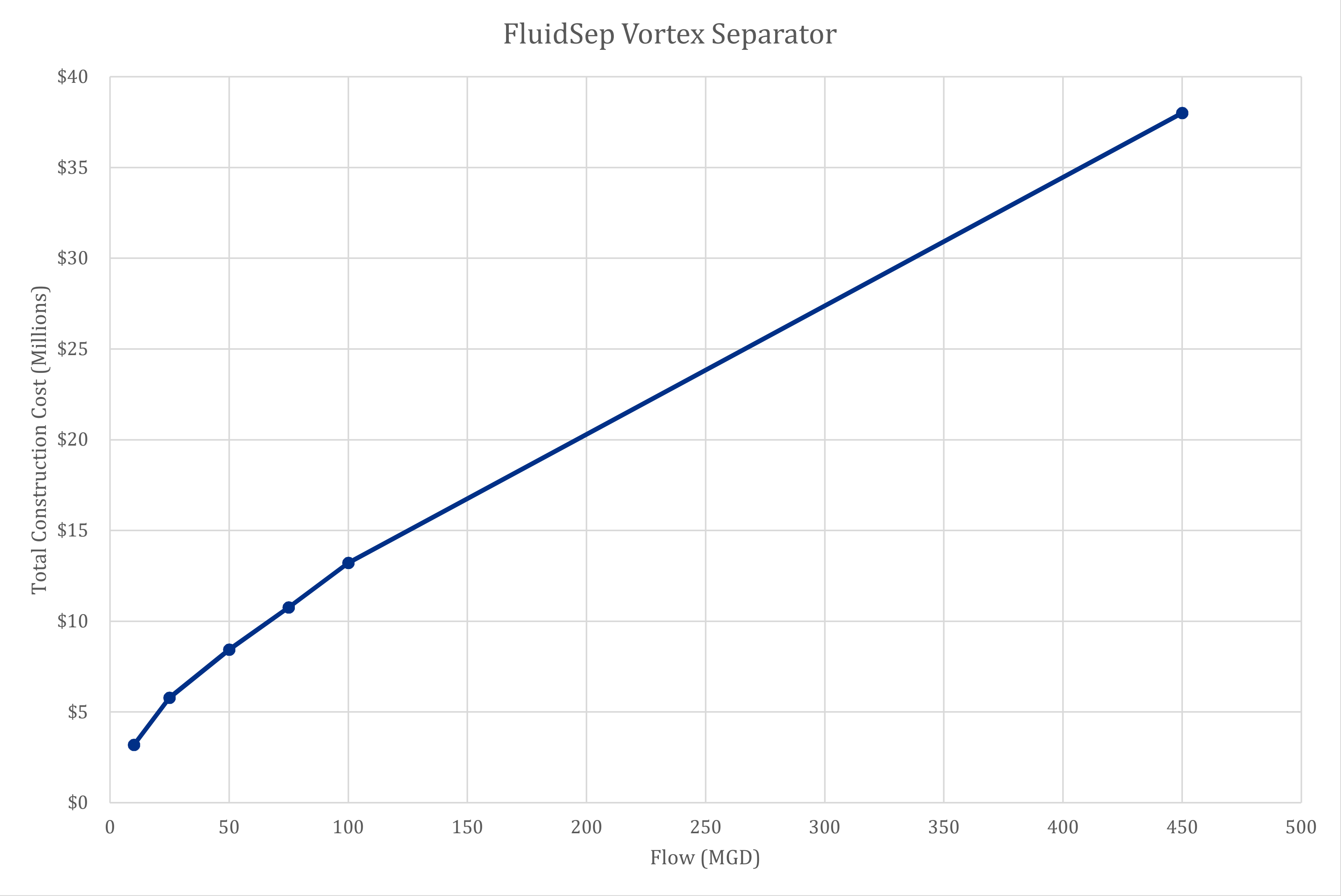


Table 2-12 - Annual Operation Cost of HYDROVEX Fluidsep Vortex Separator

Flow	System	Total Horsepower (HP)	Total Power (kW)⁽¹⁾	Annual Energy Usage (kW-hr)⁽²⁾	Annual Cost⁽³⁾
10 MGD	(1) Type 1	14	10	1	$731
25 MGD	(1) Type 2	35	26	4	$1,827
50 MGD	(1) Type 2	70	52	7	$3,654
75 MGD	(1) Type 2	104	78	11	$5,429
100 MGD	(1) Type 2	139	104	15	$7,256
450 MGD	(4) Type 2	625	466	65	$32,624

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-13 - Annual Maintenance Labor Cost of HYDROVEX Fluidsep Vortex Separator

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost⁽¹⁾
Biannually	Tank and pipe	Visual check and removal of coarse debris (if any)	1	300
Annually	Full Inspection	Cleaning, check for leaks/cracks in unit tank and pipes; visual inspection of all anchors and bolted assemblies	2	300
Biannually	Underflow pumps	Replacement of underflow pumps	8	400
Total Annual Maintenance Cost				$1,000

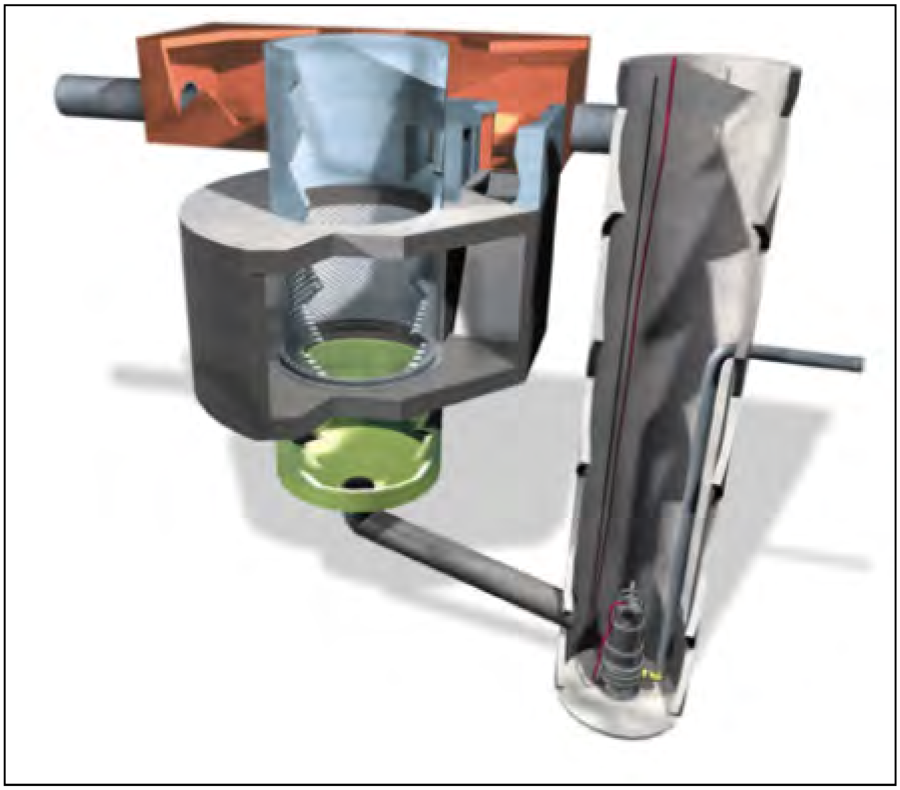
Notes:
(1) Assumes labor rate of $150/hour

2.3.1.3 SANSEP

Description of Process

The SanSep process is a variation of the typical vortex/swirl separation process, in that it utilizes a screen at the mid-depth of the tank where the treated flow exits the tank. Using the patented non-blocking screen, all gross solids larger than 0.04" and finer sediments down to below 0.004" are captured and retained inside the unit. The settleable solid pollutants settle into the lower catchment chamber while the floatables are retained at the surface of the upper chamber. A flow of liquid is maintained across the face of the screen producing a "washing" effect that keeps the solids moving while the fluid passes through the screen. The SanSep is typically automated with an underflow pump, which periodically removes the solids and returns them to the interceptor sewer. The non-blocking screen operates continuously at its maximum design flow. Cross section of a SanSep unit is shown in Figure 2-11.

Figure 2-11 - Cross Section of a SanSep Unit



(Source:PWTech.)

Application to the Project

SanSep was initially developed in Australia as a stormwater treatment system by the corporate predecessor of PWTech (CDS Technologies). The system was introduced in the US in the mid 90’s and first used for CSO applications in Louisville Kentucky. Three units have been in continuous operation there since the late 90s. SanSep units have been installed on CSO applications in Cohoes, New York since 2004, and in in Akron, OH and in Weehawken, NJ. since 2004. See Appendix E for an installation list for SanSep for CSO applications in the US, Europe and the Pacific Rim.

Performance

The SanSep unit is more efficient in removal of solids and other pollutants than conventional vortex/swirl separation units due to the use of the screen. The unit removes all solids larger than 1 mm, including organic debris such as vegetation and coarse sediments, fine organic sediments, and significant amounts of BOD and Phosphorus associated with the organic material and fine sediments captured. The SanSep units are also capable of operating at high separation efficiency, over a larger range of hydraulic loading rates than the conventional vortex/swirl separation units. Hydraulic loading rates for conventional units are based upon the horizontal area of the vortex unit, whereas the hydraulic loading rate for the SanSep units are based upon the area of the screen. The screening area, which is greater than the horizontal surface area, and the continuous cleaning action of the flow across the screen enables the SanSep unit to maintain the higher removal rates than conventional units over a wider range of hydraulic loading rates. The performance information from the manufacturer show that there is light drop in removal of TSS as the hydraulic loading rate increases. TSS removal can drop from approximately 70% to 50% as loading rate increases to about 60 gpm/sf.

Hydraulics

Vortex units are hydraulically efficient. The head loss through the unit consists of the losses through the inlet to the unit, and the head loss through the screen. The losses in the lower hydraulic loading rates will be limited to less than six inches. At higher hydraulic loading rates, the losses will increase.

Generation of Waste Stream

The SanSep process has a reduced underflow of 2-3% of the design flow which will continuously be removed as underflow, compared to conventional vortex units with an underflow of 10%. This flow must be pumped from the vortex unit, and since no or limited capacity will exist in the interceptor during an overflow event, the underflow must be stored in ancillary tanks. The capacity of the ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process, especially since there are no moving parts within the unit. Removals are achieved using natural forces and no adjustment of equipment is necessary. The only controls that are needed are in the flow coming to the unit, in order to ensure that the unit operates within its hydraulic loading rates. This is typically accomplished using sluice gates or overflow weirs. The other area requiring instrumentation would be the control of the underflow sump where underflow is pumped out. The control of the pumping units would be by floats, bubblers, or ultrasonic level sensors.

Limitations

As stated above, the hydraulic loading rate is key to the performance of the vortex/swirl separator. However, since the SanSep unit is able to maintain high removal rates over a wider range of hydraulic loading they perform better in removing TSS, and as a result enable the downstream disinfection processes to be more effective.

Construction Costs

The preliminary report level construction cost estimates provided in Table 2-14 include the equipment, installation, building, land, and contingency for SanSep of design flow ranging from 10 MGD to 100 MGD. Budgetary equipment pricing information for SanSep was gathered from equipment manufacturer Echelon Environmental. Flowrate higher than 100 MGD was considered impractical to use the SanSep unit by the equipment manufacturer. Installation costs are estimated at 150% of the equipment cost per manufacture recommendation. The estimated total construction costs for the SanSep are plotted against flowrate from 10 MGD to 100 MGD in Figure 2-12.

Operation and Maintenance

The operating costs for the SanSep vortex separator are the power costs for the underflow pump. The horsepower of the pumps increases as the size of the vortex separator, and correspondingly the underflow, increase. Regular maintenance required for SanSep unit includes inspection of the vortex separator after each rainfall event. After each event, the PLC for the unit initiates a cleaning and wash-down cycle. During this cycle, the underflow pumps empty the unit, followed by a wash-down with clean water directed at the screen through a series of water jets. If a clean water source is not available, the wash-down can also be accomplished using the spray from a vactor truck. The screen should also receive a periodic inspection from the surface to ensure that the cleaning cycle is removing accumulated debris. Unless large debris is accumulating in the structure, it shouldn't be necessary to enter the unit. If it is ever necessary to enter the unit, confined space entry regulations would apply. The underflow pumps are recommended to be replaced every 6 months for overhaul and sharpening of the cutter blades.

Estimated annual operation costs for the SanSep separator are presented on Table 2-15 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-16.

Space Requirements

The space requirements of the SanSep vortex separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Study

The Fort Wayne, Indiana Public Utilities installed the SanSep unit in 2009 at one of their CSO locations to catch floatables half and inch and larger. Prior to the installation, a pilot study was completed in which baskets were installed to observe the types of materials collected. The pilot study showed that the unit was able to capture fine materials. According to the CSO Program Manager, the unit was in use until about 2015 at which point the CSO location was almost entirely eliminated due to Consent Decree regulations. During its operation, there had been no plugging or washdown of the system needed and maintenance consisted of the general routine maintenance. There was also a small pump station which pumps debris back into the wastewater treatment plant. Overall the CSO Program Manager was satisfied with the product.

Table 2-14 - Preliminary Construction Cost Estimates for SanSep

Flow	System	Length X Width	Budgetary Equipment Price	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) Model 80_80	23'-0" x 25'-6"	$300,000	$420,000	$1,080,000	$180,000	$72,000	$1,026,000	$3,078,000
25 MGD	(2) Model 80_80	42'-0" x 25'-6"	$430,000	$680,000	$1,665,000	$277,500	$111,000	$1,581,750	$4,745,250
50 MGD	(3) Model 80_80	42'-0" x 38'-6"	$560,000	$1,000,000	$2,340,000	$390,000	$156,000	$2,223,000	$6,669,000
75 MGD	(4) Model 80_80	42'-0" x 51'-0"	$690,000	$1,300,000	$2,985,000	$497,500	$199,000	$2,835,750	$8,507,250
100 MGD	(4) Model 80_80	42'-0" x 51'-0"	$690,000	$1,570,000	$3,390,000	$565,000	$226,000	$3,220,500	$9,661,500

Notes:
(1) Installation costs are estimated at 150% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-12 - Total Estimated Construction Cost of SanSep

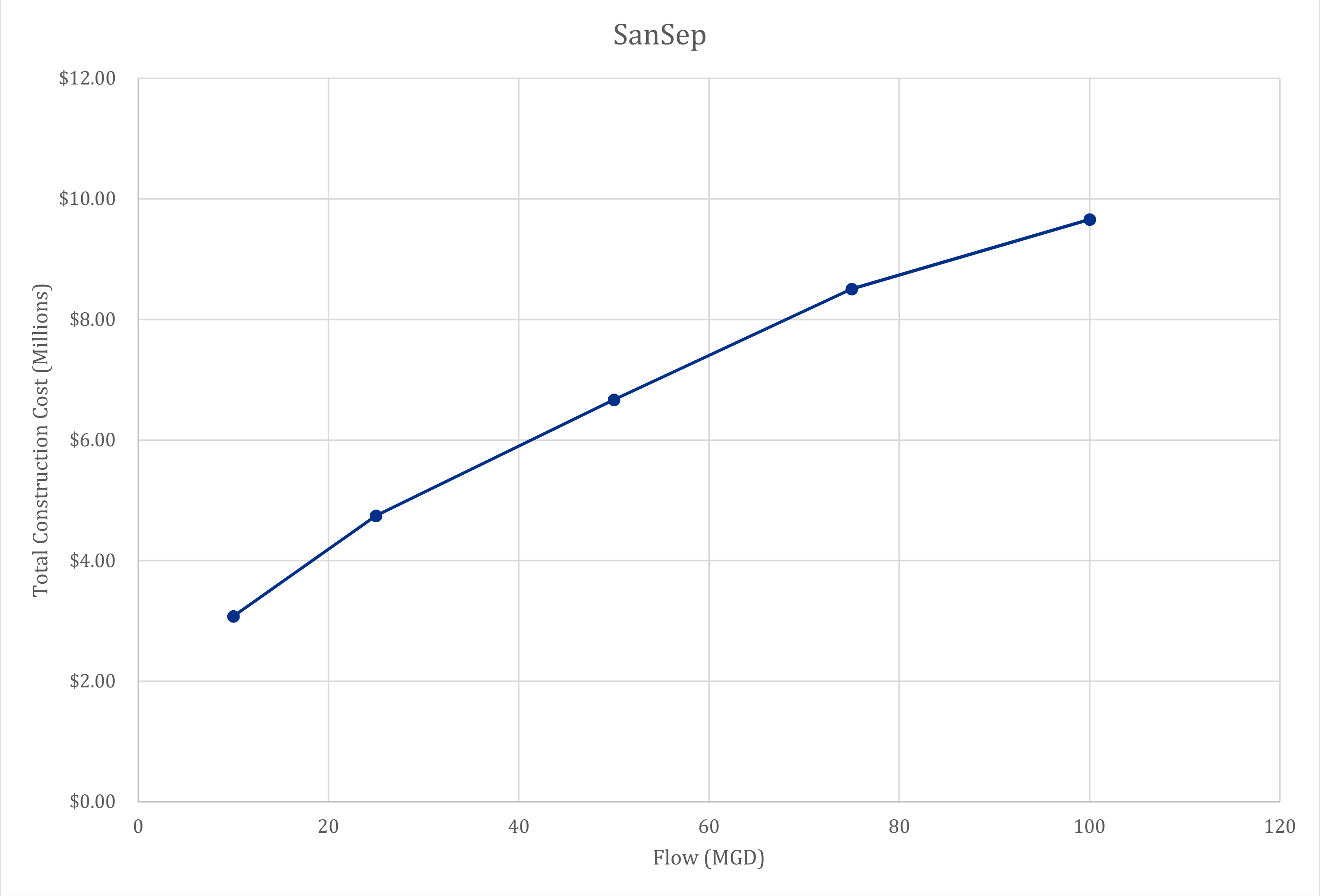


Table 2-15 - Annual Operation Cost of SanSep

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) Model 80_80	6	4	1	$313
25 MGD	(2) Model 80_80	10	7	1	$522
50 MGD	(3) Model 80_80	10	7	1	$522
75 MGD	(4) Model 80_80	15	11	2	$783
100 MGD	(4) Model 80_80	20	15	2	$1,044

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-16 - Annual Maintenance Labor Cost of SanSep

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)
Biannually	Tank and pipe	Visual check and removal of coarse debris (if any)	1	$300
Annually	Full Inspection	Cleaning, check for leaks/cracks in unit tank and pipes; visual inspection of all anchors and bolted assemblies	2	$300
Biannually	Underflow pumps	Replacement of underflow pumps	8	$400
Total Annual Maintenance Cost				$1,900

Notes:
(1) Assumes labor rate of $150/hour

2.3.2 Ballasted Flocculation

Ballasted flocculation, also known as high rate clarification, is a physical-chemical treatment process that uses microsand, or sludge and a variety of additives to improve the settling properties of suspended solids through improved floc bridging. The objective of this process is to form floc particles with a specific gravity of greater than two. Faster floc formation and decreased particle settling time allow clarification to occur up to ten times faster than with conventional clarification, allowing treatment of flows at a significantly higher rate than allowed by traditional unit processes. Ballasted flocculation units function through the addition of a coagulant, such as ferric chloride; an anionic polymer; and a ballast material such as microsand, a microcarrier, or chemically enhanced sludge. When coupled with chemical addition, this ballast material has been shown to be effective in reducing coagulation-sedimentation time.

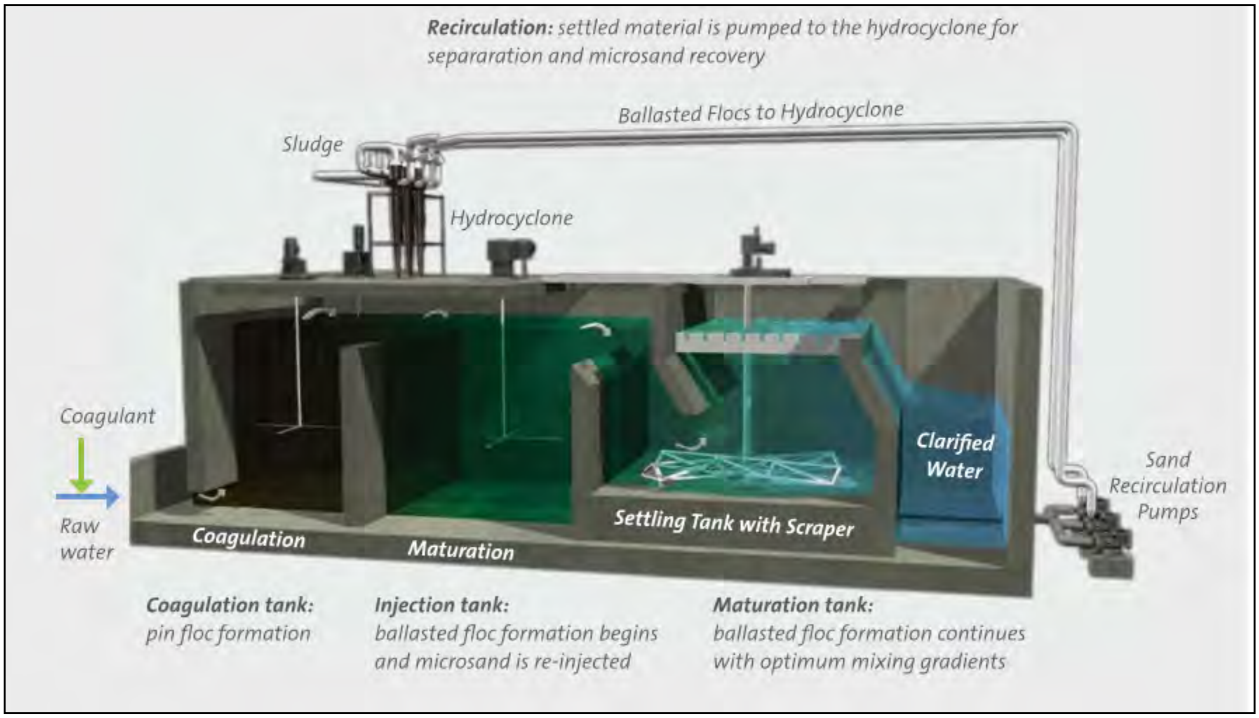
The ballasted flocculation processes, using chemical addition as a critical part of their operation, have higher removal percentages than vortex/swirl separation processes for virtually all the pollutants with the exception of total nitrogen and NH_3. The compact size of ballasted flocculation units can significantly reduce land acquisition and construction costs. This technology has been applied both within traditional treatment trains and as overflow treatment for peak wet weather flows. Several different ballasted flocculation systems are discussed in more details in sections below.

2.3.2.1 ACTIFLO® Ballasted Flocculation Process

Description of Process

ACTIFLO® is a microsand ballasted clarification process that may be used to treat water or wastewater. The process begins with the addition of a coagulant, such as an iron or aluminum salt, to destabilize suspended solids. The flow enters the coagulation tank for flash mixing to allow the coagulant to rapid mix with the flow after which it overflows into the injection tank where microsand is added. The microsand serves as a seed for floc formation, providing a large surface area for suspended solids to bond to, and is the key to the ACTIFLO® process. The larger flocculation particles allow solids to settle out more quickly, thereby requiring a smaller footprint than conventional clarification. Polymer may either be added in the injection tank or at the next step, the maturation tank. Mixing is slower in the maturation tank, allowing the polymer to help bond the microsand to the destabilized suspended solids. Finally, the settling tank effectively removes the floc with help from the plate settlers. The plate settlers allow the settling tank size to be reduced. Clarified water exits the process by overflowing weirs above the plate settlers. The sand and sludge mixture is collected at the bottom of the settling tank with a conventional scraper system and pumped back to a hydrocyclone, located above the injection tank. The hydrocyclone converts the pumping energy into centrifugal forces to separate the higher-density sand from the lower density sludge. The sludge is discharged out of the top of the hydrocyclone while the sand is recycled back into the ACTIFLO® process for further use. Screening is required upstream of ACTIFLO® so that particles larger than 0.1 - 0.25 mm do not clog the hydrocyclone. Cross section of ACTIFLO® unit is shown in Figure 2-13.

Figure 2-13 - Cross Section of ACTIFLO® Unit



(Source: Veolia Water Technologies)

Applicability to the Project

High rate clarification (HRC) was traditionally used for water treatment until in the late 1990s when HRC demonstration testing programs were performed to verify whether HRC technology would be able to be used for wastewater and CSO treatment. The results of the demonstration programs indicated that HRC can be used for CSO treatment and the effluent quality produced during pilot-testing surpassed CSO treatment standards, making it amenable to subsequent UV disinfection.

The ACTIFLO® system, as one type of HRC that uses ballasted flocculation, can be installed at the treatment plant or at a satellite facility within the collection system. The Actiflo process can be fully automated and the process train(s) can sit idle for extended periods of time and still be fully operational within 15 minutes of start-up. Installations at the WWTP also enable the sludge produced by the unit to be processed with existing systems. When installing the ACTIFLO® unit in a remote CSO location, the flows will vary widely, and the sludge must be stored in ancillary tanks so it can be put back into the interceptor during periods of low flow. Appendix F summarizes ACTIFLO® installations in the USA. The table lists only installations used for wastewater treatment operations. System applications include Primary WW, Primary WW/CSO, Primary WW/ Tertiary WW, CSO, CSO/Tertiary WW, and Tertiary WW treatment operations.

Performance

The ACTIFLO® ballasted flocculation process is sized for the peak hour or day flow to prevent flow from exceeding the capacity of the unit. The units are designed for a surface-loading rate of 60 gallons per minute per square foot, at a peak hydraulic loading rate of 150%. When starting up the unit it takes between 15-30 minutes for the process to reach steady state conditions. Accordingly, the initial 15-30 minutes of operation receives only little or partial treatment. The ACTIFLO® ballasted flocculation process is very effective in removing most of the pollutants; especially since the addition of flocculants and polymers helps remove smaller particles. Performance for removal of pollutants is reportedly constant up to for a surface-loading rate of 60 gallons per minute per square foot. See Table 2-17 for manufacturer provided performance efficiency. Performance deteriorates quickly for higher surface loading rates than 60 gallons per minute per square foot.

Table 2-17 - Anticipated Performance Efficiency

Parameter	Removal Rate
TSS	80 - 95%
COD	50 - 70%
Total BOD	50- 80%
Soluble BOD	10 - 20%
Total P	80 - 95%
TKN	15 -20%
Heavy Metals	85 -100%
Oils & Grease	50 -80%
Fecal Coliform	85 -95%

Hydraulics

The head loss through the units at peak flow rates are reported at less than two feet.

Generation of Waste Streams

As previously noted, the initial 15-30 minutes of operation of the unit provides no or only partial treatment. Since the disinfection process requires consistent pretreatment removals of TSS, the discharge of this partially treated flow will result in only partial disinfection. One potential means of eliminating this problem would be to provide ancillary tanks for storage of the initial discharge. This storage can then be reintroduced to the treatment process once the unit is fully operational. Under the description of the process, sludge is produced and separated in a hydrocyclone unit. The solids percentage of the waste sludge will vary depending on the concentration of the influent TSS and the coagulant dosage. In most cases the solids concentrations will vary from 0.1 to 1.0% with an average of 0.3%. Sludge from the ACTIFLO® process is easily treated and dewatered. When the ACTIFLO® process is located at the WWTP the sludge is sent back to the head of the plant or primary clarifiers, in some cases it is sent to intermediate gravity thickeners and then on to centrifuges or belt thickeners for final processing. The sludge production is approximately 4.8% of the design capacity of the unit.

Complexity

The ACTIFLO® ballasted flocculation process is more complex than the vortex/swirl separator process. The ACTIFLO® ballasted flocculation process consists of chemical addition, which must be controlled by the flow rate, mixers and flocculators, sludge pumps and a hydrocyclone, which separates the sludge from the microsand.

Limitations

The startup time for the ACTIFLO® process of from 15 to 30 minutes is a limitation in that for stringent treatment objectives the flow from the unit during this time period must be stored and fed back into the system later. For some drainage areas, this startup period may correspond to the first flush when the loading is the greatest. Also, the ACTIFLO® process has 4:1 turndown ratio, which means the minimum flow through the unit is 25% of the unit's capacity. Flows lower than this result in process problems. There is a maximum TSS limit on the ACTIFLO® process at the higher loading rate of 60 gpm/sf, of between 500 to 1000 mg/L TSS. This value is high and should not provide a routine problem in the operation of the unit. In remote locations, the ACTIFLO® process will see intermittent operation which will make operation more challenging.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-18 for ACTIFLO® Ballasted Flocculation Unit of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for ACTIFLO® Ballasted Flocculation Unit was gathered from equipment manufacturer Veolia Water Technologies. The equipment price includes engineering and project management time. Cost for concrete structure and auxiliary tank for waste sludge storage were also estimated based on equipment sizing and design flowrate. Installation cost was assumed at 115% of equipment cost based on equipment manufacturer's recommendations. The installation cost includes assembly of the ACTIFLO® ballasted flocculation unit, excavation and backfilling, and the cost of the Chemical Building and the chemical feed equipment. The estimated total construction costs for the ACTIFLO® Ballasted Flocculation Unit are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-14.

Operation and Maintenance

Operating costs for the ACTIFLO® Ballasted Flocculation unit consists of the power and chemical costs. Power costs are based upon the horsepower of the mixers, flocculators, chemical feed equipment and pumps. Chemical costs are based on usage of coagulant and polymer. Regular maintenance includes routine lubrication and maintenance of the mixers, scrapers, pumps, hydrocyclones and other mechanical components. Weekly inspections and preventive maintenance are important to keep an intermittent-use facility ready to operate at a moment's notice. When the unit will be offline for more than 8 hours, the units will be completely drained and all equipment stopped.

Estimated annual operation costs for the ACTIFLO® system are presented on Table 2-19 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-20.

Space Requirements

The space requirements of the ACTIFLO® units consist of the size of the tanks and a buffer of 5 feet around the unit for access and maintenance.

Case Study

The Water Environment Federation's (WEF) February 2012 issue of Water Environment and Technology (WE&T) provided a case study on the use of HRC in the city of Bremerton, Washington. Bremerton adopted a proprietary high rate compact clarification process to reduce its CSO discharges. Followed by an ultraviolet disinfection treatment, the HRC process was piloted by CDM Smith in 1999. The pilot testing determined effluent capable of being discharged into sensitive waterways would be produced by the HRC process and that a UV disinfection treatment could be added to the process. This project received the 2002 Grand Award in Small Projects by the American Academy of Environmental Engineers (Annapolis, MD).

The process takes wet weather flow that cannot be handled by the wastewater treatment plant, and puts it through a flash mixing tank with polymer added, and a maturation tank before it is sent through a clarifier. Reduction of BOD5 and TSS is typically 60-65% and 90-95%, respectively. Sludge from the clarifier is pumped back to the hydrocyclone and then either to the solids processing plant, or through a microsand filter and into the flash mixing tank. The facility utilizes a 10 MGD nominal capacity with a maximum hydraulic capacity of 20MGD. Additionally, flow to the facility is minimized by a 100,000-gallon storage tank, which has reduced overall CSO occurrences by 80% in the surrounding collection system. The HRC facility only receives flow when the storage tank fills over a weir wall.

Weekly inspection and maintenance is required to ensure the facility is ready to operate when the next rainfall occurs. Additionally, a small flow (less than 3 gal/min) of chlorinated potable water is discharged into the injection tank during periods of dry weather to eliminate the chance of biofouling on lamella tubes and other components. The facility has had issues with UV ballast burnout due to short durations of high intensity operation. Since installation, operators have adjusted the coagulant injection point to increase flocculation time. Additionally, the discharge was relocated from the hydrocyclone to the far side of the storage tank to reduce sand loss and resuspension of separated solids. Operators spent several years altering the chemical dosing to meet permitted discharge requirements as there are very few events each year which trigger the HRC.

Table 2-18 - Preliminary Construction Cost Estimates for ACTIFLO Ballasted Flocculation Unit

Flow	System	Length X Width of ACTFLO Unit	Auxiliary Tank Volume	Budgetary Equipment Price	Concrete Cost	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions(2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) 10 MGD	44’-9” x 14’-0”	0.1 MG	$1,325,000	$204,300	$610,000	$1,604,475	$374,378	$374,378	$2,246,265	$6,738,795
25 MGD	(1) 25 MGD	60’-9” x 22’-0”	0.25 MG	$1,900,000	$341,100	$970,000	$2,408,325	$561,943	$561,943	$3,371,655	$10,114,965
50 MGD	(1) 50 MGD	82’-3” x 32’-0”	0.5 MG	$2,725,000	$532,800	$1,570,000	$3,620,850	$844,865	$844,865	$5,069,190	$15,207,570
75 MGD	(3) 25 MGD	60’-9” x 66’-0”	0.75 MG	$4,725,000	$675,000	$2,100,000	$5,625,000	$1,312,500	$1,312,500	$7,875,000	$23,625,000
100 MGD	(2) 50 MGD	82’-3” x 64’-0”	1.0 MG	$5,250,000	$801,900	$2,300,000	$6,263,925	$1,461,583	$1,461,583	$8,769,495	$26,308,485
450 MGD	(6) 75 MGD	116’-0” x 73’-2”	4.5 MG	$10,000,000	$3,204,900	$6,900,000	$15,078,675	$3,518,358	$3,518,358	$21,110,145	$63,330,435

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-14 - Total Estimated Construction Cost of ACTIFLO® Ballasted Flocculation Unit

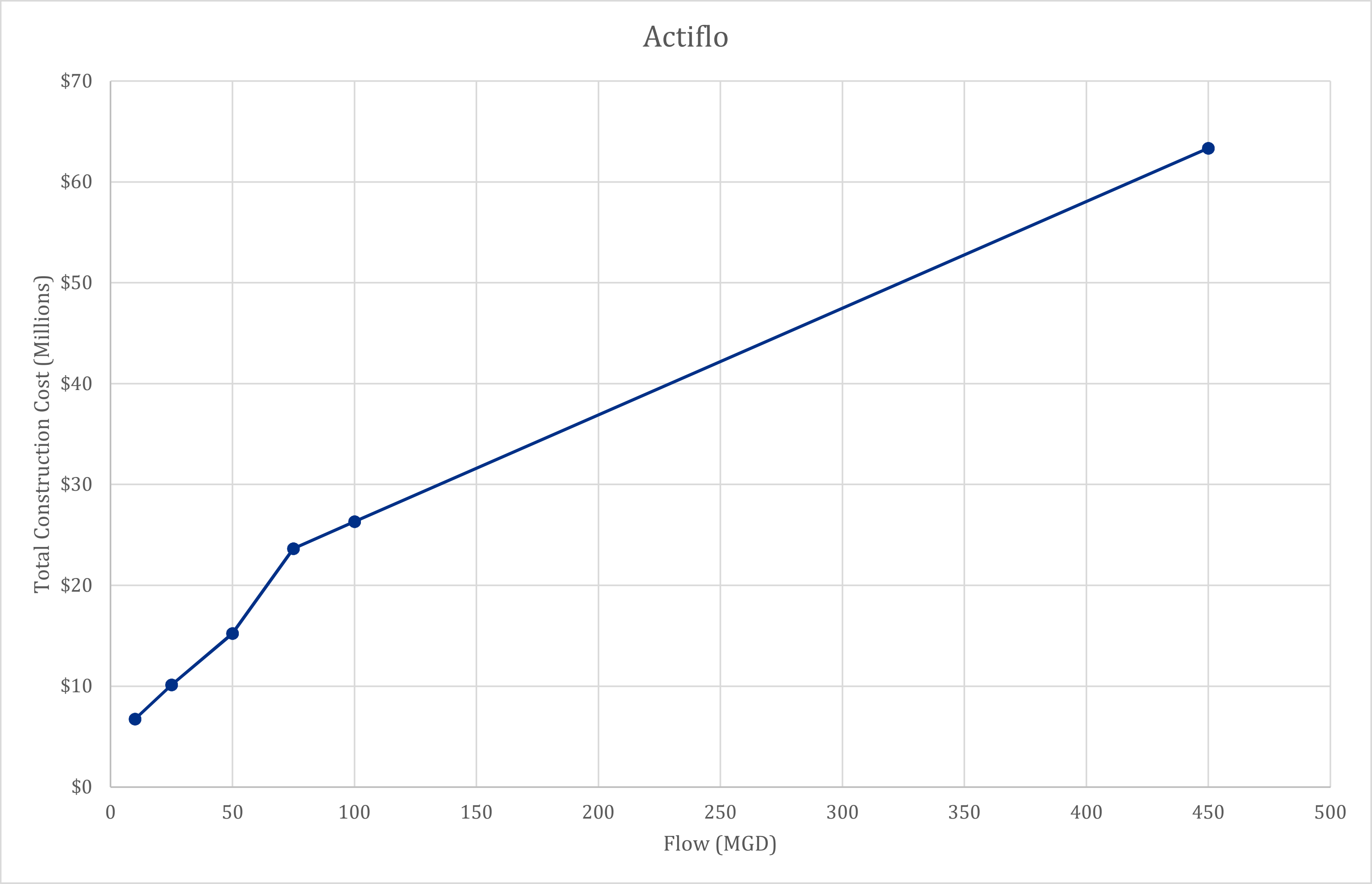


Table 2-19 - Annual Operation Cost of ACTIFLO® Ballasted Flocculation

	Required Horsepower (HP)													
Flow	Coag-ulation Mixer	Matur-ation Mixer	Scraper Drive & Mech-anism	Sand Pump	Chemical Pump	Total HP	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Power Cost(3)	Alum Usage (lbs)(4)	Polymer Usage (lbs)(5)	Alum Cost(6)	Polymer Cost(7)	Total Annual Cost
10 MGD	10	7.5	2	80	0.5	100	75	37,285	$5,220	173,854	3,477	$10,014	$6,676	$21,910
25 MGD	25	20	7.5	100	0.5	153	114	57,046	$7,986	434,635	8,693	$25,035	$16,690	$49,711
50 MGD	20	30	15	120	1	186	139	69,350	$9,709	869,271	17,385	$50,070	$33,380	$93,159
75 MGD	75	60	22.5	300	1	458.5	342	170,952	$23,933	1,303,906	26,078	$75,105	$50,070	$149,108
100 MGD	80	60	30	240	1.5	411.5	307	153,428	$21,480	1,738,542	34,771	$100,140	$66,760	$188,380
450 MGD	360	270	135	1,080	2	1847	1,377	688,654	$96,412	7,823,438	156,469	$450,630	$300,420	$847,462

Notes:

(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assume an alum dosage of 100 mg/L
(5) Assumes a polymer dosage of 2 mg/L
(6) Assumes an alum cost of $0.0576/lb
(7) Assumes a polymer cost of $1.92/lb

Table 2-20 - Annual Maintenance Labor Cost of ACTIFLO Ballasted Flocculation Unit

Frequency	Parts	Description	Estimated Man-Hours	Annual Cost$^{(1)(2)}$
Biannually	Coagulation Mixers	Change oil and grease bearings	1	$300
Biannually	Maturation Tank Mixer	Change oil and grease bearings	1	$300
Biannually	Scraper	Change oil and grease bearings	1	$300
Annually	Chemical pumps	Grease bearings	0.5	$75
Biannually	Sand Pumps	Grease bearings	0.5	$150
Annually	Sand Pumps	Change belts	1	$150
Annually	Hydrocyclone	Inspect / change apex tips	0.25	$38
Monthly	Lamella	Cleaning	1 / basin	$3,600
Weekly	System	Inspection and preventive maintenance	0.5	$3,900
After each overflow event	System	System shut down and drain	2	$30,000
Total Annual O&M Cost				$38,813

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.3.2.2 DensaDeg® Ballasted Flocculation Process

Description of Process

The DensaDeg® is a is a high-rate settling clarifier process combining solids contact, ballast addition and solids recirculation to provide enhanced, high-rate settling of solids. Different from ACTIFLO®, recycled sludge, instead of microsand, is added to increase floc density and precipitation. The process consists of:

1. Rapid mix / coagulation stage: Raw water flows into the rapid (flash) mix zone where a coagulant is added. Coagulation is the destabilization of colloidal particles, which facilitates their aggregation and is achieved by the injection of a coagulant such as alum or ferric chloride.

2. Flocculation zone: Coagulated water then flows to the flocculation zone where, with a lower energy vertical turbine mixer, a continuous ballast media recirculation feed and a low dose of a flocculating agent (polymer) are added to begin the process of agglomerating the coagulated water into floc particles.

3. Maturation zone: Flocculated particles are then developed and grown into large, very dense mature particles. This is achieved with optimized mixing energy and detention time. The result is a floc which settles at extremely high rates.

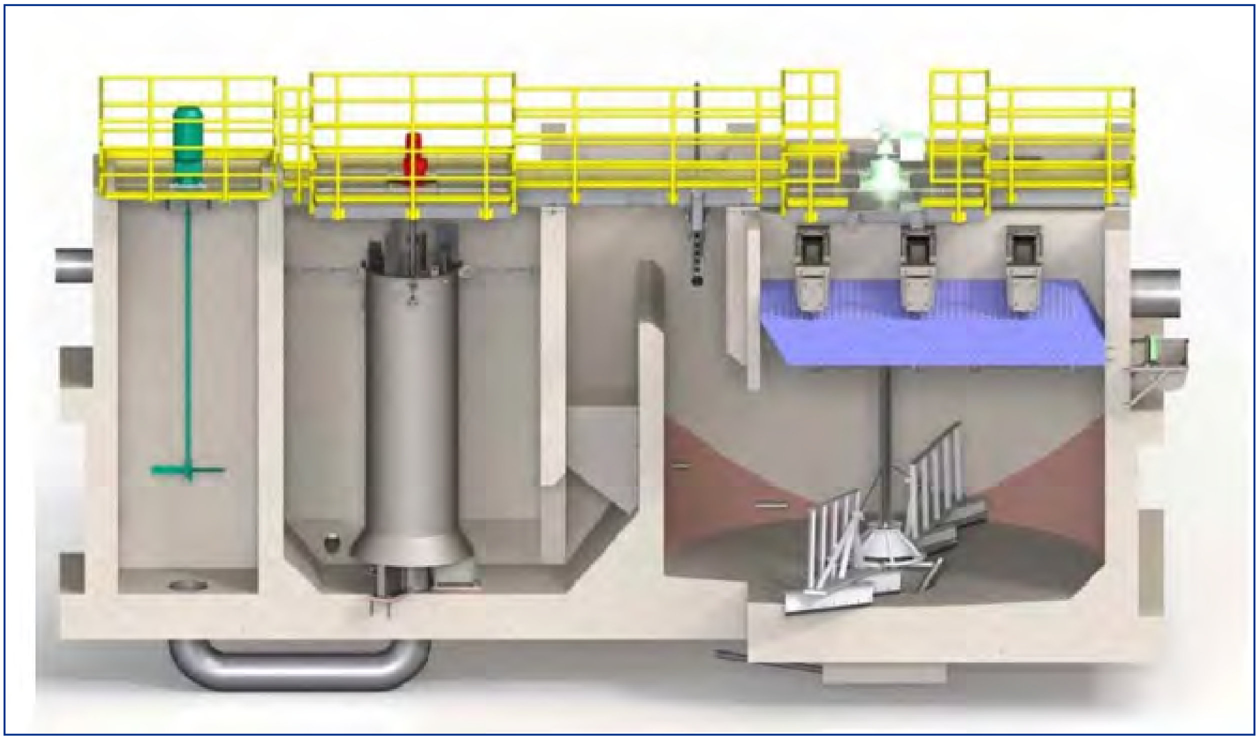
4. Settling & clarification zone: Flocculated solids enter the settling zone, over a submerged weir wall, where dense, suspended matter settles to the bottom of the clarifier. Clarified water is displaced upward from the downward moving slurry, through inclined plate settlers. The plate modules act as a polishing step for lighter, low density solids.

5. Hydrocyclone and ballast recovery: Settled sludge is continuously recycled via a recirculation pump to the hydrocyclone where the ballast media is separated from the waste stream. Ballast is returned to the flocculation zone and the waste stream is sent to sludge handling.

6. Effluent Collection: Uniform collection of clarified water is accomplished in effluent launders above the settling plate assembly.

Cross section of a DensaDeg® unit is shown in Figure 2-15.

Figure 2-15 - Cross Section of a DensaDeg Unit



(Source: Suez North America)

Applicability to the Project

The DensaDeg® ballasted flocculation process is a treatment process that combines solids contact, ballast addition and solids recirculation in a packaged system. It started with the original solids-contact clarifier, the Accelator, which was the first to incorporate internal sludge recycling. In the late 1980’s the original DensaDeg clarifier was introduced to the market for high-rate sludge ballasted and solids recirculation systems. The earliest DensaDeg® CSO installation was in 1995.

The DensaDeg® process can be fully automated and the process train(s) can sit idle for extended periods of time and still be fully operational within 30 minutes of start-up. It can be installed at the treatment plant or at a satellite facility within the collection system. Installations at the WWTP also enable the sludge produced by the unit to be processed. When installing the DensaDeg unit in a remote CSO location, the flows will vary widely, and the sludge must be stored so it can be put back into the interceptor at periods of low flow.

Appendix G presents a list of select installations for the original DensaDeg® in CSO/SSO applications.

Performance

The DensaDeg® ballasted flocculation process is sized for the peak hour or day flow to prevent flow from exceeding the capacity of the unit. The units are designed for a surface-loading rate of 40-60 gallons per minute per square foot. When starting up the unit it takes 30 minutes for the process to reach steady state conditions and no sludge inventory is required for startup. The DensaDeg® ballasted flocculation process is very effective in removing vast quantities of pollutants. Its performance is comparable to ACTIFLO® in terms of contaminants removal with TSS removal of 80-90%, typically providing effluent <30mg/L TSS (inlet dependent) and BOD %-removal similar in magnitude to TSS %-removal, when treating typical municipal WW which is 30-40% of total BOD. Removal could be higher depending on soluble ratio.

Hydraulics

The head loss through the units at peak flow rates are reportedly less than two feet.

Generation of Waste Streams

As previously indicated in the description of the process, a portion of the sludge is wasted. The solids percentage of the waste sludge will vary depending on the concentration of the influent TSS and the coagulant dosage. In most cases the solids concentrations will 4%. The quantity of sludge is approximately equal to 0.5% of the capacity of the DensaDeg® unit. When the DensaDeg® process is located at the WWTP, the sludge is sent back to the head of the plant or primary clarifiers, in some cases it is sent to intermediate gravity thickeners and then on to centrifuges or belt thickeners for final processing.

Complexity

Similar to ACTIFLO®, the DensaDeg® ballasted flocculation process consists of chemical addition, which must be controlled by the flow rate, mixers and flocculators, and sludge pumps.

Limitations

DensaDeg® has similar limitations as previously stated for ACTIFLO® plus it requires a longer start time.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-21 for DensaDeg® ballasted flocculation equipment of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for DensaDeg® ballasted flocculation units was gathered from equipment manufacturer Suez. The equipment price includes engineering and project management time. Cost for concrete structure and auxiliary tank for waste sludge storage were also estimated based on equipment sizing and design flowrate. Installation cost was assumed at 115%. The installation cost includes assembly of the DensaDeg® ballasted flocculation unit, excavation and backfilling, and the cost of the Chemical Building and the chemical feed equipment. The estimated total construction costs for the DensaDeg® ballasted Flocculation Unit are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-16.

Operation and Maintenance

Similar to ACTIFLO® ballasted flocculation system, operating costs for the DensaDeg® Ballasted Flocculation unit consist of the power and chemical costs. Power costs are based upon the horsepower of the mixers, flocculators, chemical feed equipment and pumps. Chemical costs are based on usage of coagulant and polymer. Routine maintenance and preventive care measures are similar to those for ACTIFLO® unit.

Estimated annual operation costs for the DensaDeg® Ballasted Flocculation unit are presented on

containing factors for calculation of operating costs; while estimated DensaDeg® Ballasted Flocculation unit annual maintenance labor cost including cost factors are included on Table 2-23.

Space Requirements

The space requirements of the DensaDeg® unit shall consist of the size of the tanks and a buffer of 5 feet around the unit for access and maintenance.

Case Study

Veolia Water Technologies provided a white paper[1] detailing the City of Akron, OH, BIOACTIFLO™ demonstration project. Beginning in March of 2012, a pilot plant at the City of Akron Water Reclamation Facility (WRF) was constructed to demonstrate effectiveness of the BIOACTIFLO™ technology. Incorporating high-rate activated sludge in the ACTIFLO™ high-rate ballasted flocculation process, BIOACTIFLO™ is designed to remove soluble BOD that would not otherwise be removed. Influent flow to the pilot plant was pumped from a location that had already undergone preliminary treatment, consistent with plans for the full-scale configuration. Return activated sludge (RAS) was supplied to the pilot plant from the gravity belt thickener building of the WWTP, consistent with plans for the full-scale configuration. Optimal doses for coagulant (alum) and polymer were determined. Both BIOACTIFLO™ and main plant secondary effluent were disinfected in a 0.53 MLD (0.14 mgd) pilot UV disinfection system and comparable results were obtained. Following all testing, effluent from the BIOACTIFLO™ pilot was sent back to the main plant for complete secondary treatment.

The pilot unit was operated during a total of twenty (20) wet weather events between April and December 2012, however the last two events (19 and 20) were performed using slightly different Operational Criteria. Pilot plant operation and sampling was conducted over a range of event durations and volumes, ranging from just under an hour to nearly a day in duration. Results showed an average 85% reduction in CBOD (90% reduction for events 19 and 20). Soluble CBOD concentration dropped from 9.2 mg/L in the influent of the BIOACTIFLO™ to 4.1 mg/L in the effluent from the BIOACTIFLO™. Meanwhile, TSS was reduced by 97%, from influent 144.8 mg/L to 4.0 mg/L effluent. Overall results document the effectiveness of BIOACTIFLO™ as a potential parallel wet weather treatment process at facilities facing wet weather treatment challenges.

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[1] Heath, Gregory; Gsellman, Patrick; Hanna, Genny; Starkey, Daniel. Pilot Testing of BIOACTIFLO for Wet Weather Treatment at the Akron, Ohio Water Reclamation Facility

Table 2-21 - Preliminary Construction Cost Estimates for DensaDeg Ballasted Flocculation Unit

Flow	System	Length X Width	Budgetary Equipment Price	Concrete Cost	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) XRC-2 Concrete	39' x 16'	$988,000	$204,300	$210,000	$1,612,645	$301,495	$301,495	$1,808,967	$5,426,901
25 MGD	(1) XRC-5 Concrete	54' x 22'	$1,111,400	$341,100	$320,000	$2,038,375	$381,088	$381,088	$2,286,525	$6,859,575
50 MGD	(1) XRC-8 Concrete	78' x 32'	$1,405,800	$532,800	$420,000	$2,712,390	$507,099	$507,099	$3,042,594	$9,127,782
75 MGD	(3) XRC-5 Concrete	54' x 66'	$2,458,320	$675,000	$550,000	$4,235,818	$791,914	$791,914	$4,751,483	$14,254,448
100 MGD	(2) XRC-8 Concrete	78' x 64'	$2,811,600	$801,900	$610,000	$4,857,025	$908,053	$908,053	$5,448,315	$16,344,945
450 MGD(5)	(8) XRC-9 Concrete	84' x 136'	$5,727,000	$3,204,900	$1,570,000	$12,077,185	$2,257,909	$2,257,909	$13,547,451	$40,642,353

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.
(5) The cost was conservatively higher based on nine units of 50 MGD system.

Figure 2-16 - Total Estimated Construction Cost of DensaDeg Ballasted Flocculation Unit

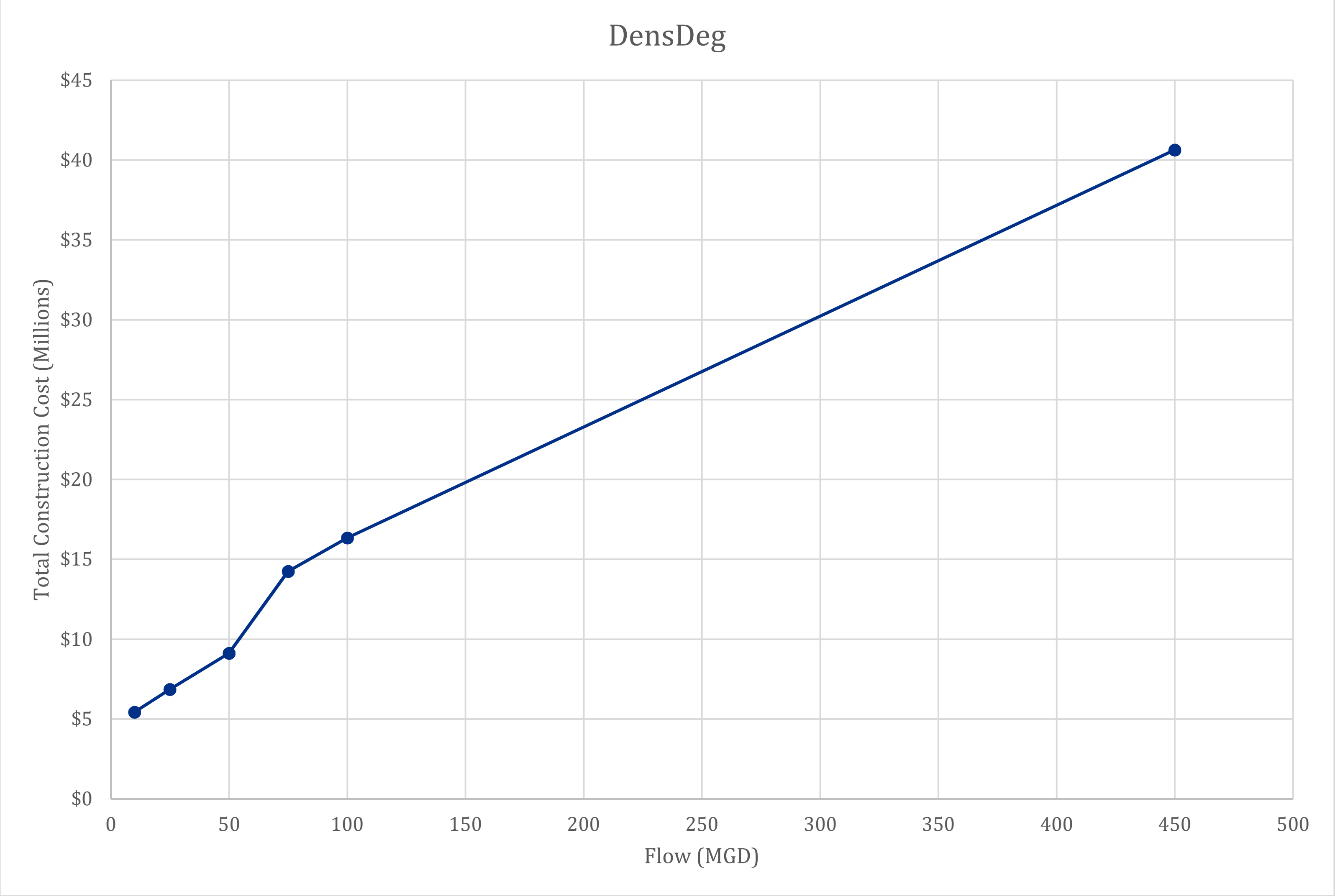


Table 2-22 - Annual Operation Cost of DensaDeg Ballasted Flocculation Unit

Flow	Required Horsepower (HP)						Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Power Cost(3)	Alum Usage (lbs)(4)	Polymer Usage (lbs)(5)	Alum Cost(6)	Polymer Cost(7)	Total Annual Cost
	Rapid Mixer	Reactor Drive	Scraper Drive	Recycle Pump	Chemical Pump	Total HP								
10 MGD	3	5	0.5	30	0.5	39	29	14,541	$2,036	173,854	3,477	$10,014	$6,676	$18,726
25 MGD	5	15	0.5	50	0.5	71	53	26,472	$3,706	434,635	8,693	$25,035	$16,690	$45,431
50 MGD	7.5	15	0.75	50	1	74.25	55	27,684	$3,876	869,271	17,385	$50,070	$33,380	$87,326
75 MGD	12	25	1.25	75	1	114.25	85	42,598	$5,964	1,303,906	26,078	$75,105	$50,070	$131,139
100 MGD	15	30	1.5	100	1.5	148	110	55,182	$7,725	1,738,542	34,771	$100,140	$66,760	$174,625
450 MGD	45	240	6	350	2	643	479	239,743	$33,564	7,823,438	156,469	$450,630	$300,420	$784,614

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assume an alum dosage of 100 mg/L
(5) Assumes a polymer dosage of 2 mg/L
(6) Assumes an alum cost of $0.0576/lb
(7) Assumes a polymer cost of $1.92/lb

Table 2-23 - Annual Maintenance Labor Cost of DensaDeg Ballasted Flocculation Unit

Frequency	Parts	Description	Estimated Man-Hours	Annual Cost$^{(1)(2)}$	Frequency
Biannually	Coagulation Mixers	Change oil and grease bearings	1	150	$300
Biannually	Maturation Tank Mixer	Change oil and grease bearings	1	150	$300
Biannually	Scraper	Change oil and grease bearings	1	150	$300
Biannually	Sludge Pumps	Inspect, lubricate pumps and valves, and clean them	2	150	$600
Annually	Chemical pumps	Grease bearings	0.5	150	$75
Annually	Hydrocyclone	Inspect / change apex tips	0.25	150	$38
Monthly	Lamella	Cleaning	1 / basin	150	$3,600
Weekly	System	Inspection and preventive maintenance	0.5	150	$3,900
After each overflow event	System	System shut down and drain	2	150	$30,000
Total Annual O&M Cost					$39,113

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.3.3 Compressible Media Filtration Process

Description of Process

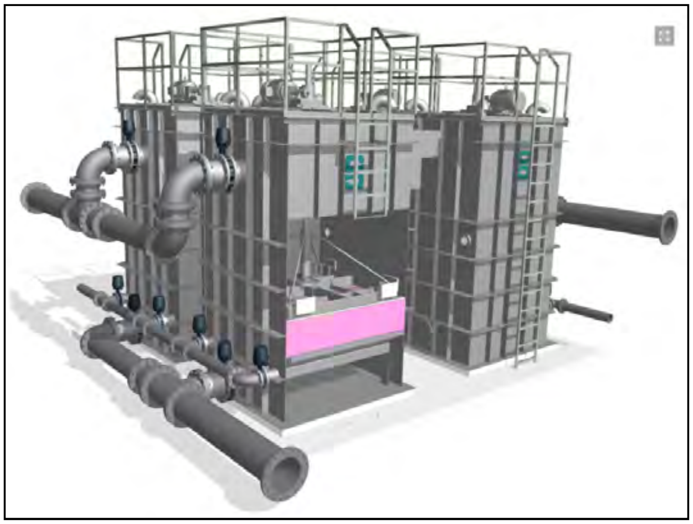
The compressible media filtration is a process that uses a synthetic, porous filter media. The filter is unusual in a number of ways: (1) the synthetic media is highly porous (89%), (2) filter media and bed properties can be modified because the media is compressible, (3) the fluid to be filtered flows both around and through the media instead of only flowing around the filtering media (as in granular media filters), (4) the fluid that is filtered is used to backwash the filter, (5) to backwash the filter, filter bed volume is increased mechanically, and (6) the filter operates at high filtration rates (up to 40 gal/min/sq. ft.) Performance of the filter, with respect to removal of turbidity and total suspended solids, is similar to the performance of other more conventional filters with the exception that filtration rate is more than 3 to 6 times the rate of other filters. Also, percent backwash water required is significantly less than that used in conventional filtration technologies (typically 1 to 2% versus 6 to 15%).

Compressible media filtration is commercially available as either the “Fuzzy Filter” by Schreiber Industries or the “FlexFilter” by WesTech (both are proprietary technologies covered by patents or pending patents). Both technologies use synthetic fiber spheres as filter media; however, they have different flow configuration, method of bed compression, composition of the synthetic fibers, and media washing details.

The Fuzzy Filter receives the influent at the inlet pipe located at the bottom of the unit. The influent is pressurized upward through the compressed filter media and the effluent is piped out towards the top of the unit, as shown in the process diagram found in Figure 2-17. Porous plates are used to both compress the filter media as well as open up the filter bed to allow movement during backwashing. Figure 17 provides a cross-sectional view of the Fuzzy Filter process, and Figure 2-18 provides an overall picture of the Fuzzy Filter Unit.

Figure 2-17 - Fuzzy Filter Process Diagram

Figure 2-18 - Fuzzy Filter Unit

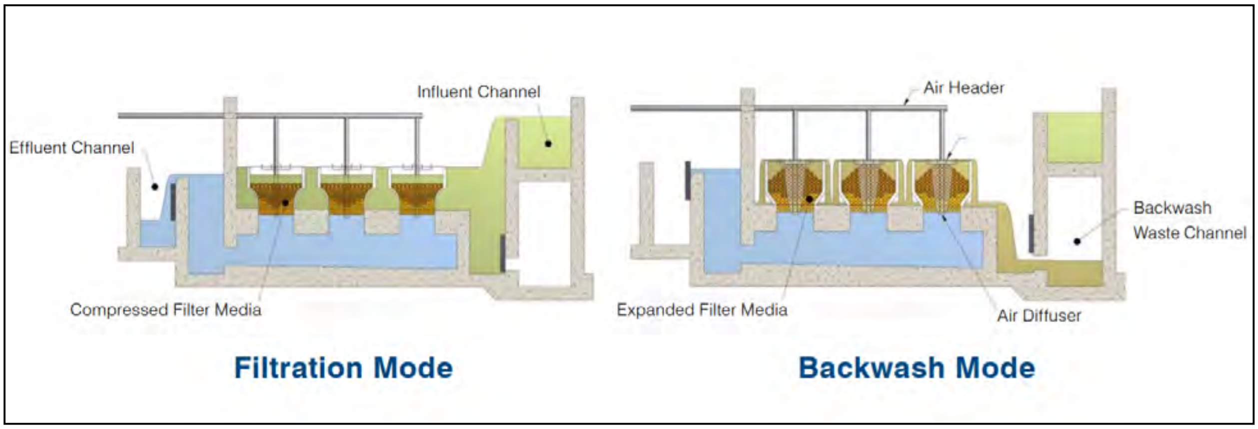


(Source: Schreiber, LLC.)

The FlexFilter receives the inflow from the influent channel. The influent channel is connected to the influent basin where the filter vessels are located. As the influent water accumulates in the influent basin, compression is added to the reinforced rubber sidewalls on the bottom of the filter vessel and compresses the filter bed laterally as the water elevation rises. As the water level in the influent basin reaches the inlet weir elevation, the influent water pours over the influent weir and passes downward through the compressed media bed. Since the bottom of the filter bed compresses more than the top of the filter bed, a porosity gradient is established through the filter bed to capture the largest particles in the upper portion of the filter bed while reserving the deeper portions of the bed to trap finer particles. As particles collect within the media bed, the influent level above the bed rises to a point that signals the need for the media to be cleaned.

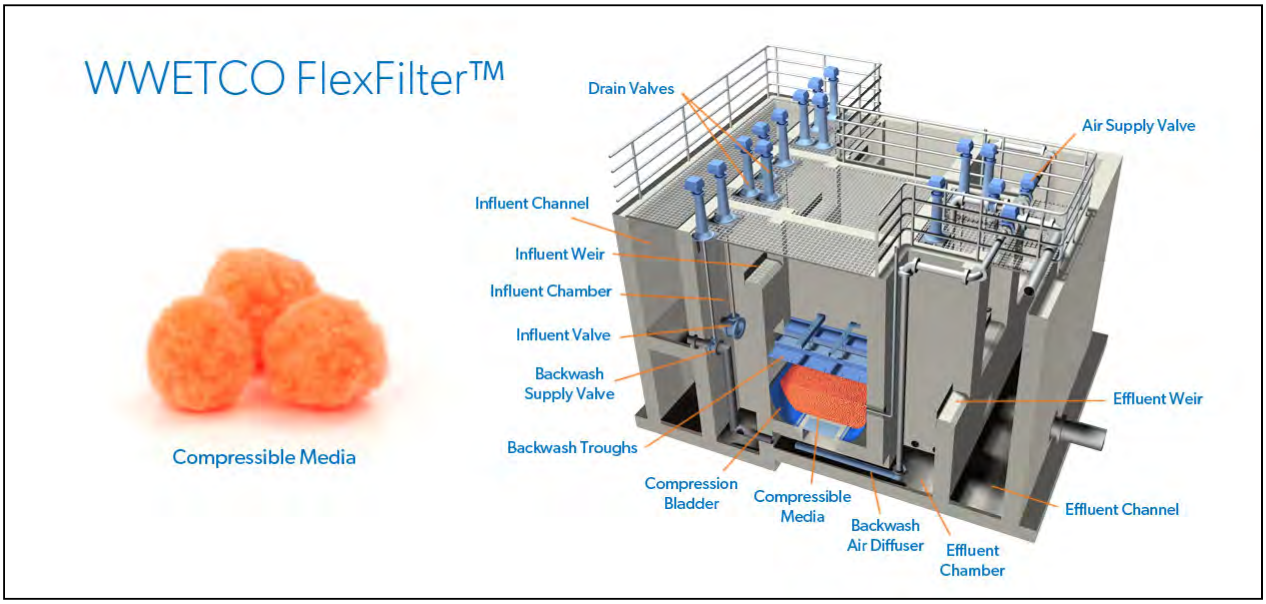
The filters use air scouring in the wash cycle to clean the media. During the wash cycle, the feed to the filter is stopped, allowing the media to uncompress. The air scour is initiated along with a small amount of backwash water. The length of the backwash cycle is adjustable. Once cleaned, the filter is put back into service. Figure 2-19 provides a cross-sectional view of the FlexFilter process, and Figure 2-20 provides an overall picture of the FlexFilter Unit.

Figure 2-19 - FlexFilter Process Diagram (Source: WesTech)



(Source: WesTech Engineering, Inc.)

Figure 2-20 - FlexFilter Unit (Source: WesTech)



(Source: WesTech Engineering, Inc.)

Applicability to the Project

The Fuzzy Filter is only used as a polishing step for CSO treatment to meet the most stringent treatment objectives. It does not have a history of treating flows larger than 50 MGD while the FlexFilter has been applied at the 100 MGD Springfield Ohio WWTP treating combined sewer overflow. In addition, the FlexFilter is a simple gravity system requiring no moving parts. The compression of the media is accomplished through a lateral hydraulic force applied from the incoming liquid, eliminating mechanically actuated internal components. For the purpose of the Technical Guidance Manual, FlexFilter was selected for further evaluation.

Performance

For CSO applications FlexFilter is typically operated at 4 gpm/sq. ft. HLR during the first flush portion of a CSO event and gradually increases the operating HLR as the CSO flow rate increases and solids concentration decrease. The maximum HLR of CSO treatment is typically limited to 10 gpm/sq. ft. at design peak flow. The performance information provided by the manufacturer indicates that the contaminants removal efficiency of WWETCO FlexFilter in CSO application ranges from 73% to 94% for TSS removal and 16% to 69% for CBOD removal.

In the Bayonne MUA pilot study, FlexFilter was evaluated in terms of TSS removal. The influent to the FlexFilter was pumped from the Storm King effluent. No raw CSO feed to the FlexFilter was evaluated due to limited wet weather events during the time of the pilot test. The FlexFilter units experienced operating issues primarily related to the pumps and the time needed to backwash. Shorter filter run times and frequent backwashing were experienced when testing was conducted at the higher end of the filter loading rate recommended for CSO treatment.

The pilot study showed that the compressed media filter was consistent and effective in removing finer and organic suspended solids. Overall the FlexFilter was capable of removing 90% of the TSS even at a HLR of 12 to 18 gpm/sq. ft. The unit as tested spent up to 1/2 of the typical four hour run time in backwash cycle, however it was operated at 3 to 4 the recommended hydraulic loading rate in order to supply downstream disinfection with higher flows. TSS removal rates for the FlexFilter improved the ultraviolet transmittance (UVT) of the effluent flow; however, UVT values were still modest. The effluent from the FlexFilter averaged approximately 25 mg/L for TSS and 40% on UVT.

Hydraulics

The headloss through the FlexFilter structure, under the conditions stated above, is about 8 feet.

Generation of Waste Streams

The only waste stream produced by the FlexFilter is the backwashing of the filters. The FlexFilter utilizes low head air to accomplish the media scrubbing while lifting the backwash water to waste, thus minimizing backwash waste volumes. Portions of the backwash water would be diluted with filter drains and recycled back to filter influent. The concentrated backwash water would be stored and put back into the interceptor system when there was available capacity, for removal at the WWTP.

Complexity

As a result of how this unit operates; the automated valves, hydraulically operated porous plate, the air injection into the beds during backwashing, and the monitoring needed for the flow and headloss conditions, this process is the most complex of the pretreatment processes being considered as part of this Technical Guidance Manual.

Limitations

The influent TSS concentration to the FlexFilter is limited to less than 100 mg/L. Higher TSS concentrations will increase the backwash time resulting in overall reduced performance of the units. The 7 feet of headloss through the units is also a limitation since there is usually minimal head available from the regulator to the discharge at the water body. The valves in the FlexFilter unit are an issue during outdoor operation in freezing weather conditions.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-24 for FlexFilter design flows ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for FlexFilter was gathered from equipment manufacturer WesTech Engineering, Inc. The equipment price includes engineering and project management time. Installation cost was assumed at 150% of equipment cost based on equipment manufacturer's recommendations. The installation cost includes assembly of the FlexFilter system, excavation and backfilling, conduits, filter matrix, and backwash and effluent pumping. The estimated total construction costs for the FlexFilter are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-21.

Operation and Maintenance

Estimated annual operation and maintenance costs for FlexFilter unit are presented Table 2-25 based on vendor provided information. It consists of the power costs for the blowers, recycle pumps, and backwash pumps as well as media change-out cost, labor for preventative and routine maintenance, and labor for post event clean-out.

Case Study

According to literature obtained from WWETCO (a subsidiary of WesTech), the FlexFilter™ was installed at the Weracoba Creek Stormwater Treatment system in Columbus, GA. This 10 MGD filter capacity with 2 MGD UV disinfection capacity, was funded by a $0.9 million EPA 319(h) grant to evaluate treatment of urban stormwater runoff. The treatment system has been in operation since 2007. Influent solids ranged from 300 mg/L to 100 mg/L TSS. Effluent TSS was between 5 mg/L and 15 mg/L. Additionally, total maximum daily load (TMDL) requirements for fecal coliform and macro-invertebrates were met. This facility also installed the WWETCO FlexFlow™ Control Valve which allows aquatic biology passage during dry weather flow and causes the head differential needed to operate the filter during wet-weather flow.

Table 2-24 - Preliminary Construction Cost of the FlexFilter

Flow	# Cells	Cell Filter Area (ft^2)	Budgetary Equipment Price	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	5	720	$739,000	$1,108,500	$184,750	$184,750	$1,108,500	$3,325,500
25 MGD	5	1,800	$1,403,000	$2,104,500	$350,750	$350,750	$2,104,500	$6,313,500
30 MGD	5	2,340	$2,797,000	$4,195,500	$699,250	$699,250	$4,195,500	$12,586,500
100 MGD	10	7,200	$3,831,000	$5,746,500	$957,750	$957,750	$5,746,500	$17,239,500
200 MGD	18	12,960	$5,733,000	$8,599,500	$1,433,250	$1,433,250	$8,599,500	$25,798,500
450 MGD	32	23,040	$23,463,000	$35,194,500	$5,865,750	$5,865,750	$35,194,500	$105,583,500

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-21 - Total Estimated Construction Cost of FlexFilter

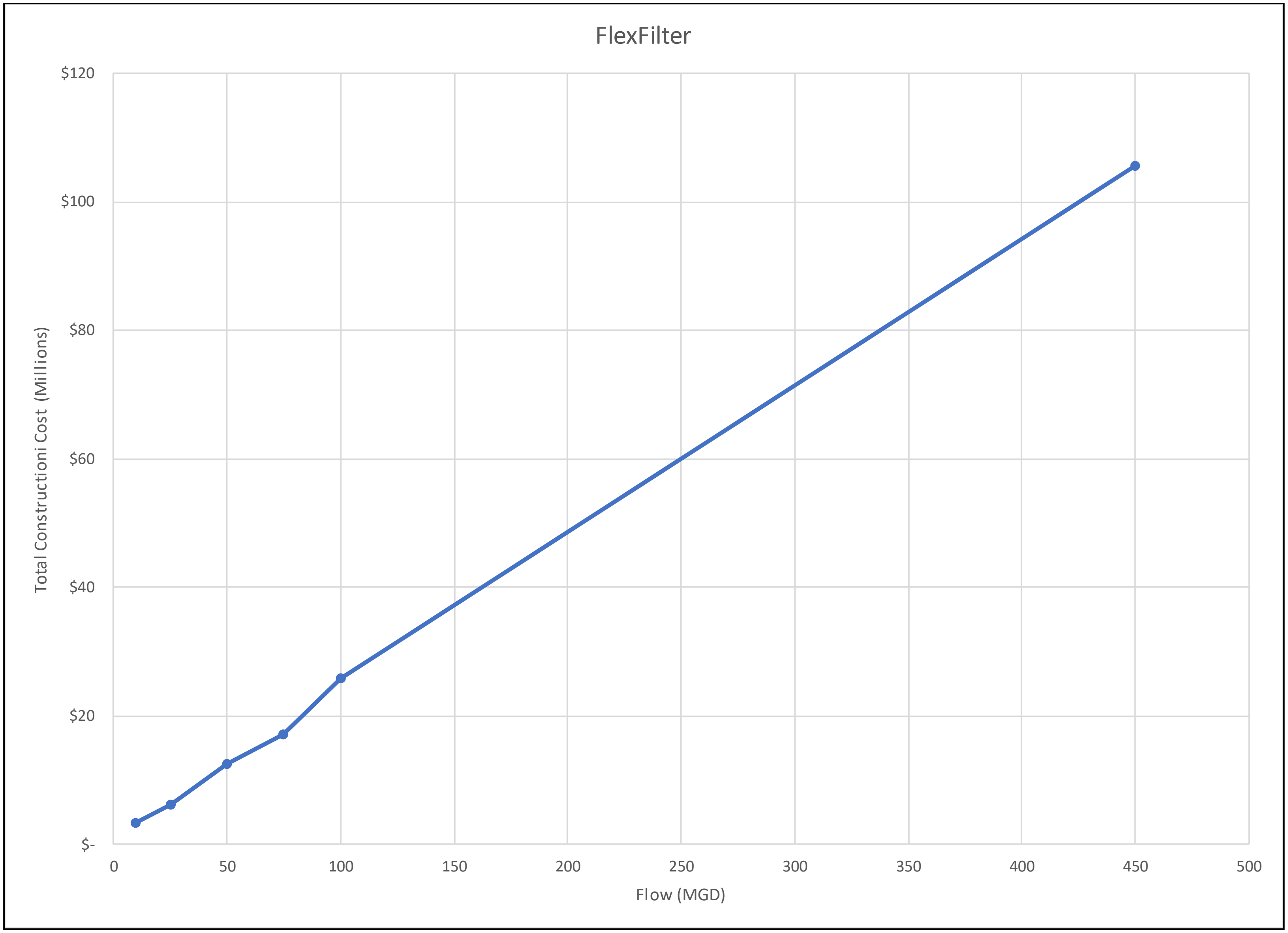


Table 2-25 - Annual Operation and Maintenance Cost of FlexFilter

Flow	Blower Power (kw-hr/MG Treated)	Blower Energy Costs(1)(2)	Media Addition after 10 yrs(3)	Event Labor	Preventative O&M	Backwash & Recycle Pumping	Effluent Pumping	Total Annual O&M
10 MGD	47	$700	$2,254	$20,000	$800	$703	$879	$25,336
25 MGD	48	$1,750	$5,636	$20,000	$2,000	$1,758	$2,198	$33,342
50 MGD	50	$3,500	$7,326	$20,000	$2,400	$2,110	$2,637	$37,973
100 MGD	48	$5,250	$22,542	$20,000	$8,000	$7,033	$8,791	$71,616
200 MGD	53	$7,000	$40,576	$20,000	$16,000	$14,066	$17,582	$115,224
450 MGD	50	$31,500	$72,135	$20,000	$36,000	$31,648	$39,561	$230,844

Notes:
(1) Assumes 500 hours of annual operation
(2) Assumes energy costs of $0.14/kW-hr
(3) Media cost is distributed annually based on given future cost

2.3.4 Evaluation of Pretreatment Technologies

The above process descriptions provide general information on pretreatment processes that may be required for disinfection of CSO discharges. These processes have been evaluated for pretreatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the highest, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each pretreatment process in relationship to each category and subcategory. The results of the evaluation are illustrated in Table 2-26.

Based upon the evaluation results in Table 2-26, the SANSEP process has the highest rating, followed by the ACTIFLO® ballasted flocculation, the DensaDeg® ballasted flocculation, FluidSep vortex units and Storm King®. The Compressible Media Filter received the lowest rating, however this process is used only for polishing the effluent from the other processes in the most stringent treatment objective.

For the vortex/swirl process, the performance of the Storm King® and FluidSep vortex units are essentially the same, but the construction cost of the FluidSep is significantly less, due to the limited use of fabricated metal components, as compared to the Storm King® Unit.

For the ballasted flocculation processes, a similar simplification is possible. The ACTIFLO® process produces less sludge than the DensaDeg® process requiring less ancillary tankage, no cyclone separator and no sand replacement.

Table 2-26 - Evaluation of Pretreatment Technology

	Vortex Separator		**Modified Vortex**	**Ballasted Flocculation**		**Polishing Filter**
Criteria	**Fluidsep Vortex**	**StormKing Vortex**	**SANSEP**	**ACTIFLO® Ballasted Flocculation**	**DensaDeg® XRC Ballasted Flocculation**	**FlexFilter**
Applicability	5	5	4	4	4	2
Performance						
TSS	3	3	5	5	5	5
Hydraulics	3	3	4	3	3	1
Wastestreams	1	1	4	3	3	2
Complexity	5	5	4	3	3	1
Limitations	2	2	4	4	3	3
Construction Cost	4	2	5	3	3	1
Operations	4	4	4	2	2	1
Maintenance	4	4	4	2	2	1
Space Requirements	3	3	3	4	4	2
Requiring:						
Ancillary Tanks	1	1	4	3	3	5
Total	35	33	45	36	35	24

2.4 Disinfection

This section evaluates the implementation of the following chemical and physical disinfection technologies:

- Chlorination (consisting of Chlorine Dioxide, Sodium Hypochlorite, and Calcium Hypochlorite)
- Peracetic Acid
- Ultraviolet (UV) Disinfection
- Ozonation

The evaluation will consist of a description of the particular disinfection technology, the concentrations or intensities normally needed and the equipment or process used to apply the disinfectant. The evaluation will also discuss any limitations of the process or equipment. Also considered in the evaluation will be any inhibiters that will interfere with the disinfection process, and the need for any for dechlorination. The analysis will also consider the safety of the process and the availability of the chemicals or the equipment to produce them.

Disinfection is more difficult to design and operate in CSO applications than in wastewater treatment plants due to the complex characteristics of CSOs. The flowrates of CSOs are highly variable which makes it difficult to regulate the addition of disinfectant. The concentration of suspended solids is high and the temperature and bacterial composition varies widely. Pilot studies are commonly conducted to characterize the range of conditions that exist for a particular area and the design criteria to be considered.

In the cases of chemical addition; chlorine dioxide, sodium hypochlorite, calcium hypochlorite, and peracetic acid, the disinfectant must be mixed with the liquid to be disinfected. Experience has shown that the long contact time required for conventional wastewater treatment is not appropriate for the treatment of CSOs; however, chemical disinfection of CSOs can be accomplished using high-rate disinfection. High-rate disinfection is defined as employing high-intensity mixing to accomplish disinfection within a short contact time, generally five minutes. For this TGM, a chemical induction flash mixer, such as manufactured by The Mastrr Company, will be used to mix either the gas or liquid with the flow to be disinfected. The mixer develops a "G" value of 1,000/sec. The detention time in the mixing zone of the mixer is 3 seconds. Following the mixer, a tank area with a detention time of 5 minutes at the design rate, will be used to provide adequate mixing. In the case of sodium hypochlorite and calcium hypochlorite, a second induction mixer will be used to mix the dechlorination chemicals, sodium bisulfite, with the flow before discharging to the receiving water. No tankage would be provided following the addition of dechlorination chemicals.

The efficiencies of virtually all the disinfection processes being considered in this TGM are dependent upon the TSS concentration of the liquid being disinfected. The required TSS concentration for each of the disinfection processes for different treatment objectives is shown in

Table 2-27.

Table 2-27 - Maximum TSS Concentration for Each Disinfection Process

Fecal Coliform Objectives (MPN/100ml)	Maximum TSS Concentration (mg/L)			
	Chlorine Dioxide	Sodium Hypochlorite	Peracetic Acid	Ultraviolet Disinfection
200	70	45	70	25
770	70	45	70	25
1,500	70	45	70	25

2.4.1 Chlorine Dioxide

Process Description

Chlorine dioxide (ClO_2) is most commonly used for drinking water treatment to oxidize reduced iron, manganese, sulfur compounds, and certain odor-causing organic substances in raw water. Chlorine dioxide is often used as a pre-oxidant because, unlike chlorine, it will not chlorinate organic compounds and therefore will not react with organic matter in the water to form trihalomethanes (THMs) or other byproducts. In industrial markets, chlorine dioxide has been most readily used in the paper and pulping industry. In this application, chlorine dioxide is used as bleach for paper pulp since it does not react with the organic lignin in the wastewater to form by-products such as the THMs.

The data for chlorine dioxide shows that it is a more effective disinfectant than sodium hypochlorite. However, chlorine dioxide needs to be generated on site because it is too unstable even for short periods of time. There is one type of chlorine dioxide generator that utilizes hydrochloric acid and sodium chlorite in either commercially available or diluted concentrations to generate chlorine dioxide. They produce chlorine dioxide and consistently maintain a product yield greater than 95%, making it ideal for drinking water treatment. The use of chlorine gas is not required when using these systems. These systems produce relatively small amounts of chlorine dioxide for disinfection in water systems where low concentrations of ClO_2 are needed.

There is a second process, which produces "large quantities" of gas for disinfection of drinking water and wastewater. This is the Ben Franklin™ process, manufactured by CDG Environmental, LLC. The Ben Franklin™ process uses the chemical reaction of hydrochloric acid with sodium chlorate to generate chlorine dioxide to produce a mixture of chlorine and chlorine dioxide, both in the gas phase. These gases, as produced by the Ben Franklin™ generator, may be applied directly to water as a combination, or they may be separated and applied at different points in the water treatment process. In its most direct application, the mixed chlorine/chlorine dioxide product can be injected into the water to be treated. The result is a mixed disinfectant containing chlorine dioxide and chlorine. The chlorine dioxide acts as a very rapid disinfectant/oxidant while the chlorine persists longer. This can be an advantage in the water systems where a residual is desired but a disadvantage in the receiving water where disinfection byproduct is a concern.

The use of chlorine dioxide in wastewater disinfection has been very limited in US. Technologies are currently unavailable to provide an easier and safer way to produce chlorine dioxide at a concentration for CSO treatment at remote satellite locations. Chlorine dioxide is extremely unstable and explosive and any means of transport is potentially hazardous. Chlorine dioxide can produce potentially toxic byproducts such as chlorite and chlorate. Chlorine dioxide will not be considered further.

2.4.2 Sodium Hypochlorite

Description of Process

Hypochlorite is a commonly used disinfectant in water and wastewater treatment and has been applied as a CSO disinfectant. It can be produced on site or can be delivered in tanker trunks with concentrations between 3 to 15% of available chlorine. Hypochlorite decays over time. The decay rate can increase as a result of exposure to light, time, temperature increase or increased concentration of the compound. The solution can be stored for 60 to 90 days before the disinfecting ability degrades below recommended values (5% concentration). Degradation of the solution over time is a major disadvantage of sodium hypochlorite for CSO applications, due the variability of the size and frequency of rain events. There are two types of hypochlorite: Sodium hypochlorite ($NaOCl$) and Calcium hypochlorite ($Ca(ClO)_2$). Sodium hypochlorite is often referred to as liquid bleach or soda bleach liquor, while Calcium hypochlorite is manufactured either as a grain or powder under various names, and all have either approximately 35% or 65% available chlorine content. Sodium hypochlorite is the most widely used of the hypochlorites for potable water and waste treatment purposes. Although it requires much more storage space than high-test calcium hypochlorite and is costlier to transport over long distances, it is more easily handled and gives the least maintenance problems with pumping and metering equipment. It will be used as the basis for evaluating disinfection alternatives.

Based on molecular weight, the amount available as chlorine is 0.83 lbs/gal for a 10% solution of sodium hypochlorite and 1.25 lbs/gal for a 15% solution.

Required Concentrations

The application of sodium hypochlorite as a disinfectant was studied by the USEPA in Syracuse, New York. An equation was developed to estimate the chlorine concentration needed to achieve a particular log-kill of fecal coliform. The parameters included in the equation include the pH of the liquid, the influent fecal coliform count to the disinfection process, the TSS concentration, and the mixing factor of GT. The equation is as follows:

Log-kill = (0.08C^0.36) * (GT^0.42) * (SS^-0.07) * (FC^0.02) * (10^(-0.03pH))

Where: C = concentration of disinfectant (mg/L as Cl_2)
SS = concentration of SS (mg/L)
FC = Influent level of fecal Coliform, (counts/100 ml)
pH = pH
GT = mixing intensity x detention time.

This is based upon the G of 1000 discussed above, and a three second detention time in the mixing zone of the mixer.

Computations done using this equation, for the range of parameters expected in CSO waters, indicate that a chlorine concentration of between 18-24 mg/L will disinfect the fecal coliform concentrations to the levels expected in the LTCP treatment objectives.

Equipment Needed

Sodium hypochlorite is delivered to the site in liquid form as either a 10% or 15% solution. The sodium hypochlorite is stored in a tank and is fed into a rapid induction type mixer at a rate established by the flow, through a chemical feed pump. A 12.5% solution may degrade to 10% in 6 to 8 weeks, in which case the degradation rate slows. Typically it is stored as a 5% solution of available chlorine. It should be stored at temperatures below 85 degrees Fahrenheit in a corrosion resistant tank and protected from light exposure. For the purpose of this TGM, the chemical storage is estimated to store enough chemical for 24-hours of continuous treatment at the design overflow rate plus a safety factor of 1.5.

The chemical storage tank and the feed pump would be stored in a building with the induction mixer installed in a channel, followed by a detention tank with a 5-minute detention time, as described at the beginning of this section.

Limitations

One of the problems with sodium hypochlorite is that the solutions are vulnerable to a significant loss of available chlorine in a few days. This is described as the shelf life of the chemical. The stability of hypochlorite solutions is greatly affected by heat, light, pH, and the presence of heavy metal cations. The higher the concentration, and the temperature the higher the deterioration. A 15% solution will deteriorate to half strength in approximately 120 days. A 10% solution will take approximately 220 days.

The limited shelf life of sodium hypochlorite makes it difficult in an intermittent application like a CSO to ensure that the correct amount of disinfectant is being introduced into the waste stream. This can lead to under or over disinfecting, which can make it difficult to achieve the required treatment objective.

Inhibitors

High TSS concentrations would be an inhibitor to disinfection using sodium hypochlorite, primarily by shielding the fecal Coliform from the disinfectant.

Need for Dechlorination

The use of chlorine disinfection of wastewater can result in several adverse environmental impacts especially due to toxic levels of total residual chlorine in the receiving water and formation of potentially toxic halogenated organic compounds. Chlorine residuals have been found to be acutely toxic to some species of fish at very low levels. Other toxic or carcinogenic chlorinated compounds can bioaccumulate in aquatic life and contaminate public drinking water supplies. For this reason, excess chlorine must be dechlorinated. Gaseous sulfur dioxide, liquid sodium bisulfite, sodium thiosulfate, sodium sulfite, and sodium metabisulfite can be used for this purpose. Sodium bisulfite is the most commonly used chemical for dechlorination due to the ease of handling, fewer safety concerns, economic reasons, and availability. For this TGM the use of sodium bisulfite is assumed. Typical characteristics are shown in the Table 2-28 below. Sodium bisulfite can decay about 40 % over a period of six-months. The storage should consider the release of sulfur dioxide when the sodium bisulfite is stored in a warm environment; a water scrubber is typically used to diffuse and dissolve off-gas. Another operational problem is the crystallization of sodium bisulfite when the temperature drops below the saturation point: -6.7^{0}C for 25% solutions and 4.4^{0}C for 38% solutions.

Table 2-28 - Sodium Bisulfite Key Properties

Property	Value
Concentration	38% (25% solutions)
Molecular Weight	104.06
Boiling Point	> 100˚C
Freezing Point	-12˚C
Saturation Temperature	4.4˚C @ 38%
Vapor Pressure	78 mm Hg @ 37.7˚C
Specific Gravity	1.36 @25˚C
pH	3 to 4
Solubility in water	Completely

Sodium bisulfite could be stored indoors in a conditioned building to minimize the degradation due to high temperature and sunlight exposure. To minimize the potential of chemical interaction the storage tanks of sodium hypochlorite and sodium bisulfite have to be isolated from each other.

A rapid induction mixer located in a channel downstream of the contact chamber, as described earlier in this section will accomplish the mixing of sodium bisulfite. Since the Dechlorination process is essentially instantaneous, no contact chamber is required downstream of the injection.

Costs

The costs for the sodium hypochlorite disinfection system include several components including chlorine contact tank, the chemical storage facility for sodium hypochlorite and sodium bisulfite, pumping system for disinfection and dechlorination, mixers, piping and storage tanks.

The preliminary report level construction cost estimates provided in Table 2-29 include the equipment, installation, building, and contingency for a sodium hypochlorite disinfection system of design flow ranging from 10 MGD to 450 MGD. Budgetary equipment pricing information was gathered from equipment manufacturers.

Operation and Maintenance

Operating costs for hypochlorite disinfection systems consist of the power and chemical costs. Power costs are based upon the horsepower of the metering pumps and rapid mixers. Chemical costs are based on usage of sodium hypochlorite and sodium bisulfite.

The equipment would be housed in a building; therefore, maintenance costs consist of labor costs for housekeeping of the building, preventative and corrective maintenance of the mechanical equipment including the chemical metering pumps, mixers, and other appurtenances, and restocking of the chemicals. The chlorine contact tanks will also need periodic maintenance to clean debris.

Estimated annual operation costs for the hypochlorite disinfection system are presented on Table 2-30 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on

Table 2-31.

Space Requirements

The space requirements of the facilities required for disinfection using sodium hypochlorite are based upon the size of the mixing chamber/tank size for chlorination, the chemical building size for chlorination and de-chlorination, the size of the mixing chamber for de-chlorination, and a buffer of 5 feet around each.

Table 2-29 - Preliminary Construction Cost for Chlorination Systems

Flow	Chlorine Contact Tank Cost	Building Cost	Hypochlorite Pump System and Apprt. Cost	Bisulfite Pump System and Apprt. Cost	Hypochlorite Storage Tank Cost	Bisulfite Tank Cost	Mixer and control valves Cost
10 MGD	$125,000	$156,475	$28,000	$16,450	$21,495	$7,900	$150,000
25 MGD	$310,000	$336,159	$35,700	$16,450	$44,990	$8,495	$200,000
50 MGD	$620,000	$507,778	$49,000	$19,250	$97,485	$10,685	$380,000
75 MGD	$930,000	$681,742	$50,750	$19,250	$129,980	$13,183	$450,000
100 MGD	$1,240,000	$820,039	$61,250	$27,300	$162,475	$13,483	$550,000
450 MGD	$5,580,000	$3,883,107	$231,000	$105,000	$779,880	$50,872	$2,000,000

Flow	Installation Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	$757,980	$126,330	$126,330	$757,980	$2,273,939
25 MGD	$1,427,690	$237,948	$237,948	$1,427,690	$4,283,071
50 MGD	$2,526,297	$421,050	$421,050	$2,526,297	$7,578,891
75 MGD	$3,412,357	$568,726	$568,726	$3,412,357	$10,237,072
100 MGD	$4,311,820	$718,637	$718,637	$4,311,820	$12,935,461
450 MGD	$18,944,788	$3,157,465	$3,157,465	$18,944,788	$56,834,364

Notes:
(1) Installation costs are estimated at 150% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Table 2-30 - Annual Operation Cost for Hypochlorite Disinfection

Flow	Sodium Hypochlorite Metering Pump⁽⁸⁾	Sodium Bisulfite Metering Pump⁽⁸⁾	Total HP	Total Power (kW)⁽¹⁾	Annual Energy Usage (kW-hr)⁽²⁾	Annual Power Cost⁽³⁾	Sodium Hypochlorite Usage (lbs)⁽⁴⁾	Sodium Bisulfite Usage (lbs) ⁽⁵⁾	Sodium Hypochlorite Cost⁽⁶⁾	Sodium Bisulfite Cost⁽⁷⁾	Total Annual Cost
10 MGD	1.5	0.5	2	1	746	$104	39,986	8,693	$19,993	$17,385	$37,483
25 MGD	2	0.5	2.5	2	932	$130	99,966	21,732	$49,983	$43,464	$93,577
50 MGD	5	1	6	4	2237	$313	199,932	43,464	$99,966	$86,927	$187,206
75 MGD	7.5	1	8.5	6	3169	$444	299,898	65,195	$149,949	$130,391	$280,784
100 MGD	5	1.5	6.5	5	2424	$339	399,865	86,927	$199,932	$173,854	$374,126
450 MGD	25	4	29	22	10813	$1,514	1,799,391	391,172	$899,695	$782,344	$1,683,553

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assumes a sodium hypochlorite dosage of 23 mg/L
(5) Assumes a sodium bisulfite dosage of 5 mg/L
(6) Assumes a sodium hypochlorite cost of $0.50/lb
(7) Assumes a sodium bisulfite cost of $2/lb
(8) Metering pump HP based on quotations by Pyrz Water Supply Co., Inc.

Table 2-31 - Annual Maintenance Labor Cost of Hypochlorite Disinfection

Frequency	Estimated Man-Hours	Annual Cost
Daily Check	1	$54,750
Weekly Check	4	$31,200
Monthly Check	8	$14,400
Quarterly Clean and Check	12	$7,200
Total Annual Maintenance Cost		$107,550

Notes:
(1) Assumes labor rate of $150/hour

2.4.3 Peracetic Acid Disinfection

Description of Process

Peracetic acid (CH_3CO_3H), also known as PAA, is an organic peroxy compound, which has strong oxidizing properties. In the presence of water (H_2O), it breaks down into a mixture of hydrogen peroxide (H_2O_2) and acetic acid (CH_3CO_2H). The mixture is clear and colorless with no foaming capabilities and has a strong pungent acetic acid (vinegar) odor. PAA is a very strong oxidizing agent and has a stronger oxidation potential than chlorine or chlorine dioxide. It has been used as a bactericide and fungicide in various industries including the food and beverage industries, the textile and pulp and paper industries, as well as smaller, more confined applications, including hospital settings.

The U.S. EPA approved peracetic acid as a primary disinfectant for wastewater in 2007 while PAA has been used to treat wastewater in Europe for over a decade. Since the EPA approval, only a limited number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant, including a wastewater treatment plant in St. Augustine, Florida that discharges treated flow to environmentally-sensitive wetlands. Case studies have also been conducted at a number of treatment plants including a wastewater treatment plant in Frankfort, Kentucky and the Bayonne MUA pilot study for CSO treatment.

PAA decomposes quickly and its ultimate fate in the environment is the basic molecules of carbon dioxide, oxygen, and water. Toxicity studies were conducted on PAA in the 1980's to evaluate impact of PAA disinfected primary effluent on the bay environment. The study concluded that there was no toxicity impact. The Bayonne MUA pilot study and other studies on PAA disinfection of wastewater did not experience toxicity of residual PAA. However, more studies are still required to prove that residual PAA poses no toxicity to aquatic life.

Solutions of PAA for wastewater disinfection are typically of 10% and 15% concentrations, higher concentrations have issues with stability. The shelf life of PAA is normally 12 months. However, PAA must be stored at the site where it is dispensed, as underground piping is not permitted. PAA are fed using a diaphragm pump with Teflon diaphragms and polypropylene, Teflon materials and degassing heads are recommended for feeding. The product should be fed into the waste stream at an area of good mixing to promote rapid dispersion. It may be introduced continuously or intermittently depending upon the needs of the user.

Required Concentrations

This is an area where more research and investigation needs to be done, particularly as it related to disinfection of CSOs. The application of PAA as a disinfectant was studied in the Bayonne MUA pilot study. PAA disinfection tests were performed with PAA dose of typically 2 to 3 mg/L, but up to 7 mg/L, targeting PAA residual in 1 to 2 mg/L range. The best-defined relationship derived from the study results was that between the applied dose of PAA as normalized by COD present in the wastewater and the log reduction of pathogen indicators. PAA dose of 0.01 mg/L of PAA per mg/L of COD present in wastewater resulted in 3-log reduction of fecal coliforms (on average), with slightly higher effectiveness for E. coli and slightly lower for Enterococci. Increasing the relative dose to above 0.015 mg/L of PAA per mg/L of COD increased log reduction to 4. Further increase of the PAA dose appeared to have limited effect on further increasing reduction of the bacterial densities, although data in that range are too limited to allow for a firm conclusion.

Equipment Needed

PAA is typically delivered to the site in liquid form as a 12% solution. The PAA is stored in a tank and is fed into a rapid induction type mixer at a rate established by the flow, through a chemical feed pump. The chemical storage tank and the feed pump would be stored in a building with the induction mixer installed in a channel, followed by a detention tank. Pilot testing has determined that the majority of kill happens in the first 10 minutes regardless of the concentration of PAA. Therefore, the contact time required by PAA has been determined to be between 2 and 10 minutes.

Limitations

The use of peracetic acid in wastewater disinfection has been very limited in the US. There is no known application of peracetic acid in CSO disinfection in the US. In addition, the cost of PAA may be of concern largely due to small consumer market worldwide and the limited production capacity. One manufacturer has listed the price per pound between $0.50 and $0.70 in 2008 dollars, which corresponds to between $3 per gallon and $5.50 per gallon depending on concentrations. Use of peracetic acid in CSO locations could also be complicated by a need for on-site storage of the chemical, which requires secondary containment and appropriate safety measures.

Inhibitors

Studies have shown that variations in water quality parameters related to NH3, TSS, COD, dissolved oxygen and pH, did not have significant effect on the performance of PAA and PAA produces negligible disinfection by-products.

Need for Dechlorination

At the time of this TGM, there is no indication that de-chlorination will be required. The short half-life means that PAA is not persistent and rarely needs to be neutralized prior to discharge.

Costs

The Bayonne MUA pilot study presented equipment cost of PeraGreen, INJEXX TM unit for flowrate ranging from 5 MGD to 250 MGD (Figure 2-22). The costs provided include the cost of equipment delivered to the site and are 2017 dollars as well the cost of a contact tank providing three minutes of hydraulic retention time.

Operation and Maintenance

O&M costs were also provided by the Bayonne MUA pilot study to maintain a PAA residual of 0.8-1.0 mg/l in flowrate ranging from 5 MGD to 250 MGD (Figure 2-23).

Figure 2-22 - Equipment Cost for Peracetic Acid System

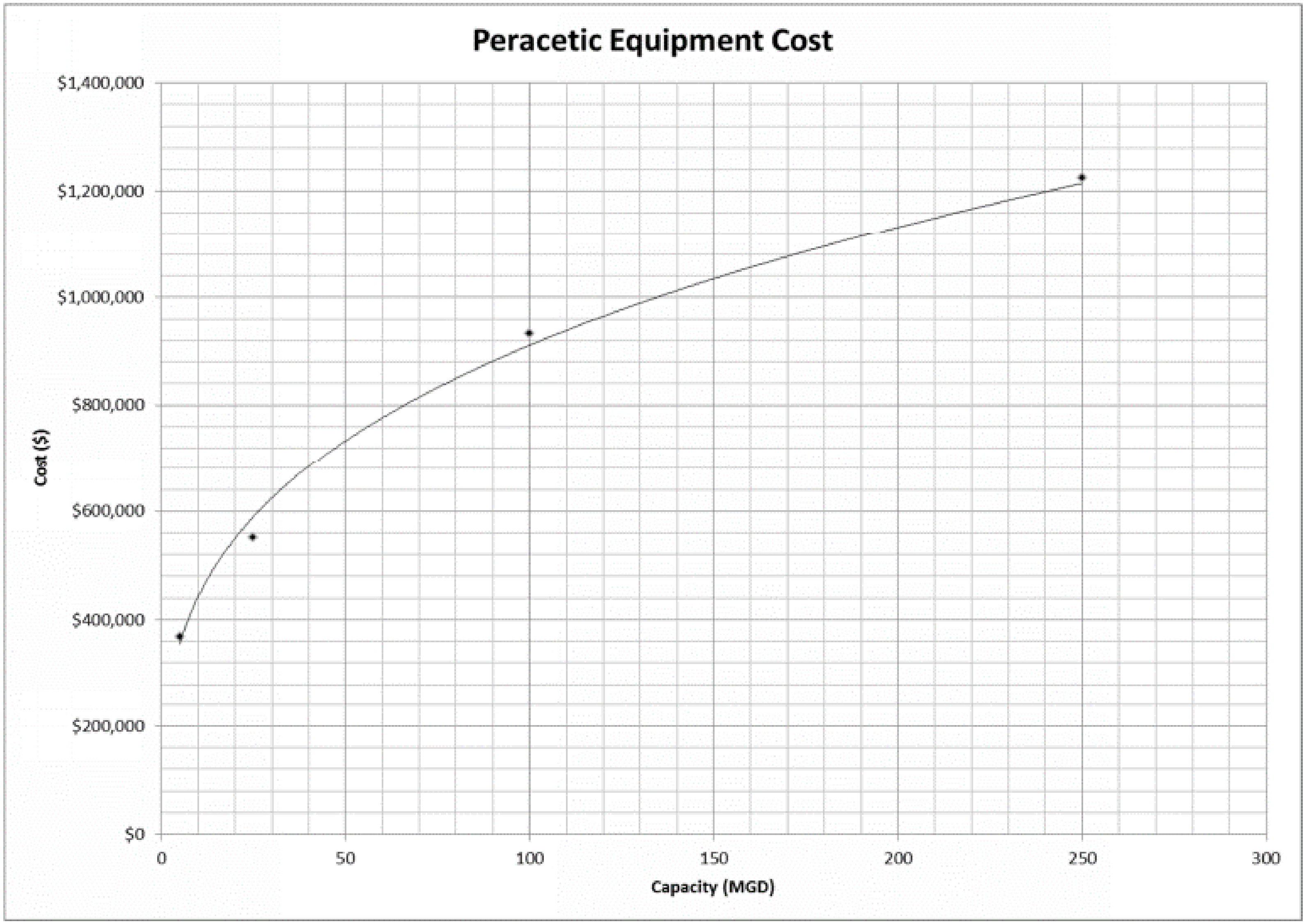
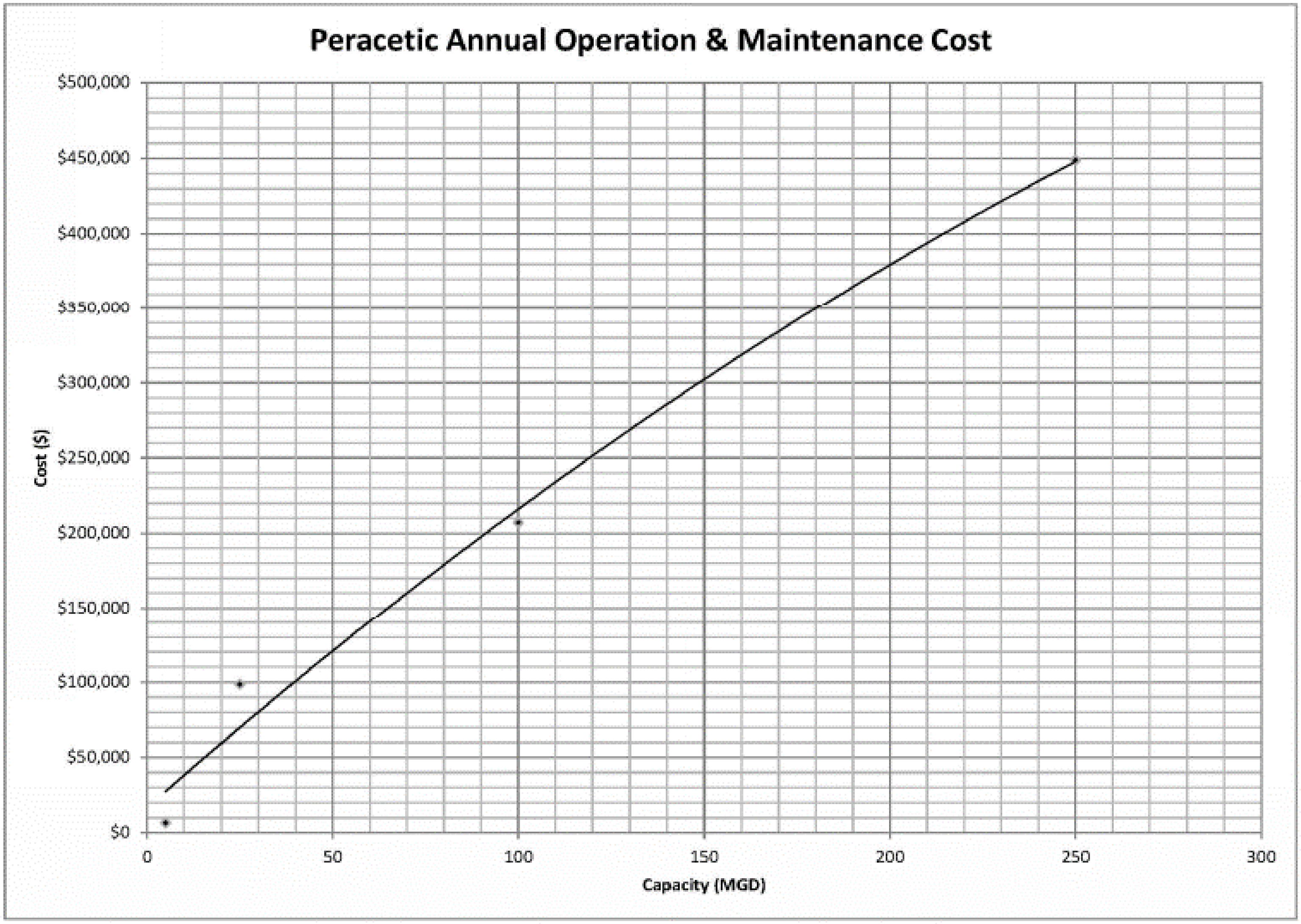


Figure 2-23 - Annual O&M Cost for Peracetic Acid System



2.4.4 Ultraviolet Disinfection

Description of Process

The use of ultraviolet (UV) light is one of the common methods for disinfection of treated wastewaters. In fact, UV disinfection has become the favored technology for new plants and upgrades for existing plants. There are reportedly over 3,500 UV wastewater disinfection systems currently operating in North America, treating flows of up to 300 mgd. UV disinfection eliminates the operational and environmental hazards associated with the use of chlorine compounds, which is a strong oxidant (and sulfite compounds when dechlorination is required), and is cost-competitive with alternative technologies. UV systems are modular and since they require smaller volumes than a chlorination contactor, they can be easily retrofitted into existing chlorination channels.

UV disinfection is a physical process, relying on the transfer of electromagnetic energy released from UV lamps to be absorbed by the nucleic acids (DNA and RNA) in the microorganisms. When the nucleic acids of the organisms are subjected to sufficient quantity of UV radiation (the "dose"), the energy damages the DNA strands by causing specific thymine monomers to combine, which in turn prevents the cell from replicating. This inability to reproduce is, in itself, the lethal effect of UV. Organisms rich in thymine such as *C. parvum* and *G. muris* tend to be more sensitive to UV radiation. The UV radiation in the spectral region between 220 and 320 nm is germicidal, where the wavelengths between 255 nm to 265 nm are considered to be most effective for microbial inactivation. UV disinfection is very effective in inactivation of protozoa, bacteria and viruses, where viruses generally require higher UV radiation dose than protozoa and bacteria.

Electrode type lamps are used to produce light at UV wavelength. Based on the internal operation of these lamps, there are three categories of UV lamps available for use in water/wastewater treatment. These are *low-pressure low-intensity/output (LP-LO)*, *low-pressure high-intensity/output (LP-HO)* and *medium-pressure high intensity/output (MP-HO)* configurations.

In the low-pressure design, lamp output is optimized via mercury vapor pressure and electric current control to generate a broad spectrum of essentially monochromatic radiation in 200nm to 280 nm range (UV-C). Low-pressure lamps produce an intense peak at 254nm which is close to 260nm wavelength considered to be the most effective for microbial inactivation. These low-pressure lamps are highly efficient, converting 30-50% of their input energy to germicidal range of UV light, where 85 – 88 % of this light is at 254 nm. The difference between low-pressure low-intensity and high-intensity lamps are low-intensity lamps use liquid mercury where high intensity lamps use mercury-indium amalgam. Because of this difference, output of LP-LO lamps decreases when the lamp wall is not near optimum temperature of 40°C. LP-HO lamps operate at temperature range of 100 -150°C and can maintain greater stability of lamp output over a wide range of temperatures. In addition, UV output of LP-HO lamps can be modulated between 30 – 100% to adjust the UV dose.

The absolute output of LI-LO lamps is relatively low, with typical UV ratings of 25 to 27 Watts per lamp at 254 nm, for 40 to 100 W input lamps. In LP-HO higher input power (200 to 500 W) have resulted in higher lamp output at 254 nm (60 to 400 W), while retaining their highly efficient energy conversion characteristic.

A number of medium-pressure high-intensity/output UV lamps have been developed over the last decade. MP-HO lamps operate at vapor pressure of 10^2 to 10^4 mm Hg while the low-pressure lamps operating at less than 0.8 mm Hg. Also, the operation temperature of MP-HO lamps are significantly higher (600 – 800°C)_than the LP lamps. With the higher mercury pressures, the lamps are driven at substantially higher input power levels (in the range of 1,000 w to13,000 W). Medium-pressure lamps are polychromatic, effectively radiating 20 to 50 times more the total UV-C output (200 to 280 nm) compared to LP-HO lamps. However, MP-HO lamps have lower efficiency than LP-LO and LP-HO lamps. MP lamps can convert about 7 to 9% of their input power to 254 nm output, and 10 to 15% of the total output is in the germicidal region. Overall, the efficiency of the MP-HO lamps is 4 to 5-fold less than the efficiency of the low-pressure lamps. In addition, the lamp, sleeve and ballast life of MP-HO lamps are significantly lower than LP lamps. However, because of their much higher absolute output levels, fewer lamps are needed, often resulting in a smaller footprint for the UV system.

The actual application of UV to wastewater disinfection is fairly simple. The lamps are enclosed in quartz sleeves (highly transmissible in the UV region), and submerged in the flowing wastewater. The lamp/quartz assemblies are typically arranged in modules, with several modules comprising a bank of lamps. In wastewater applications, these banks of lamps are typically placed in open channels, either horizontally or vertically oriented, with level control devices that maintain water levels above the submergence level of the lamps. Pressure units, using closed-vessel reactors, are also used for wastewaters, although pressure units are more frequently applied in drinking water applications. Generally, automatic cleaning systems/wipers are integrated with each bank of lamps to periodically clean the surface of the quartz sleeve and prevent fouling of the sleeve surface and maintain high transmissivity of the sleeves.

There are many benefits associated with UV disinfection:

1. Since no harmful chemicals are added to the wastewater and no known disinfection byproducts are produced as a result of UV radiation.
2. UV system has a compact footprint and the inactivation of microorganisms occur almost instantaneously as the water passes through the UV lamps. Therefore, UV disinfections systems are set up as a modular system and can be easily configured in one or more channels.
3. Chemical storage, transportation and handling is eliminated for the purpose of disinfection.

UV disinfection does, however, require more power than chemical disinfection, which could be a significant consideration for the larger overflow applications.

Required Concentration

There are several factors that affect the design of a UV system for wastewater disinfection. These center about the design goal to efficiently deliver the necessary UV dose to the targeted microorganisms. Dose is defined as the product of the intensity of UV energy (the rate at which it is being delivered, mJ/cm^2 and the exposure time of the organism to this intensity. Ideally, these factors can be applied such that every element in the water receives the same dose as it passes through the UV unit. However, in practice, the UV dose will not be identical for all particles in the water. There is a variation in the intensity field within the unit and variation in the exposure times, resulting in a dose distribution. Effective design optimizes this dose distribution and avoids any appearance of hydraulic short circuiting through the UV unit. Exposure time is dependent on the hydraulic characteristics of the unit, reflecting the spacing of the quartz/lamp assemblies, inlet and outlet conditions, and hydraulic loading rates. The output energy of the lamps, the transmissibility of the quartz sleeves, and the transmittance of the wastewater itself affect intensity. The loss of energy due to the aging of the lamps and degradation of the quartz sleeve transparency must be incorporated in the design of the UV units. Generally, the lamp output will decrease to between 50% and 80% of their nominal output by the end of lamp life (typically LP-HO lamps have 9,000 to 15,000 hours and MP-HO lamps have 3,000 to 8,000 hours lamp life). Sleeve fouling will typically account for a 20% to 30% decrease in transparency through the life of the quartz sleeve, even if they get cleaned regularly. The transmittance of treated wastewater effluents will range between 50% and 75%, depending on the influent water quality and the degree of treatment provided before disinfection. Combined sewer overflows and storm water have significantly low UV transmittances and it is generally in the range of 20% to 50% per cm at 254 nm. Since this directly affects the portion of the energy from UV lamps reaching the microorganism, design should call for closely spacing the lamps and using higher-powered lamps. The medium-pressure lamp units can meet these criteria, as can the LP-HO lamp technologies, although to a lesser degree. Head losses are generally manageable for these systems, typically in the order of 6 to 24 inches for the medium-pressure units. Typically, a dose of 30 to 40 mJ/cm^2 is specified for treated wastewater disinfection, where three to four log inactivation rates are generally required to meet disinfection targets. Demonstration that the proposed unit will deliver this dose under design conditions (flow, UV transmittance, end-of-lamp life output, degraded quartz surfaces, etc.) is often required either as a prequalification for bidding, or at the time of commissioning. This is done through direct bio-dosimetric testing on full-scale or scaled systems, whereby a challenge organism of known dose-response is injected into the UV unit under design flow and UV transmittance conditions. By measuring the kill of the organism, the dose that was delivered by the unit can be estimated. This method has become an industry standard for validating the performance of UV systems. These protocols are articulated by the USEPA UV Design Guidance Manual (November 2006), the NWRI/AWWA RP UV Guidance (May 2003), and the USEPA Environmental Verification Program protocols for reuse, secondary effluents, and wet weather flows (2002). This method accounts for the variations in hydraulics through the UV lamps and UV radiation intensity in a system, and allows for a more consistent comparison of performance expectations and design sizing between different UV technology configurations.

The Bayonne MUA pilot study evaluated performance of Trojan UV3000Plus unit using low-pressure lamps. Correlation of all the individual data from the study indicated required approximately 25 mJ/cm^2 effective irradiation dose input to achieve 3log inactivation of pathogen indicators.

Equipment Needed

For purposes of this preliminary assessment of cost associated with the disinfection of combined sewer overflows, the low-pressure high intensity lamp technology is considered. As discussed earlier, the LPHO lamps are very efficient and with advancement in UV lamp technology, there are up to 1,200 W lamps available. The Sigma low-pressure high-intensity lamps offered by Trojan

Technologies has been used for preliminary sizing, layout, design and costs estimation; however, it is not the intent of this exercise to recommend a given manufacturer for such applications.

Limitations

In large applications, significant power is required for operation of UV system. In some locations power availability can be a limitation.

Inhibitors

Certain water quality parameters can have a big impact on the disinfection efficiency of the UV system. UV transmittance or UV absorbance is one the key parameter which impact the UV dose that the microorganisms get subjected to. Iron, ozone, manganese, natural organic matter (NOM), TSS are strong absorbers of UV light, which would reduce the UV transmittance. The threshold values for Ferric iron, Ferrous iron and ozone are set as 0.057 mg/L, 9.6 mg/L and 0.071 mg/L, respectively. If iron salts are used within the treatment process, alternative should be evaluated to compare savings of smaller UV system compared to cost associated with change of precipitation aid. Alkalinity, hardness (Ca, Mg and other salts) and TDS can form mineral deposits on quartz tubes and reduce the UV dose reaching microorganisms and would increase the frequency and sleeve cleaning. Alkalinity and pH also effect the solubility of metals carbonate which may absorb UV light. Oil and grease in the wastewater would accumulate on the quartz sleeves and reduce the UV transmittance.

Need for De-chlorination

Since no chemical is used in UV disinfection and there is no residual disinfectant in the wastewater due to UV disinfection, de-chlorination or residual disinfectant removal is not required in UV disinfection systems. If any chemical disinfectant is added in upstream of the UV disinfection, residual disinfectant removal may be required specific to chemical disinfectant used.

Costs

The costs for the ultraviolet disinfection system consist of the equipment cost, including its installation, the cost of the channels for the ultraviolet disinfection equipment.

The preliminary report level construction cost estimates provided in Table 2-32 include the equipment, installation, building, and contingency for UV disinfection system of design flow ranging from 10 MGD to 450 MGD. Budgetary equipment pricing information was gathered from equipment manufacturers.

Operation and Maintenance

UV disinfection systems have been used for continuous operation for many years at various treatment facilities. Routine operating and maintenance programs and guidelines have been established for these continuous operations. However, in the case of CSO discharges, the O&M requirements for the UV disinfection technology would be intermittent during the year and be based on the number of storm events per week, month or year. The CSO locations at remote sites would require field crews to be on site before a storm event to make sure the system is in operating conditions and after the storm event to perform general washdowns and maintenance check.

The O&M requirements would center on lamp cleaning, parts replacement, and general maintenance. Recent applications of UV lamps have cleaning systems that employ chemically-assisted mechanical wipers, which are effective for low-grade wastewater applications such as CSOs. This has significantly reduced labor time required for lamp cleaning and has also improved lamp effectiveness. However, one of the main challenges with CSO systems is that the lamps are not always submerged in the water and when there is long period between storm events, dust will accumulate on the sleeves. These dust particles would scratch the surface of the sleeve and reduce the penetration/transmittance of the UV light. Therefore, additional precaution and manual cleaning would be required from time to time. It is recommended that UV banks would be raised and inspected for debris after each event to ensure that there is not large debris caught up in the system. The wipers have a debris scraper that will handle smaller debris and push it out of the way, but it will be a good practice to inspect the equipment after each event.

Parts replacement is another major maintenance requirement and would include the replacement of lamps, ballasts, wipers and quartz sleeves. Since the UV system is not going to be operating continuously, lamp replacement is not going to be as often as continuously operating systems in wastewater treatment plants. While some manufacturers offer a lamp warranty only for set operation hours ranging from 12,000 hours to 16,000 hours for LP-HO lamps, which equates to 24 to 32 years of warranty for lamps. This long duration of lamp operation is not believed to be reasonable due to operational conditions of CSO systems. On the other hand, some manufacturers provide a warranty based on a set limit of operation hours or a set duration, which occurs first. The output of UV lamps decreases as lamps age. Generally, after 12,000 to 15,000 hours of operation, the lamps need to be replaced due to low power output. In this report, it is assumed that UV lamps would be replaced every 10 years. In addition to lamp replacement, the ballasts, a type of transformer that is used to limit the current to the lamps, will need to be replaced. For the specific brand and model used for cost estimation in this report, each ballast serves 2 lamps and has an expected life of 5 years.

The third major maintenance requirement would be general O&M requirements at the CSO site. General maintenance at each UV disinfection site would include repairs, cleaning the channels and surrounding areas, maintaining product inventories, system monitoring, and documenting site visits. Assuming that there would be a two-person field crew visiting each site for one hour before and after each storm event, the estimated maintenance hours per event would be 4 to 8 hours depending on the system sizes. UV disinfection systems for CSO discharges can be designed to operate intermittently during the year and also during winter conditions.Instrumentation for intermittent disinfection operations would be incorporated into the UV reactor's operation including monitoring CSO flows, CSO characteristics such as UVT and CSO water levels in the reactor and support channel. These controls would be programmed to turn the reactor on and off, increase or decrease the lamps' intensity based on UVT and open appropriate valves to drain the reactor when not in operation. Operations in the winter, however, would include other specific requirements in the reactor for controlling freezing conditions in the reactor. These requirements would include any or all of the following guidelines:

1. Drain the reactor and apply warm air to the module to maintain temperature above 32°F; and

2. Manually drain the cleaning solution from the wipers and refill the wipers before the next storm event (approximately 5 minutes per lamp). Leave the reactor full of water and

provide a heat source to maintain the water temperature above 32°F during freezing temperatures.

Space Requirements

The space requirements of the facilities required for disinfection using UV are based upon the size of the contact chamber and a buffer of 5 feet on upstream and downstream of the UV lamps.

Table 2-32 - Preliminary Construction Cost Estimates for UV Disinfection

Flow	Length x Width X Depth$^{(1)}$	Budgetary Equipment Price	Concrete Cost$^{(2)}$	Install Cost$^{(3)}$	GC General Conditions $^{(4)}$	GC OH&P$^{(5)}$	Contingency$^{(6)}$	Total
10 MGD	4’-0” x 4'-0" x 9’-0”	$300,000	$885,600	$1,778,400	$296,400	$296,400	$1,778,400	$5,335,200
25 MGD	50’-5” x 5'-1" x 9’-0”	$625,000	$1,138,536	$2,645,304	$440,884	$440,884	$2,645,304	$7,935,912
50 MGD	50’-5”x 5'-1" x 9’-0”	$1,100,000	$1,959,552	$4,589,328	$764,888	$764,888	$4,589,328	$13,767,984
75 MGD	53’-5”x 5'-1" x 9’-0”	$1,400,000	$2,076,192	$5,214,288	$869,048	$869,048	$5,214,288	$15,642,864
100 MGD	52’-3” x 4'-10" x 9’-0”	$1,600,000	$2,931,552	$6,797,328	$1,132,888	$1,132,888	$6,797,328	$20,391,984
450 MGD	68’-8” x 8'-11" x 11’-9”	$8,480,000	$12,060,757	$30,811,136	$5,135,189	$5,135,189	$30,811,136	$92,433,408

Notes:
(1) Channel size based on assumed channel size with length of twice the width before and after UV lamp banks, and 1.5 feet of free board for the side walls
(2) Concrete costs based upon assumed $900 per cubic yard
(3) Installation costs are estimated at 150% of the equipment cost.
(4) GC general conditions are estimated at 10% of the total direct cost.
(5) GC OH&P are estimated at 10% of the total direct cost.
(6) 50% of contingency is used for the planning level of cost estimates.

Table 2-33 - Annual Operation Cost for Ultraviolet Disinfection

Flow	Total Number of UV Lamps	Power Consumption per Lamp (kW)	Total Power (kW)	Annual Energy Usage (kW-hr)$^{(1)}$	Total Cost$^{(2)}$
10 MGD	32	1	32	16,000	$2,240
25 MGD	66	1	66	33,000	$4,620
50 MGD	132	1	132	66,000	$9,240
75 MGD	176	1	176	88,000	$12,320
100 MGD	240	1	240	120,000	$16,800
450 MGD	1152	1	1152	576,000	$80,640

Notes:
(1) Assumes 500 hours of annual operation
(2) Assumes energy costs of $0.14/kW-hr

Table 2-34 - Annual Maintenance Cost for Ultraviolet Disinfection

		Annual Number of Units Replaced			
Flow	**Lamps**	**Lamps(1)**	**Ballasts(2)**	**Sleeves(3)**	**Wipers(4)**
10 MGD	32	3	3	6	16
25 MGD	66	7	7	13	33
50 MGD	132	13	13	26	66
75 MGD	176	18	18	35	88
100 MGD	240	24	24	48	120
450 MGD	1152	115	115	230	576

	Annual Maintenance Labor Costs (5)						
	Lamps	**Ballasts**	**Sleeves**	**Wipers**	**Check UV Sensors(6)**	**Routine(7)**	**Total Annual Labor**
Estimated Man Hours per Unit	*0.25*	*0.25*	*1*	*1*	*2*	*4 to 8*	
10 MGD	$150	$150	$1,050	$2,400	$7,800	$60,000	$71,550
25 MGD	$300	$300	$2,100	$4,950	$7,800	$60,000	$75,450
50 MGD	$600	$600	$4,050	$9,900	$7,800	$75,000	$97,950
75 MGD	$750	$750	$5,400	$13,200	$7,800	$90,000	$117,900
100 MGD	$900	$900	$7,200	$18,000	$7,800	$90,000	$124,800
450 MGD	$4,350	$4,350	$34,650	$86,400	$7,800	$120,000	$257,500

	Annual Maintenance Equipment Costs					
	Lamps	**Ballasts**	**Sleeves**	**Wipers**	**Total Annual**	**Total Annual Maintenance**
Unit Costs	*$300*	*$750*	*$175*	*$30*		
10 MGD	$960	$2,400	$1,120	$480	$4,960	$76,510
25 MGD	$1,980	$4,950	$2,310	$990	$10,230	$85,680
50 MGD	$3,960	$9,900	$4,620	$1,980	$20,460	$118,410
75 MGD	$5,280	$13,200	$6,160	$2,640	$27,280	$145,180
100 MGD	$7,200	$18,000	$8,400	$3,600	$37,200	$162,000
450 MGD	$34,560	$86,400	$40,320	$17,280	$178,560	$436,060

Notes:
(1) Assumes lamps replaced every 10 years
(2) Assumes ballasts replaced every 5 years
(3) Assumes sleeves replaced every 5 years
(4) Assumes wipers replaced every 2 years
(5) Assumes labor rate of $150/hour
(6) Assumes UV sensors are inspected bi-weekly
(7) Routine inspection and maintenance should be performed after each event with 4hr for 10MGD and 25 MGD system, 5 hours for 50 MGD System, 6 hours for 75MGD and 100 MGD systems, and 8 hours for 450 MGD system. Assumed 100 events.

2.4.5 Ozone Disinfection

Description of Process

Ozone (O_3) is an unstable gas that is produced when oxygen molecules are dissociated into atomic oxygen and subsequently collide with another oxygen molecule to produce ozone. Due to the instability of ozone, it must be generated on-site from air or oxygen carrier gas. The most efficient method of producing ozone today is by the electric discharge technique, which involves passing the air or oxygen carrier gas across the gap of narrowly spaced electrodes under a high voltage. Due to this expensive method of producing ozone, it is extremely important that the ozone is efficiently transferred from the gas phase to the liquid phase. The two most often used contacting devices are bubble diffusers and turbine contactors. With the bubble diffusers, deep contact tanks are required. Ozone transfer efficiencies of 85% and greater can be obtained in most applications when the contactor is properly designed. The contactors must be covered to control the off-gas discharges. Since any remaining ozone would be extremely irritating and possibly toxic, the off-gases from the contactor must be treated to destroy the remaining ozone. Ozone destruction is normally accomplished by thermal or thermal-catalytic means.

An ozonation system can be considered to be relatively complex to operate and maintain compared to chlorination. The process becomes still more complex if pure oxygen is generated on site for ozone production. Ozonation system process control can be accomplished by setting an applied dose responsive to wastewater flow rate (flow proportional), by residual control, or by off-gas control strategies. Ozone disinfection is relatively expensive with the cost of the ozone generation equipment being the primary capital cost item, especially since the equipment should be sized for the peak hourly flow rate as with all disinfectant technologies. Operating costs can also be very high depending on the power costs, since Ozonation is a power intensive system.

Since ozonation is expensive to operate, and maintain, produces off-gas that can be toxic, is a complex system, and not utilized for disinfection at wastewater treatment plants where flow is more controlled and less variable, we feel it is not an acceptable application for disinfection of CSO flows and will not be evaluated further.

2.4.6 Evaluation of Disinfection Technologies

The above sections evaluated each of the disinfection technologies considered for treatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the most effective, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each screening unit in relationship to each category and subcategory. The results of the evaluation are illustrated on Table 2-35.

Table 2-35 presents the relative effectiveness of the different disinfection technologies with respect to bacteria, viruses, and encrusted parasites. For the purposes of this table the bacteria are identified as pathogens, E. coli, enterococci, and salmonella. Viruses are identified as the polio virus, with encrusted parasites consisting of giardia and cryptosporidium.

Table 2-35 - Evaluation of Disinfection Technologies

Criteria	Sodium Hypochlorite	Peracetic Acid	Ultraviolet Disinfection
Complexity	5	5	2
Safety	4	4	5
Limitations	3	3	3
Inhibitors	3	5	3
De-chlorination Requirement	1	5	5
Commercial Product Availability	5	1	5
CSO Application	5	2	2
Total	26	25	25

Section 3

Storage Technologies

Storage technologies are used to store flow for subsequent treatment at the wastewater treatment facility when downstream conveyance and treatment capacity are available. Two general types of storage need to be considered: in-line storage, which is storage in series with the sewer; and off-line storage, which is storage in parallel with the sewer. More detailed information on each type and sub-type is provided below. Construction cost opinions/guidelines for each storage technology are included in this section. Operation and maintenance cost opinions/guidelines are included in Appendix I.

3.1 In-Line Storage

In-line storage is generally developed in two ways. One way would be to use control structures to store the flows from smaller storm events (those below the design storm for the facilities) using the excess pipe capacity within the existing sewer. The other, also used with a control structure, is to replace segments of the existing sewer with larger diameter pipes to act as storage units. In both cases the use of in-line storage typically needs large diameter pipe with flat slopes. In-line storage within the existing combined sewer system is currently provided to some extent by the overflow weir typically used in existing CSO control facilities. Maximizing that storage, selecting the location of other flow control structures, and sizing of these facilities must be determined and verified by using a calibrated and verified hydraulic model.

In-line storage facilities require an extensive control and monitoring network. These includes flow regulators, such as orifices, weirs, flow throttle valves, automated gates and continues monitoring network such as level sensors, rain gages, flow monitors, and overflow detectors. Effective and efficient in-line storage requires the utilization of site-specific information together with modeling data and information on downstream flow elevations and available capacity.

3.1.1 Using Existing Sewers

Existing sewers can sometimes provide additional in-line storage by installing an in-line weir structure or flow regulator within a pipe section or at a manhole. On large diameter sewers, the weir structure would typically consist of an inflatable rubberized fabric dam, which could be pressurized to create an impoundment on the upstream of the regulator and thus create inline storage. Another flow regulator that has been used to develop in-line storage is an automatically controlled sluice gate. Instrumentation is typically provided for automatic control to prevent overloading the system. Sections of pipe utilized for in-line storage should not have any service lateral connections, or should be deep enough to prevent sewage backups within the system.

The storage available in a sewer is directly related to the cross-sectional area of the sewer that is typically unused during typical wet weather events. Typical storage requirements for wet weather flows are in the tens or hundreds of thousands of gallons. A 4-foot (48- inch) diameter circular pipe has a total capacity of less than 100 gallons per foot, a 6- foot (72-inch) pipes has a total capacity of around 210 gallons per foot, while a 6-foot x 12-foot rectangular section has a total capacity of around 540 gallons per foot.

Most combined sewer systems within the region were constructed during the period of 1880 through 1920 when few paved roads and concrete sidewalks and other impervious areas were limited to roofs. Land development, changes within land use, and changes in sewer utilization over the past century have all impacted the flow characteristics of most combined sewer systems. Most of the combined sewer systems within the region have a diameter of 48-inch or less. These sewers are expected to have little or no storage capacity due to increase inflow rates and limited pipe size and slope.

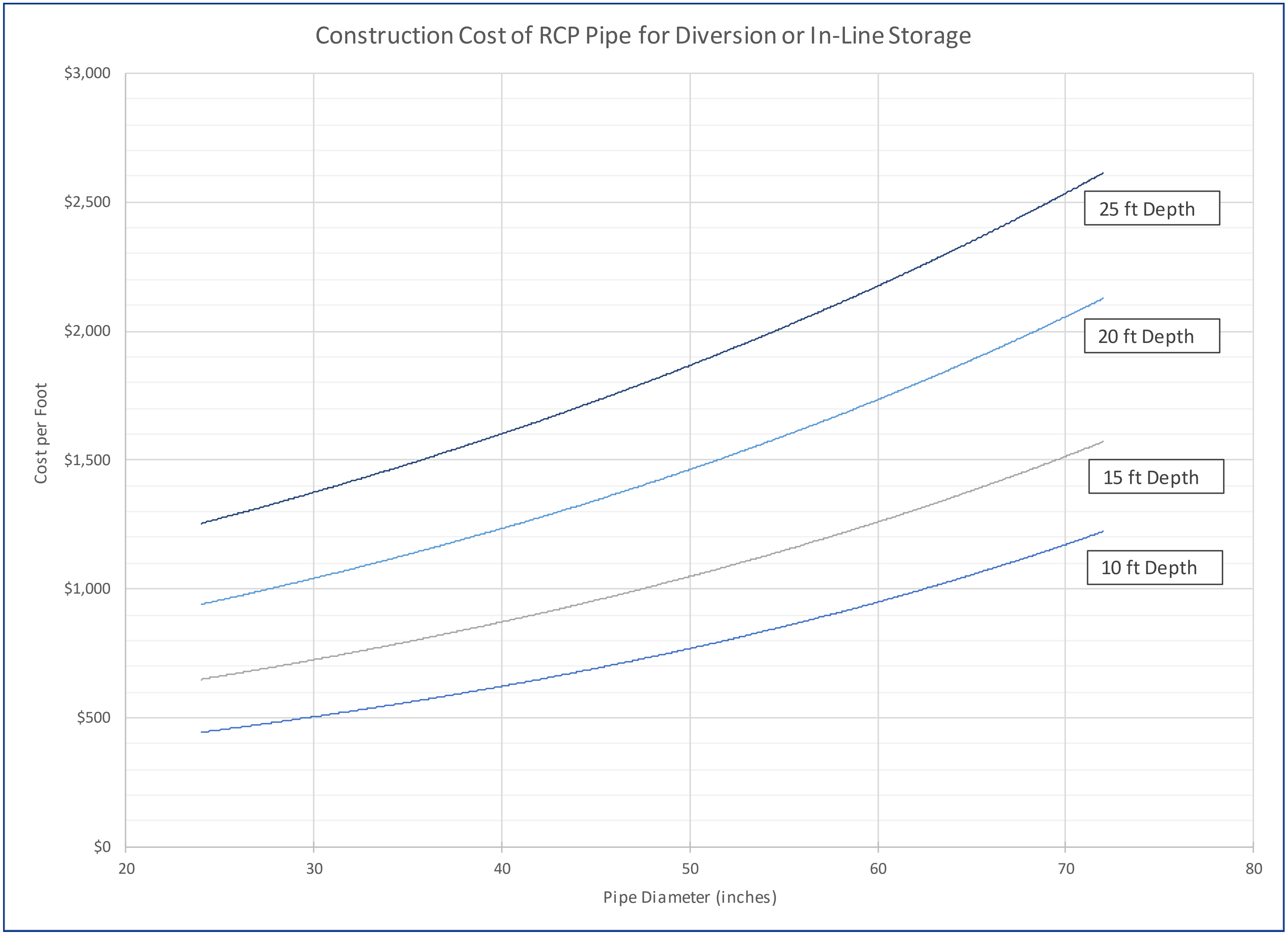
A CSO Facility Plan was completed by Killam Associates (now Mott MacDonald) in 1983 for the Passaic Valley Sewerage Commissioners on the combined sewer systems within the Cities of Newark and Paterson, and Towns of Harrison and Kearny, and the Borough of East Newark. The evaluation of in-line storage was conducted to review the feasibility of inline storage within the region. This study concluded that, with the exception of a few areas within the City of Newark, the volume of inline storage available within the sewer system was insignificant. It is anticipated that in-line storage using existing sewer will not provide a significant volume of storage.

3.1.2 Using New Large Dimension Sewers

In-line storage can also be developed by the construction of new large diameter sewers in place of, or parallel to existing combined sewers. The general principal that governs inline storage in either existing or new sewers are the same. In-line storage developed by replacing segments of the existing combined sewer system with larger diameter pipes still requires extensive controls and monitoring to assure proper operation. Accordingly, the cost of constructing the additional sewer capacity must be determined in addition to the cost of the control and monitoring network.

The original Technical Guidance Manual provided cost information suitable for the preliminary analysis of in-line storage using newly constructed large dimensional sewers in place of existing pipe. Those cost estimates were based on an assumed minimum replacement length of 500 feet for circular conduit sizes varying from 24-inch to 72-inch, and were based on an Engineering News Record (ENR) Construction Cost Index (CCI) of 7630. For this TGM update, that cost information was obtained from those cost curves and escalated to 2017 dollars using the October 2017 ENR CCI of 10817. The resultant cost estimates for the construction of segments of large diameter pipe are provided in Figure 3-1. The cost of the control and monitoring network is site specific, and should also be considered when evaluating the use of in-line storage.

Figure 3-1 - Construction Cost Estimates for RCP Pipe for Diversion or In-Line Storage



3.1.3 System Evaluation

Effective control of in-line storage can be achieved through proper flow regulator equipment and hardware selection, a SCADA system that provides early warning and accurate storm forecast. Seasonal storm patterns and types need to be identified and thoroughly evaluated to assure that the control system can properly handle current and potential rainfall patterns within the drainage area. The cost of implementation is significant for areas with limited existing storage due to the cost and challenges associated with the construction of new sewers especially in urban areas, where the access to sewer can be limited and above ground vehicle and pedestrian traffic is heavier. One advantage of in-line storage is the potential of reducing flooding and other system problems that may be localized within the system.

Operational problems that have been noted include computer programming and hardware problems especially with telemetry or data transmission, which could lead to a loss of accuracy in system control. In addition, deposition of solids in the sewers can occur, since the flow velocity during dry weather can be lower than self-cleansing velocity in large diameter sewers. In areas where smaller diameter sewers are replaced with large diameter sewers to provide in-line storage, consideration should be given to provide a low flow channel within the invert. A thorough analysis should be conducted for the potential of sewage backups in service laterals due to surcharging the system above previous hydraulic grades.

3.2 Off-line Storage

Off-line storage is storing the combined sewage in a storage system that is not on the typical flow path of dry weather flow. Off-line storage systems use tanks, basins, tunnels or other structures located adjacent to the sewer system for storing wet weather flow that is above the capacity of the conveyance system. The wastewater flows from the collection or conveyance system is diverted to off-line storage when conveyance capacity of the collection system has been exceeded. They can be used to attenuate peak flows, capture the first flush, or to reduce the frequency and volume of overflows. Wastewater flows diverted to storage facilities must be stored until sufficient conveyance or treatment capacity becomes available in downstream facilities. Off-line storage is typically accomplished by the construction of storage tanks, lagoons, basins, or deep tunnels.

Off-line storage is the predominant form of CSO prevention method currently in operation throughout the United States. The major advantages of off-line storage include:

- It can accommodate intermittent and variable storms.
- It is not impacted by varying water quality flow characteristics.
- It can accommodate solids deposition and control; and
- Storage tanks are easily accessible.

Off-line storage is not a flow through facility and thus ancillary facilities must be constructed for a complete installation. Ancillary facilities typically include some type of flow diversion or regulator structure, possibly coarse screening to keep large solids from entering the tank, and some type of tank drain facility to divert the sewage back to sewer system. To keep solids from accumulating within the tank, most storage facilities also provide facilities to flush solids from the bottom of the tanks into the pumping sump or gravity sewer.

Two types of off-line storage are typically used in CSO system depending on the volume of the overflows that need to be captured. The most prevalent form of off-line storage is a concrete storage tank/structure. These tanks/structures can be constructed above or below ground. The second form is the deep tunnel, wherein a large diameter tunnel is constructed to capture and store CSO discharges. While other forms, including uncovered earthen basins, have been used in less populated areas, open forms of CSO storage would not be applicable to highly urbanized areas.

3.2.1 Off-line Storage Tanks

The most prevalent form of off-line storage for CSO discharges is the concrete/steel tank. While large diameter parallel sewers can provide a mechanism for off-line storage, the storage volumes associated with these facilities are limited and thus are typically used within the collection system to prevent or minimized the surcharging associated with local restrictions or conditions. Large volume storage requirements can best be accommodated by the construction of off-line storage facilities at or near the CSO outfall. The design and sizing of these facilities are based upon computer modeling of drainage area and collection system to develop an understanding of the frequency and volumes associated with individual outfalls.

Advantages of off-line storage using concrete tanks are simplicity of operation and maintenance, and capability to handle high flow and water quality variations. In addition, storage tanks have the capacity for storage and collection of solids even when storm events exceed the design capacity of the off-line storage tank. In these cases, the off-line storage tank acts like a sedimentation tank. Storage tanks, in conjunction with fine screening of CSO discharges above the storage volume, are used as a primary means of CSO control throughout Europe.

As with in-line storage, the original Technical Guidance Manual provided cost information for off line storage that was obtained and escalated to 2017 dollars based on the ENC CCI. Those cost estimates were developed for concrete tanks of various storage volumes and are inclusive of all ancillary facilities and include construction costs for coarse screens, diversions, control gates, pumping facilities, flushing facilities and ventilation. The resultant cost curves are presented in Figures 3-2 through 3-4.

Figure 3-2 - Construction Cost Estimates for Off-Line Storage – 15’ SWD Rectangular < 1 MG

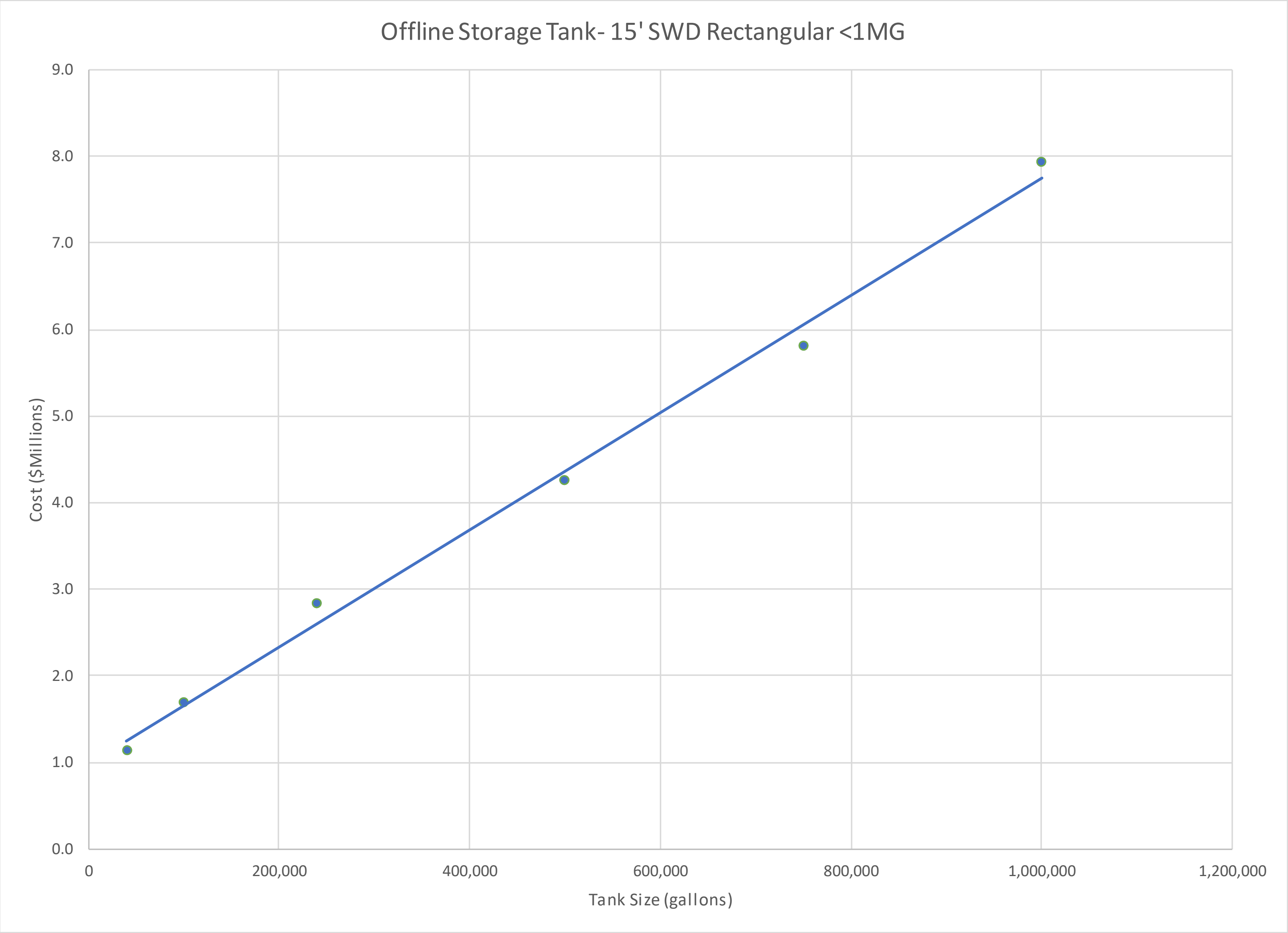


Figure 3-3 - Construction Cost Estimates for Off-Line Storage – 15’ SWD Rectangular > 1 MG

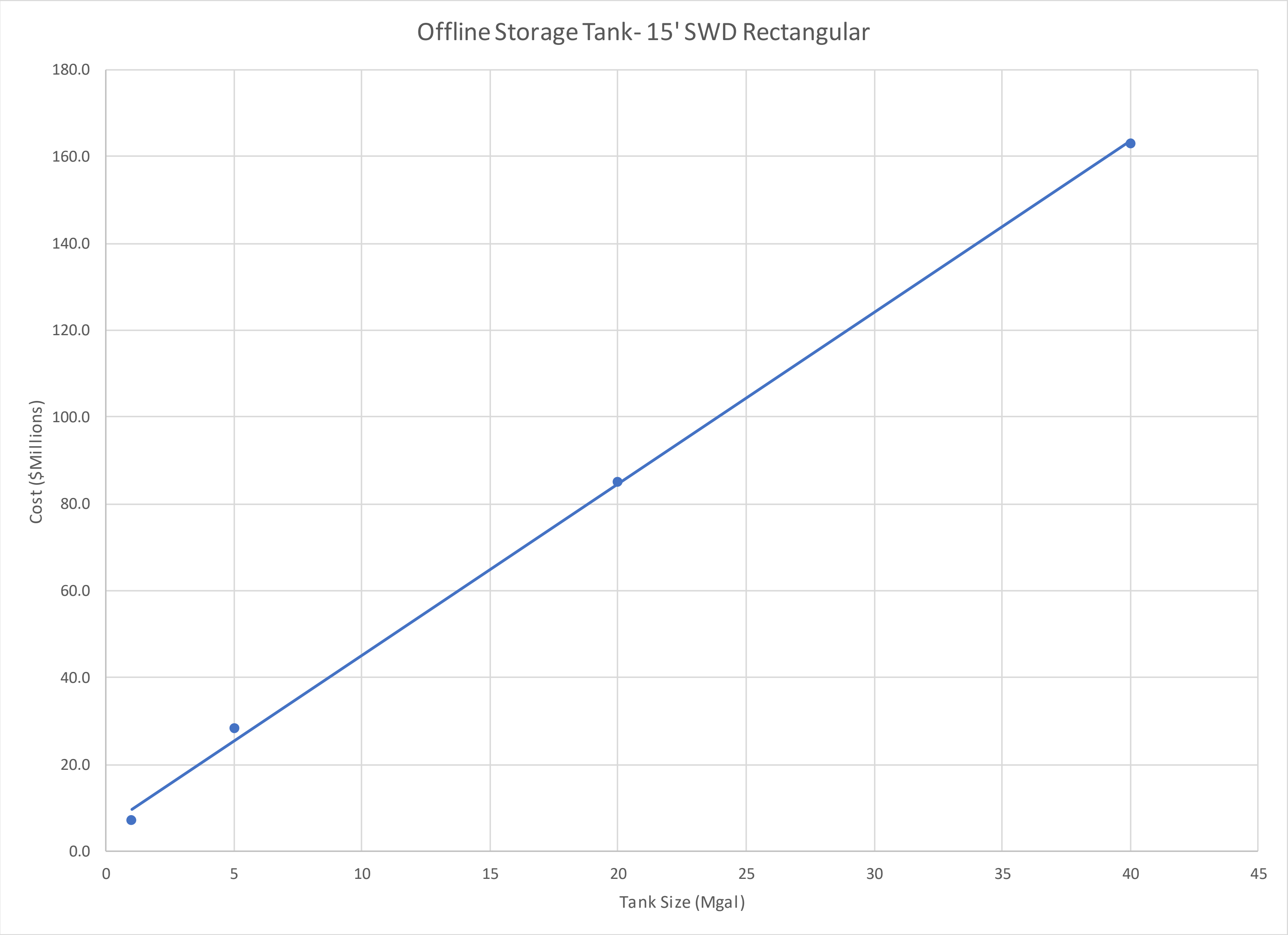
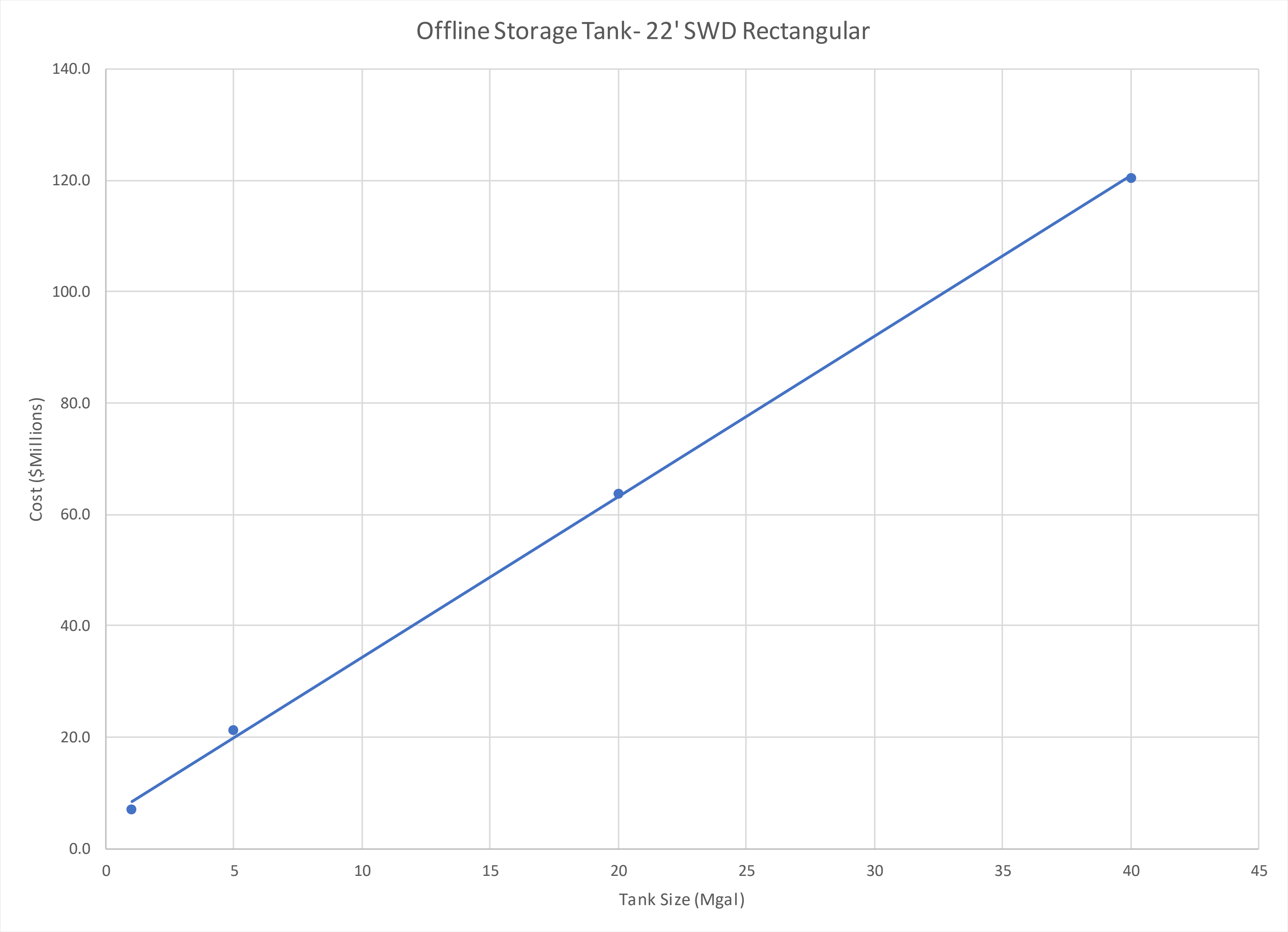


Figure 3-4 - Construction Cost Estimates for Off-Line Storage – 22' SWD Rectangular



3.2.2 Deep Tunnel Storage

Deep tunnel storage has been gaining popularity as a positive means of reducing the volume of CSO discharges, especially in large urban areas where property values and disruptions to existing utilities and structures prohibit other forms of control. This control alternative involves the capture and storage of CSO discharges in a tunnel during wet weather events, and pumping the stored overflow back into sewer when conveyance and treatment capacity is available. New methods of construction have made deep tunnel storage a competitive option when considering the relatively low land requirements. Limitations of deep tunnels primarily include the need for specialized high-lift pumping stations and the inability to provide any treatment when the overflow exceeds the deep tunnel storage volume.

As with in -line and off-line storage, the original Technical Guidance Manual provided cost information for deep tunnel storage. Preliminary tunnel cost estimating graphs were prepared using compiled cost data from previously completed projects for the following tunneling scenarios:

- Tunnel in soft ground above the water table using an open faced boring machine with ribs and lagging primary liner and cast-in-place concrete final liner.
- Tunnel in soft ground below the water table driven using an earth pressure balanced boring machine with full gasketed concrete segmental liner erected immediately behind.
- Tunnel in rock driven using a rock-boring machine with pattern rock bolting and mesh reinforcement in the tunnel crown for primary support, and cast-in-place concrete final liner.

Since ground conditions may be unknown, an idealized cost estimate using certain assumptions on the amount of difficult conditions was also presented. A determination will need to be made as to the method that would need to be used based on general soil classifications and conditions within the region.

Notwithstanding the above, construction costs on tunneling projects are influenced by a multiplicity of factors. Tunnel cost estimates should only be used as a general initial guideline as they are based on a number of base assumptions and are not at all project specific. The major factors influencing costs on tunneling projects are described below:

- Tunnel length - assuming similar size and type of tunnels, a longer tunnel will generally have a lower unit rate than a smaller tunnel due to economies of scale. The original Technical Guidance Manual cost graphs assumed a 1.5 miles length of tunnel.
- Tunnel depth relative to the surface - deeper tunnels have deeper access shafts, which adds to the overall cost of the project. The original Technical Guidance Manual cost graphs assumed a tunnel no deeper than 30ft.
- Ground type & water table elevation - this can often be the most important cost factor as it influences the advance rates achieved, and choice of equipment and tunnel support. The original Technical Guidance Manual cost graphs assumed reasonable ground conditions and minimal water ingress problems to hinder the tunneling effort.

- Rate of advance achieved in the prevailing ground conditions. Average advance rates were assumed in the preparation of the tunnel cost graphs.
- Local labor conditions including availability of experienced personnel, prevailing wage rates, and union rules governing workers conditions, hours, and the minimum number of personnel which should be utilized for construction of the tunnel. The tunnel cost graphs presented in the original Technical Guidance Manual utilized labor conditions and numbers, which were believed to be appropriate for New Jersey.
- Local availability of appropriate tunneling equipment. The tunnel original Technical Guidance Manual cost graphs assumed that appropriate tunneling equipment is readily available in New Jersey.
- Occurrences of unforeseen ground conditions and obstructions. The original Technical Guidance Manual cost graphs assumed no major unforeseen conditions.
- Presence of sub-surface utilities and structures above requiring advance protection or monitoring during construction. The original Technical Guidance Manual cost curves assumed that no advance protection is required.

The foregoing list represents only a few of the factors which influence tunnel construction costs, and beyond the earliest stages of conceptual design it is recommended that all tunnel cost estimating be undertaken by an experienced tunneling engineer with an intimate awareness of the factors influencing tunnel costs. To cater for the unknown components inherent in preparation of the cost curves a relatively large cost contingency of 65% was applied throughout. In practical cost estimating, the cost contingency is reduced to as low as 5% as the design develops and more is known about the conditions which are likely to be encountered, and the tunneling techniques which will be utilized for the project.

In addition to tunnel costs, there are costs associated with conveying the flow into the tunnels. Typically, the discharges from outfalls are consolidated to decrease the number of drop shafts that will be needed. In addition, drop shafts are needed to transport flow from the regulators to the tunnel. The drop shaft consists of a large diameter shaft in which a vortex drop tube, vent shaft and access way are constructed. The space between the various components in a large diameter shaft is backfilled upon completion.

The original Technical Guidance Manual deep tunnel cost information was obtained and escalated to 2017 dollars based on the ENC CCI. The resultant cost curves are presented in Figures 3-6 through 3-8.

Figure 3-6 - Estimated Cost of Deep Tunnels Less Than 10,000 Linear Feet

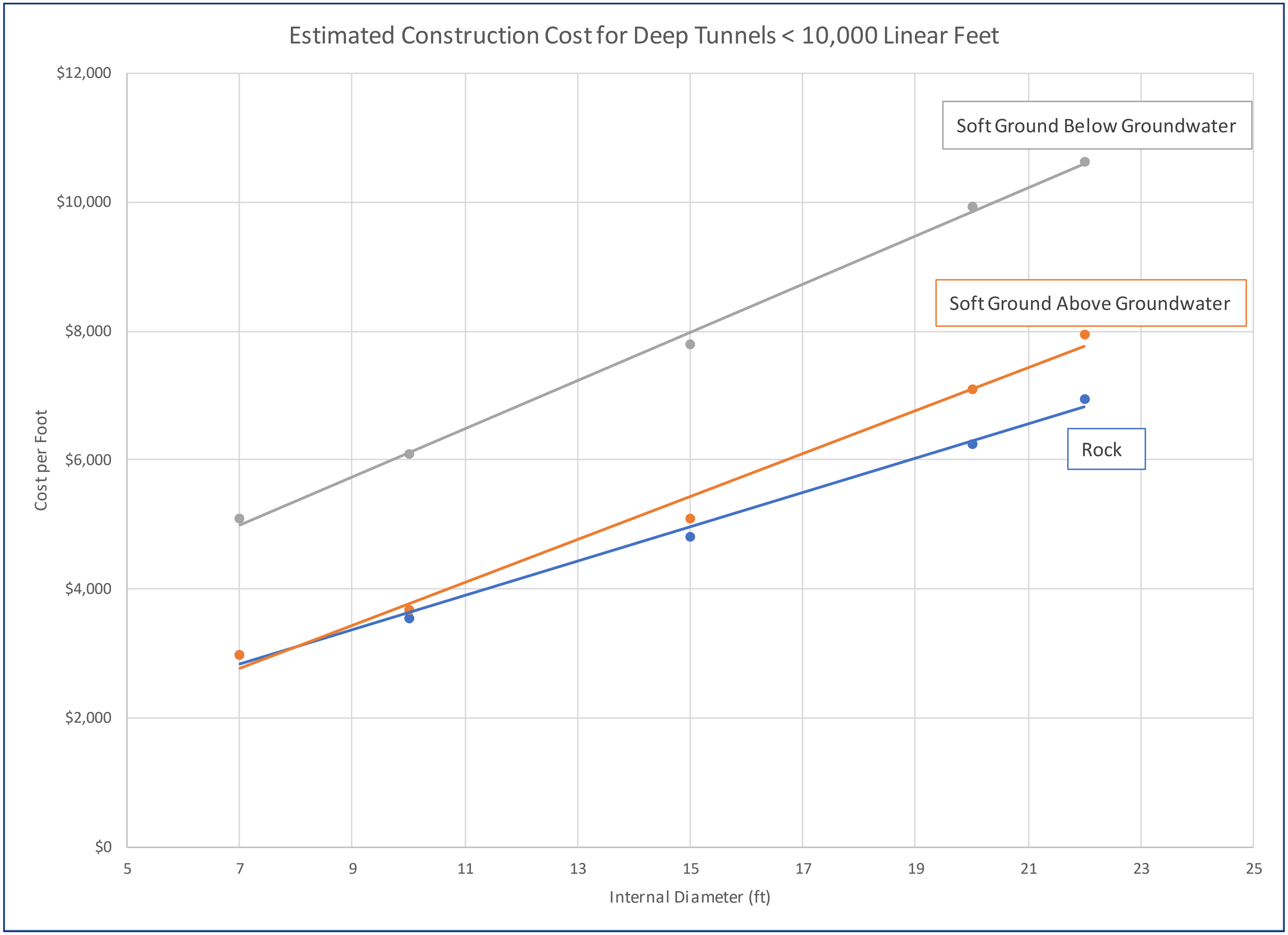


Figure 3-7 - Estimated Cost of Deep Tunnels Greater Than 10,000 Linear Feet

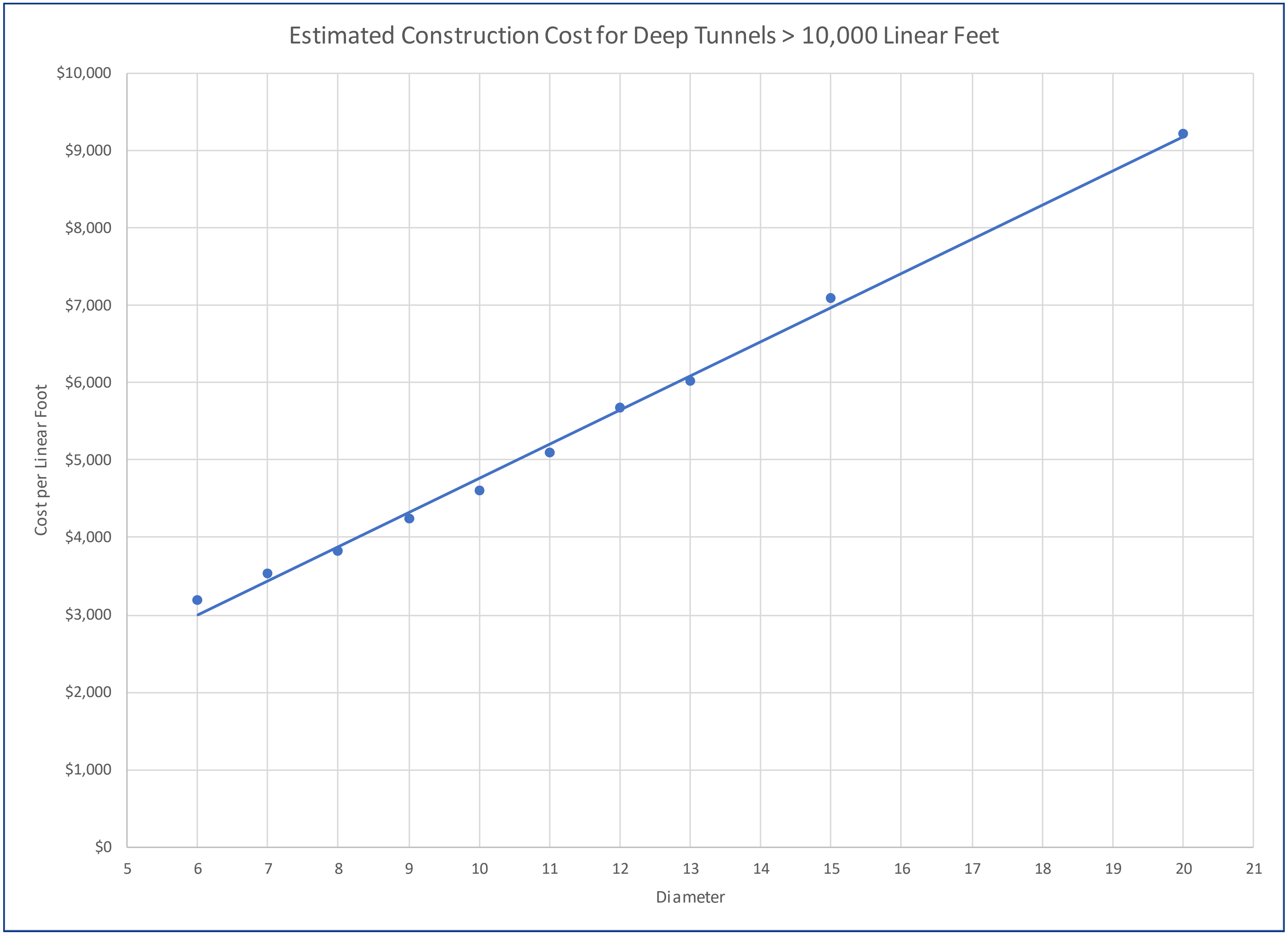
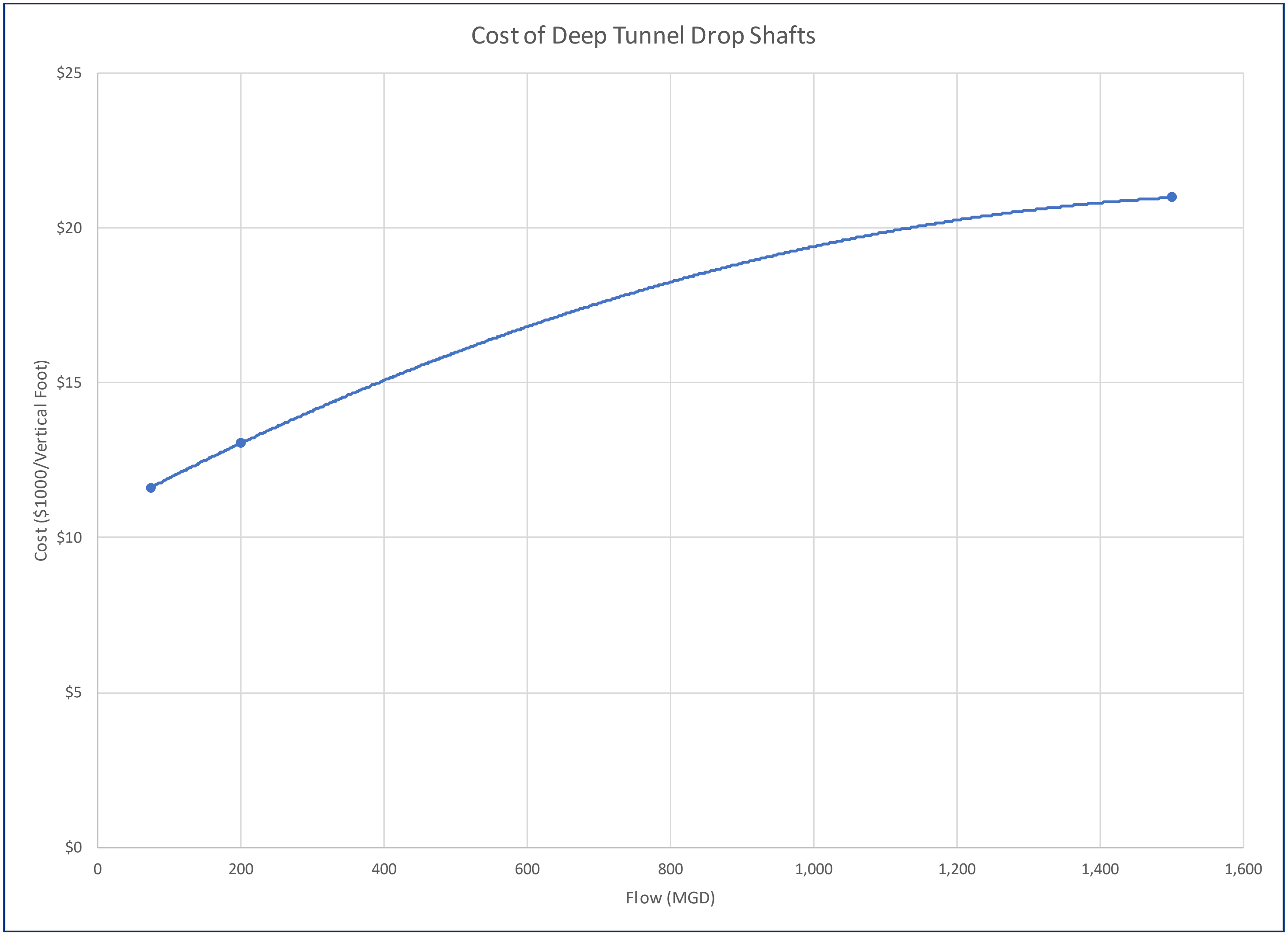


Figure 3-8 - Construction Cost Estimates for Tunnel Drop Shaft



Section 4

Green Infrastructure

The evaluation of Green Infrastructure for CSO control was not required by the prior NJPDES permit, and therefore was not included in the original Technical Guidance Manual. The NJPDES permits issued in 2015 however require permittees to evaluate Green Infrastructure as one of the CSO control alternatives.

The term "Green Infrastructure" is sometimes used to describe an array of source controls measures designed to capture stormwater before it enters the combined sewer collection system, as well as initiatives and regulatory requirements that reduce or limit runoff and pollutant loads. The Green Infrastructure described in this section of the TGM refers to physical structures that retain or detain stormwater runoff near where it originates. These structures are not necessary "green" in terms of being vegetated.

Green Infrastructure practices are designed to reduce the volume and/or peak of stormwater runoff that entering the combined sewer system. In retention systems, such as a rain garden, the runoff is routed to a permeable surface and allowed to infiltrate back into the ground. By preventing this stormwater from ever entering the collection system, the volume of overflow and associated pollutant loads discharging to the receiving waters is reduced. In detention systems, runoff is routed to a storage unit and returned to the combined sewer collection system, ideally after conveyance and treatment capacity have returned. By attenuating these flows, the conveyance system can accept a greater percentage of the overall runoff volume over a longer period of time, resulting in a net reduction of overflow volume and pollutant loads to the receiving waters. Construction cost opinions/guidelines for each green infrastructure technology are included in this section. Operation and maintenance cost opinions/guidelines are included in Appendix I.

4.1 Vegetated Practices

Many green infrastructure practices are in fact "green", in that they have a vegetative layer. That vegetative layer usually aides in the retention of stormwater runoff through transpiration, and the root system helps to promote soil porosity and aids infiltration. The green infrastructure practices also provide ancillary benefits, such as beautifying neighborhoods, improving air quality, and reducing urban heat. Through this section, several vegetated green infrastructure practices will be discussed:

- Rain Gardens
- Right-of-Way Bioswales
- Tree Pits
- Green Roofs

- Downspout Disconnection

4.1.1 Rain Gardens

Description of Practice

A rain garden consists of a shallow depressed area that is designed to collect stormwater runoff from surrounding surfaces. The collected water infiltrates into the ground, evaporates back into the atmosphere, or is transpired by the vegetation. To increase water absorption and promote infiltration, rain garden designs typically include an upper layer of amended soil with high porosity.

Plant selection and maintenance is critical to the long-term viability of a rain garden. Native plants should be selected that are capable of withstanding periods of ponded water as well as periods of dryness. Using native plants helps to reduce the amount of maintenance that will be required. Figure 4-1 provides a picture of a typical rain garden.

Figure 4-1 - Photo of Rain Garden

(Source: http://nemo.uconn.edu/raingardens/)

Applicability to The Project

Rain gardens can be implemented on public and private properties to capture and retain runoff. When properly designed and maintained they can provide aesthetic improvements to the urban landscape, natural wildlife habitat, and education opportunities for schools. Their shallow and relatively simple design means they can often be constructed without the use of heavy machinery.

Rain gardens are already used in CSO programs across the Country, and within the State of NJ. The Camden County MUA has installed an ~800 square foot rain garden that captures runoff from ~2,000 square feet of surrounding roadway.

Limitations

Proper rain garden design generally allows for a loading ratio of 5:1, with a maximum of about 10:1. The loading ratio is the ratio of contributing drainage area to the available infiltration area. In other words, to control runoff from a 500 square foot rooftop, a 100 square foot rain garden would be required. Infiltration practices that function at higher loading ratios have increased risk for failure due to the higher hydraulic, sediment, and pollutant loads.

The small loading ratio means that rain gardens require relatively large amounts of space. This makes them impractical for wide-spread public right-way application where such space is not available.

Construction Costs

The cost for constructing a rain garden can vary significantly based upon the complexity of the design, the location it is being built, and other local factors. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $11/sf to $35/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using the 5:1 loading ratio, this range of construction costs is $96,000 to $305,000 per acre controlled which is in-line with local project experience.

4.1.2 Right-of-Way Bioswales

Description of Practice

The right-of-way bioswale is a curb-side green infrastructure design being widely employed as part of New York City's green infrastructure program for CSO control. To date several thousand units have been constructed or are in construction. There are several variations of the design with different widths and depth (right-of-way greenstrips, right-of-way raingardens) but the functionality is essentially the same.

The typical right-of-way bioswale is between 4 and 5 feet wide by 10 to 20 feet long. They are constructed in the existing sidewalk, with curb cuts to allow street runoff traveling along the gutter to enter the bioswale on the upstream side and excess flow to return to the street on the downstream side. It is this conveyance aspect of the practice that makes it a bioswale instead of a deep raingarden.

On the surface, the right-of-way bioswale looks and functions much like a rain garden described above. The unit includes a shallow ponding area, and a vegetative surface that may or may not include a tree. However, whereas a raingarden is generally less than a foot deep, the right-of-way bioswale is approximately 4 ½ feet deep. The first 2 ½ to 3', depending on the design is made up of an engineered soil designed to allow for rapid infiltration. The lower portion of the bioswale is a stone base to provide storage. A rendering of a New York City bioswale is provided in Figure 4-2.

Figure 4-2 - Rendering of Right-of-Way Bioswale

(Source www.nyc.gov/html/dep/html/stormwater/bioswales.shtml)

Applicability to The Project

The right-of-way makes up a significant amount of a city's impervious cover. Sidewalks and streets are generally pitched to capture and convey runoff directly towards the collection system, making them efficient locations to intercept the flow. Furthermore, the municipality already has ownership of these areas.

New York City is constructing thousands of right-of-way bioswales to capture urban runoff before it enters their combined sewer collection systems. The designs could easily be adapted to meet the needs of other combined sewer municipalities.

Limitations

The New York City standard design process sizes the bioswales based upon the calculated volume that can be managed through infiltration through the native surrounding soils, and storage within the unit, during a specified period. This generally results in loading ratios well above standard rule of thumb loading ratios for bio-infiltration practices. To date New York City's post construction monitoring program has shown that overall the units are functioning at or beyond their intended designs, but long-term monitoring results are not yet available. Permittees should consider the potential failure risks of utilizing similarly high loading ratios. Infiltration practices that function at higher loading ratios have increased risk for failure due to the higher hydraulic, sediment, and pollutant loads.

Constructing bio-infiltration practices in the sidewalk requires that the existing sidewalks are wide enough to allow for the feature while still maintaining functionality for pedestrian traffic. The ability to site right-of-way bioswales will have to be determined by each permittee.

Construction Costs

The actual construction costs for right-of-way bioswales is estimated to be approximately $15,000 unit, which equates to approximately $150,000 per acre controlled. These costs are based on large construction contracts generally including 100 – 200 units where an economy of scale can be achieved. For single unit or low quantity construction estimates, the costs can be significantly higher.

Prior to construction, identifying appropriate and effective locations for right-of-way bioswales requires planning, field work, and geotechnical investigations. When attempting to implement a wide-scale right-of-way green infrastructure program, many locations will be screened out due to site constraints or poorly infiltrating soils. Typical per-site survey and geotechnical costs can be approximately $4,000 to $5,000 per location. When sites are screened out after these costs have been incurred, the programmatic cost per constructed unit goes up to as much as $50,000 per unit.

4.1.3 Enhanced Tree Pits

Description of Practice

Enhanced tree pits, or stormwater trees, can appear similar to a standard city tree pit. Unlike a standard tree pit, however, they utilize an underground system designed to infiltrate runoff. The underground system includes engineered soil capable of rapidly infiltrating water, crushed stone, and an underdrain system. Although they can be built individually, they become more effective when they are installed as a connected multi-unit linear system. In such a system, permeable pavement can be used between the tree pits to allow additional water to infiltrate into a subsurface stone layer that connects the tree pits. A photo of an enhanced tree pit is provided in Figure 4-3.

Figure 4-3 - Photo of Enhanced Tree Pits

(Source: NJ Tree Foundation)

Applicability to The Project

Enhanced tree pits are already in use in cities across the United States as stormwater control measures. They can be constructed in sidewalks, in parking lots, courtyards, etc.

Limitations

The design of enhanced tree pits can vary greatly based on capture needs. The limitation for applicability are similar to those described for rain gardens and bioswales, depending on the desired loading ratio and available space.

Construction Costs

Pre-fabricated tree pits are available for approximately $10,000 each, and cost about $5,000 to install.

4.1.4 Green Roofs

Description of Practice

A green roof generally consists of a vegetated layer on top of a lightweight soil medium, below which lies an underdrain system and waterproof membrane. The depth of the soil medium will determine the type of vegetation that can be sustained and also the weight of the vegetated roof.

A portion of the precipitation that falls on the vegetated surface is retained in the soil medium and eventually released back to the atmosphere through evaporation and taken up through transpiration. The underdrain system acts as additional detention system before the excess water is eventually discharged through the buildings downspouts to the ground or directly into the combined sewer system. A photo of the green roof on Chicago's City Hall is shown in Figure 4-4.

Figure 4-4 - Photo of Green Roof on Chicago City Hall

(Source: www.greenroofs.com/)

Applicability to The Project

Green roofs have been constructed in cities around the world and across the country, including as part of CSO programs.

Limitations

Wide spread application of green roofs is generally cost prohibitive. Most existing buildings cannot support the additional weight of a green roof without costly retrofitting.

Green roofs are generally designed with a loading ratio of 1:1, meaning that the managed area is limited to the footprint of the vegetated area itself.

Construction Costs

The cost for constructing a green roof can vary significantly based upon the complexity of the design, the location it is being built, and other local factors. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $11/sf to $56/sf for construction costs, in 2016 dollars, compiled from projects across the United States. Using the 1:1 loading ratio, this range of construction costs is $480,000 to $2,440,000 per acre controlled which is in-line with local project experience.

4.1.5 Downspout Disconnection

Description of Practice

In many urban areas, downspouts are connected directly into the combined sewer system. Disconnecting these downspouts provides opportunity for rooftop runoff to be infiltrated or intercepted before entering the combined sewer system. For buildings with exterior downspouts, disconnection can be as simple as cutting the existing downspout, installing an elbow, and routing the downspout to a pervious surface or storage unit, such as a rain barrel. For buildings with interior downspouts the process can be more complicated and may not be practical. However, opportunities may still exist where the internal drain can be located and re-routed through an exterior wall. A photo of the disconnected external downspout is shown in Figure 4-5.

Figure 4-5 - Photo of Disconnected Downspout

(Source: https://www.mmsd.com/what-you-can-do/downspout-disconnection)

Applicability to The Project

Many cities across the United States have adopted programs either requiring or encouraging downspout disconnection. A downspout disconnection program often provides the simplest and lowest cost for reduction in wet weather flow to the sewer system. The combined sewer communities within the PVSC service area should evaluate the potential for adopting such a program.

Construction Costs

Exterior downspout disconnections are usually simple, and can be accomplished for approximately $25 to $50.

4.2 Permeable Pavements

The term Permeable Pavements refers to several distinct surfaces, each of which are intended to provide a reduction in stormwater runoff as compared with traditional paving methods. The nomenclature for these different surfaces is often used interchangeably and can be confusing. The major types of permeable pavements will be discussed in this section, including:

- Porous Asphalt
- Pervious Concrete
- Permeable Pavers

4.2.1 Porous Asphalt

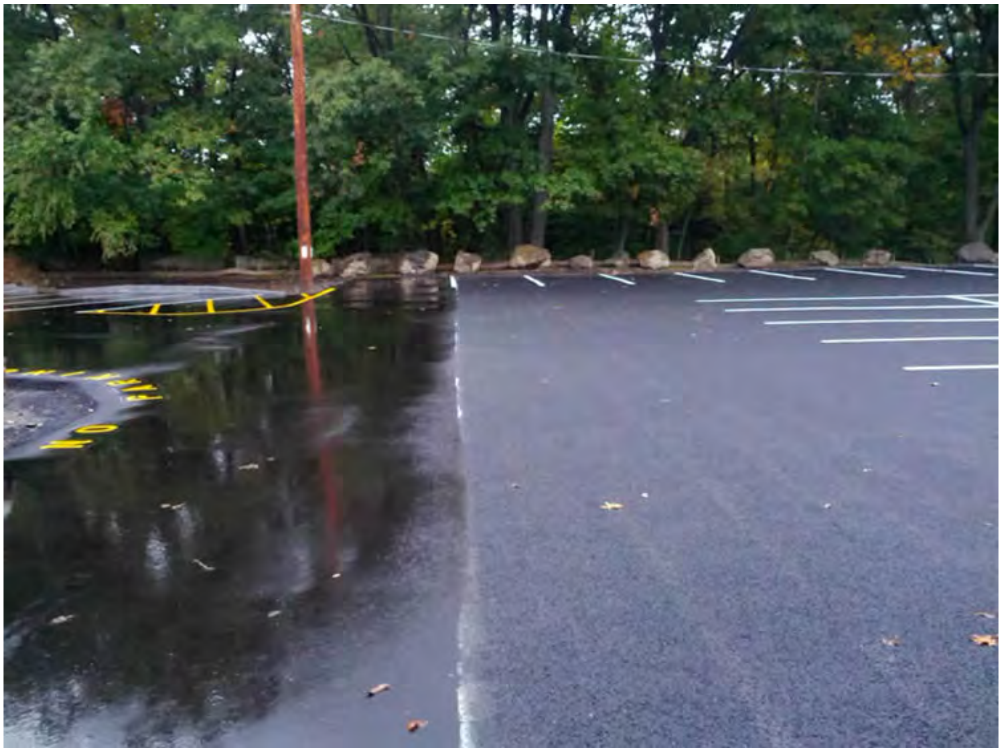
Description of Practice

Upon closer inspection, porous asphalt looks like a somewhat courser version of traditional asphalt, or “blacktop”. Porous and traditional asphalt are made in a similar fashion, but the fine particles are left out of the porous asphalt mix. Without the fines, air becomes trapped in the asphalt mix creating pore space through which water can migrate.

Below the porous asphalt layer, a stone layer acts as a reservoir to store water before it infiltrates into the native soil. An underdrain system may also be included

Figure 4-5 provides a picture of a parking lot in which half was paved using porous asphalt (right side of photo) and the other half was paved using traditional asphalt (left side of photo).

Figure 4-5 - Porous Asphalt Parking Lot



(Source: https://www.epa.gov/soakuptherain/soak-rain-permeable-pavement)

Applicability to The Project

Porous pavement has been used successfully for decades to reduce ponding , flooding, and stormwater discharges. Many combined sewer cities are now using porous pavement as part of their CSO control strategy. Porous asphalt should be considered when roads or parking lots are to be constructed or repaved.

Limitations

Porous pavement requires additional maintenance, including regular service with a vacuum truck to help maintain the open pore space. The use of salt or sand for snow melting is also discouraged. Applications of porous asphalt are typically not recommended in high traffic or heavy industrial sites due to the increased sediment and pollutant loads.

Construction Costs

The cost for porous asphalt can vary significantly based upon whether it new surface or a retrofit. The NJDEP guidance document “Review of GI as a Component of LTCPs” provides a range of $12/sf to $25/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 2:1 loading ratio, this range of construction costs is $260,000 to $545,000 per acre controlled which is in-line with local project experience.

4.2.2 Pervious Concrete

Description of Practice

Pervious concrete is a concrete mix containing little or no sand, which creates pore space through which water can migrate. Pervious concrete functions similarly to porous asphalt in that water migrates through the pavements void space down into an underlying stone bed, and either infiltrates to the natural soil or enters an underdrain system. A photo of a pervious concrete application is shown in Figure 4-6. Pre-fabricated pervious concrete panels were installed in the parking stalls.

Figure 4-6 – Pervious Concrete Panels

Applicability to The Project

Pervious concrete pavement has been used successfully for decades to reduce ponding, flooding, and stormwater discharges. Many combined sewer cities are now using pervious concrete as part of their CSO control strategy. Pervious concrete can be considered for sidewalks, courtyards, or anywhere else that traditional concrete may be used.

Limitations

Pervious concrete requires additional maintenance, including regular service with a vacuum truck and pressure washing to help maintain the open pore space. The use of salt or sand for snow melting is also discouraged.

Construction Costs

The cost for pervious concrete can vary significantly based upon the type of application. The NJDEP guidance document “Review of GI as a Component of LTCPs” provides a range of $14/sf to $28/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 2:1 loading ratio, this range of construction costs is $305,000 to $610,000 per acre controlled which is in-line with local project experience.

4.2.2 Permeable Interlocking Concrete Pavers (PICP)

Description of Practice

Unlike pervious concrete, permeable pavers do not allow water to pass through the concrete. Instead, the joints between the impervious concrete pavers are filled with a permeable medium such as small stone or sand, allowing water to infiltrate between the pavers. The subsurface includes as stone base and an underdrain, if required.

A photo of a Philadelphia parking lot utilizing concrete permeable pavers is shown in Figure 4-7.

Figure 4-7 – Permeable Interlocking Concrete Pavers (source: EPA)

Applicability to The Project

As with the other types of permeable pavements, permeable interlocking concrete pavers are being used across the country for stormwater control.

Limitations

Permeable interlocking concrete pavers require regular service with a vacuum truck. Proper erosion control is required on the surrounding areas to prevent additional loading to the pavers and clogging.

Construction Costs

The cost for permeable pavers can vary significantly based upon the desired design and type of application. The NJDEP guidance document “Review of GI as a Component of LTCPs” provides a range of $12/sf to $34/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 4:1 loading ratio, this range of construction costs is $130,000 to $370,000 per acre controlled which is in-line with local project experience.

Section 5

Water Conservation

Reducing overall water consumption can provide some reduction in CSO discharge volume by providing additional wet weather capacity in the collection system and helping to alleviate the stress on the existing wastewater treatment facilities. It is difficult to quantify the CSO reduction provided through water conservation practices without modeling, and this Technical Guidance Manual does not attempt to do so. The CSO reduction benefits provided through water conservation measures will be dependent upon the coincidence of wet weather events and the highs and lows of daily water usage

Water consumption reduction can be achieved through a variety of measures including public outreach and education; distribution system leak detection and repair; water efficient landscaping; and water efficient plumbing fixtures (i.e., toilets and urinals, faucets, and showerheads). Assuming that nearly all water use inside residences and commercial users will ultimately be disposed of in the sewer, outside water use, such as lawn watering and leaks in the distribution system will not be addressed in the TGM.

This section will focus on water efficient plumbing fixtures and discuss the water saving and costs while implementing water efficient plumbing fixtures.

5.1 Water Efficient Toilets and Urinals

Nearly one-third of total water consumption returns to the sewer system through flushed toilets and urinals. Many plumbing fixtures still in use today were designed at a time when little concern was given to water conservation. Prior to 1950, typical toilets consumed 7-gallons-per-flush (gpf). Toilets installed between 1950 and 1994 consumed 4-5 gpf. Federal laws enacted in 1994 required that residential toilets use no more than 1.6 gpf. A similar limit was established for commercial toilets in 1997, and urinals were limited to 1.0 gpf by the 1997 requirements.

Average water savings by using low-volume toilets compared to high-volume ones is shown for residential households in Table 5-1, and for industrial and commercial facilities in Table 5-2. Average water savings by using low-volume urinals compared to high-volume ones in industrial and commercial facilities only is shown in Table 5-3.

Table 5-1 - Estimated Water Savings Provided by Low Volume Toilets in Households

Year Installed	Average Toilet Water Use Rate (gpf)	Estimated Water Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1994 - Present	1.6	32	11,680	-
1980-1994	4.0	80	29,200	17,520
1950s - 1980	5.0	100	36,500	24,820
Pre-1950s	7.0	140	51,100	39,420

Notes: Assume a 4-person household at 5 uses per person per day.

Table 5-2 - Estimated Water Savings Provided by Low Volume Toilets in Commercial and Industrial Facilities

Year Installed	Average Toilet Water Use Rate (gpf)	Average Daily Use (gal/toilet/day)	Estimated Water Use Annually (gal/toilet/year)	Estimated Annual Water Savings (gal/toilet/year)
1997 - Present	1.6	38.4	14,016	-
1980-1994	4.0	96	35,040	21,024
1950s - 1980	5.0	120	43,800	29,784
Pre-1950s	7.0	168	61,320	47,304

Notes: Assume an average daily use of 24 times per toilet per day.

Table 5-3 - Estimated Water Savings Provided by Low Volume Urinals in Commercial and Industrial Facilities

Year Installed	Average Toilet Water Use Rate (gpf)	Estimated Average Daily Use (gal/urinal/day)	Estimated Water Use Annually (gal/urinal/year)	Estimated Annual Water Savings (gal/urinal/year)
1997 - Present	1	16	5,840	-
1980-1994	2.0	32	11,680	5,840
Pre 1980	5.0	80	29,200	23,360

Notes: Assume an average daily use of 16 times per urinal per day.

An estimate of the typical costs associated with replacing a toilet or urinal was developed using construction cost estimating database such as R.S. Means. In 2017 dollar, the equipment and labor costs were:

- Residential Floor Mounted Toilets = $645 per fixture
- Commercial Wall Hung Toilets = $1,225 per fixture
- Urinals = $615 per fixture

5.2 Water Efficient Faucets and Showerheads

Significant amounts of water and energy can be wasted through use of non-water efficient faucets and showerheads. Even a brief five-minute shower can consume 15-35 gallons of water with a conventional showerhead with a flow rate of 3-7 gpm.

Prior to 1980, typical faucets had a flowrate of 4 gpm. Faucets installed between 1980 and 1994 flowed at approximately 3 gpm. Federal guidelines in 1994 required that all lavatory and kitchen faucets and replacement aerators use no more than 2.5 gpm measured at normal water pressure (typically 80 pounds per square inch, psi). A similar limit was established for showerheads in 1994, which reduced the typical flowrate of a showerhead from 3-7 gpm to 2.5 gpm.

Average water savings by using low-flow faucets compared to high-flow ones is shown for residential households in Table 5-4, and for industrial and commercial facilities in Table 5-5. Average water savings by using low-flow showerheads compared to high-flow ones in residential households is shown in Table 5-6.

Table 5-4 - Estimated Water Savings Provided by Low Flow Faucets in Households

Year Installed	Average Faucet Flowrate (gpm)	Estimated Faucet Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1994 - Present	2.5	100	36,500	-
1980-1994	3.0	120	43,800	7,300
Pre-1980s	4.0	160	58,400	21,900

Notes: Assume a 4-person household at 10-minutes uses per person per day.

Table 5-5 - Estimated Water Savings Provided by Low Flow Faucets in Commercial and Industrial Facilities

Year Installed	Average Faucet Flowrate (gpm)	Average Daily Use (gal/faucet/day)	Estimated Water Use Annually (gal/faucet/year)	Estimated Annual Water Savings (gal/faucet/year)
1994 - Present	2.5	180	65,700	-
1980-1994	3.0	216	78,840	13,140
Pre-1980s	4.0	288	105,120	39,420

Notes: Assume an average daily use of 72 minutes per faucet per day.

Table 5-6 - Estimated Water Savings Provided by Low Flow Showerheads in Households

Year Installed	Average Showerhead Flowrate (gpm)	Average Daily Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1997 - Present	2.5	62.5	22,813	-
1980-1994	3.0	75	27,375	4,563
Pre 1980	7.0	175	63,875	41,063

Notes: Assume a 4-person household at 25-minutes uses per person per day.

An estimate of the typical costs associated with replacing a toilet or urinal was developed using construction cost estimating database such as R.S. Means. In 2017 dollar, the equipment and labor costs were:

- Residential Faucet Replacement = $189
- Residential Showerhead Replacement (including built-in, head, arm, and 2.5 gpm valve) = $350

Commercial Faucet Replacement (with automatic sensor and operator) = $675

Appendix A

Climber Screens® Installation List

(Source: Suez, formerly Infilco Degremont, Inc.)

July 2017

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1445	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1446	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1447	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1448	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1478	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1479	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1480	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1499	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	88	82	1	450	Carbon Steel	304SS
CS-1500	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	88	82	1	450	Carbon Steel	304SS
CS-1501	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	114	108	1	474	Carbon Steel	304SS
CS-1502	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	114	108	1	474	Carbon Steel	304SS
CS-1503	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS			72	258		0.75			
CS-1527	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1528	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1529	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1530	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1531	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1539	02253	NY	Binghamton	Binghamton-Johnson County WWTP	2002	1	IIS		MGD	48	270		0.75	381	Carbon Steel	304SS
CS-1540	02253	NY	Binghamton	Binghamton-Johnson County WWTP	2002	1	IIS		MGD	48	270		0.75	381	Carbon Steel	304SS
CS-1559	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS		MGD	72	258	135	0.75	414	304SS	304SS
CS-1560	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS		MGD	72	258	135	0.75	414	304SS	304SS
CS-1594	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1595	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS
CS-1596	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS
CS-1599	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1600	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1601	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1602	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1604	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1605	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1606	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1607	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1608	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1609	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1610	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1611	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1621	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1622	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1623	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1624	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1625	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1626	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1627	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1629	05486	NY	Onondaga County	Baldwinsville Senera Knolls	2005	1	IIS		MGD	48	66		1	360	304SS	304SS

July 2017

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1630	05486	NY	Onondaga County	Baldwinsville Senera Knolls	2005	1	IIS		MGD	48	66		1	360	304SS	304SS
CS-1631	05486	NY	Onondaga County	Ley Creek PS	2005	1	IIS		MGD	48	260.5		1	260.5	304SS	304SS
CS-1632	05486	NY	Onondaga County	Ley Creek PS	2005	1	IIS		MGD	48	260.5		1	260.5	304SS	304SS
CS-1633	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	71	203.5		0.75	203.5	304SS	304SS
CS-1634	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	71	203.5		0.75	203.5	304SS	304SS
CS-1635	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	72	150.625		1.5	150.625	304SS	304SS
CS-1636	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	72	150.625		1.5	150.625	304SS	304SS
CS-1650	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1651	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1652	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1653	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1654	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1655	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1657	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1658	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1659	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1660	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1661	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1662	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1690	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1691	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1692	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS

July 2017

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1693	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1720	09657	NY	New York	Powell's Cove PS (Replaced 84-937)	2009	1	IIS		MGD	54	90		1.25	408	Carbon Steel	316LSS
CS-1739	09671	NY	Albany	Albany North & South WWTP	2009	1	IIS		MGD	60	114		1	468	Carbon Steel	304LSS
CS-1740	09671	NY	Albany	Albany North & South WWTP	2009	1	IIS		MGD	48	88		1	444	Carbon Steel	304LSS
CS-1751	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1752	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1753	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1754	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1755	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1756	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1757	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1758	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1759	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1760	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1761	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1762	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1768	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	98.5	98.5	1	300.5625	Carbon Steel	304SS
CS-1769	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	98.5	98.5	1	300.5625	Carbon Steel	304SS
CS-1770	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	102	102	1	288	Carbon Steel	304SS
CS-1771	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	93	93	1	413.25	Carbon Steel	304SS
CS-1772	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	93	93	1	413.25	Carbon Steel	304SS
CS-1773	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	88	88	1	413.25	Carbon Steel	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

July 2017

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1794	11751	NY	Troy	Rensselear County District #1 WWTP	2011	1	IIS	30.0	GPM	48	119	119	0.75	119	Carbon Steel	304SS
CS-1795	11751	NY	Troy	Rensselear County District #1 WWTP	2011	1	IIS	30.0	GPM	48	119	119	0.75	119	Carbon Steel	304SS
CS-1799	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1800	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1801	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1806	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1807	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1808	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1809	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1816	13819	PA	Allentown	Kline's Island WWTP	2013	1	IIS	88.0	MGD							
CS-1817	13819	PA	Allentown	Kline's Island WWTP	2013	1	IIS	88.0	MGD							
CS-1818	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1819	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1820	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1839	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1840	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1841	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1842	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1850	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1851	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1852	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1862	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS

July 2017

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1863	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1864	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1865	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1866	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
				Total Number:		**106**										

Appendix B

ROMAG^{TM} Installation List

(Source: WesTech Engineering, Inc.)

WESTECH

Installation List
ROMAG CSO SCREENS

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WESTECH-INC\RSANOVICH
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Job No.	Year	Location				Qty	Size	Equipment/Model
20855	2009	MUNCIE, IN WPCF	MUNCIE	IN	US	1		ROMAG CSO SCREEN RSW854
21335	2012	10TH STREET PUMP STATION	JEFFERSONVILLE	IN	US	1	1 Meters	ROMAG CSO SCREEN RSW115.54
21629	2013	FOURTH CREEK WWTP	KNOXVILLE	TN	US	1	1 Meters	ROMAG CSO SCREEN RSW-K1034
22138	2014	ARCHBALD WWTF	JERMYN	PA	US	1	1 Meters	ROMAG CSO SCREEN RSW724
22156	2014	CLINTON CSO LONG TERM CONTROL PLAN PHASE 1	CLINTON	IN	US	1	4 Meters	ROMAG CSO SCREEN RSW724
22430	2015	GLENS FALLS WWTP	GLENS FALLS	NY	US	1	16 MGD	ROMAG CSO SCREEN RSW-K724
22440	2015	LANCASTER NORTH PUMPING STATION	LANCASTER	PA	US	2	160 MGD	ROMAG CSO SCREEN RSW1254
22463	2016	TOWN BRANCH WET WEATHER STORAGE FACILITY	LEXINGTON	KY	US	1	57 MGD	ROMAG CSO SCREEN RSW864
22596	2016	WOLF RUN WET WEATHER STORAGE FACILITY	LEXINGTON	KY	US	1	7.3 MGD	ROMAG CSO SCREEN RSW824
22676	2016	KENTUCKY AVENUE INTERCEPTOR SEWER IMPROVEMENTS	FRANKFORT	KY	US	1	20 MGD	ROMAG™ CSO SCREEN RSW634
22742	2016	LOWER CANE RUN WET WEATHER STORAGE	LEXINGTON	KY	US	1	20 MGD	ROMAG™ CSO SCREEN RSW634
23133	2017	JOLIET CSO WET WEATHER TREATMENT FACILITY	JOLIET	IL	US	1		ROMAG™ CSO Screen RSW884
		Total Qty =				**13**		

Appendix C

Storm King® Vortex Separator Installation List

(Source: Hydro International)

Hydro International®

Storm King Installation List

Plant / Job Name	Start-up Date	Contact	Plant Peak Flow, mgd	Equipment	Engineer	Rep	Appl
Hartford, CT WPCP	Jun-95		60.0	(2) 30' Storm King®	Blasland & Bouck Engineers	Aqua Solutions	CSO
Columbus, GA 19th Street - Uptown Park WRF Advanced Demostration Facility	Dec-95	Mike Burch 706-617-4981 mburch@cwwga.org	48 4.9	(6) 32' Storm King® (1) 8.5' FSU Grit King® (1) Classifier	Parsons Engineering Science	PEI	CSO-HW
Columbus, GA State Docks WRF South Commons	Sep-95	Mike Burch 706-617-4981 mburch@cwwga.org	48.0 4.0	(6) 35' Storm King® (2) 8' FSU Grit King® (2) Classifier	JJ & G	PEI	CSO
Lemont, IL WRP Wet Weather Treatment Facility and Reservoir	Jun-15		7.0	(1) 24' Storm King®	CH2M Hill	Drydon	CSO
Round Lake Beach, IL Round Lake Sanitary District	Jan-16		25.0	(1) 30' Storm King®	Christopher Burke Engineering 9575 W. Higgins Road, # 600 Rosemont, IL 60018	Drydon	CSO
Boonville, IN CSO North and South Basin	Feb-12		84.0	(2) 44' Storm King®	Midwestern Engineers	HPT	CSO
Bucksport, ME CSO	Apr-08	David Michaud, Opterator (207)469-0021 DEMichaud@aquaamerica.com	2.9	(1) 18' Storm King®	Wright Pierce Engineers	Aqua Solutions	CSO
Saco, ME CSO Treatment Facility	Nov-06	John Hart Superintendent (207) 282-3564	5.6 8.6	(1) 22' Storm King® (1) 12' ISU Grit King® (1) Type 2 Classifier	Deluca-Hoffman Associates	Aqua Solutions	HW/CSO
Redford, MI Rogue River CSO Retention Basin	Oct-96		61.0	(1) 35' Storm King®		Pumps Plus	CSO
New York, NY Corona Avenue	Oct-01		130.0	(1) 43' Storm King®	URS		CSO
Browndale, PA Clinton WWTP	Feb-06	Glenn Butler Bill Stanvitch Mike Dodgson	15.0	(1) 32' Storm King® (1) 6' ISU Grit King® (1) 12" Classifier	Montgomery Watson Harza	Sherwood Logan	CSO
Conyngham Borough, PA CSO	Nov-99	Jamie Wasilewski Operator (570)788-0608 ext.1	2.0	(1) 18' Storm King®	RDK Engineering	Sherwood Logan	CSO
Hazelton, PA Greater Hazelton JSC - CSO 002	May-11		14.0	(1) 30' Storm King®	Gannett Fleming	Sherwood Logan	CSO
Hazelton, PA Sixth & Ridge CSO	Jun-08	Chris Carcia Director of Operations (570)454-0851	2.6	(1) 18' Storm King®	Gannett Fleming		CSO

Appendix D

HYDROVEX® FluidSep Vortex Separator Installation List

(Source: Veolia Water Technologies)

VEOLIA

4105 Sartelon, Saint-Laurent, Québec, Canada, H4S 2B3
T: 514-334-7230
F: 514-334-5070
cso@veolia.com | www.hydrovex.com

HYDROVEX® FluidSep Vortex Separator
Installation List

	Country	Project	Qty	Type	Diameter (m)	Diameter (ft)	Inlet Flow Rate (L/s)	Inlet Flow Rate (MGD)	Installation Year
1	USA	Burlington, Vermont	1	2.5	12.20	40.03	2629	60	1990
2	USA	Decatur, Illinois, Lincoln Park	4	2.5	13.40	43.96	18230	416	1990
3	USA	Decatur, Illinois, 7th Ward	1	3	13.40	43.96	4951	113	1990
4	USA	Decatur, Illinois, Oakland Park	1	1.35	8.10	26.57	920	21	1991
5	USA	Saginaw, Michigan, 14th Street	3	2.5	11.00	36.09	8500	194	1991
6	USA	Saginaw, Michigan, Weiss	1	3	11.00	36.09	2848	65	1992
7	USA	Cincinnati, Ohio, Daly Rd.	1	3	12.20	40.03	2973	68	1993
8	USA	New York City, C80 #3	1	3	13.10	42.98	5663	129	1994
9	USA	Richmond, Virginia	1	1	2.60	8.53	150	3	1995
10	Canada	The Regional Municipality of Niagara, ON	2	2	12.00	39.37	2000	46	2006
11	USA	Riley Creek CSO, Mattoon, IL	1	2	6.40	21.00	657	15	2016
		Total	**17**	**Units**					

Hydrovex®
www.hydrovex.com

Appendix E

SanSep Installation List

(Source: Echelon Environmental)

SANSEP^{tm} INSTALLATION & CONTACT LIST

Oct 2013

YEAR INSTALLED	LOCATION	OWNER	ENGINEER	DETAILS
1999	LOUISVILLE, KY CSO 50	LOUISVILLE & JEFFERSON CTY MSD Roddy Williams (now works for Strand Associates in Louisville) Derek Guthrie (now works for HDR in Louisville)	HDR (OMNI ENGINEER'ING) Gary Boblett Louisville & Jefferson Cty MSD Darren Thompson	Single PCS50_50; 10 cfs
2000	LOUISVILLE, KY CSO 108	LOUISVILLE & JEFFERSON COUNTY MSD	HDR (OMNI ENGINEERING)	Twin PCS70_70; 38 cfs
2002	AKRON, IN CITY LAKE CSO TREATMENT FACILITIES	AKRON, IN PUBLIC WORKS DEPT Marty Gearhart, Superintendent (574) 893-4674	COMMONWEALTH ENGINEERS Mark Sullivan, PE 7256 Company Drive Indianapolis, IN 46237 (317) 888-1177	PCSC56_40; 10 cfs. PCSC30_30; 4 cfs
2004	COHOES, NY N. NIAGARA AVE CSO OUTFALL	CITY OF COHOES, NY PUBLIC WORKS DEPT. Billy Kane, Maintenance Mgr. Office - (518) 488-8622 ALBANY REGIONAL SEWER DIST. Timothy S. Murphy, Permit Compliance Mgr. Office - (518) 447-1614	MALCOLM PIRNIE Robert E. Ostapczuk, PE 855 Route 146 Suite 210 Clifton Park, NY 12065 Office – (518) 250-7305	PCS100_100; 42 cfs
2004	WEEHAUKEN, NJ W5	NORTH HUDSON SEWER DISTRICT, WEEHAUKEN, NJ CONTRACT OPERATOR – OMI SERVICES JAMES HOWEY, Regional Mgr. 10 Brondesbury Drive Cherry Hill, NJ 08003 856-751-0213 Mohankumar Boraiah CH2M Hill 1600 Adams Street Hoboken, NJ 07030 Ph: 201-386-9847 Cell: 201-344-2783	CH2M-HILL Vincent Rubino, PE Kelly O'Connor, PE 119 Cherry Hill Road Parsippany, NJ 07054-1102 973-316-9300	Twin PCS70_80; 64 cfs

SANSEP$^{\text{tm}}$ INSTALLATION & CONTACT LIST

Oct 2013

YEAR INSTALLED	LOCATION	OWNER	ENGINEER	DETAILS
2006	NIAGARA FALLS, ON, CANADA MUDDY RUN PUMP STA. HRT COMPARISON	NIAGARA FALLS REGION AUTHORITY		Single PCS40_30 Demonstration site with StormKing 8 ft diameter unit.
2008	FORT WAYNE CSO 58, FORT WAYNE, IN.	FORT WAYNE PUBLIC UTILITIES Wendy Reust, PE, CSO Program Mgr. One Main St., Room 480 Fort Wayne, IN 46801-1804 Office - 260-427-1367	CDM Karl E. Tanner, PE 151 N. Delaware St. Suite 1520 Indianapolis, IN 46204 Office - 317-637-5424	Twin PCS70_70; 10 cfs
2013	CSO 026 – HARBOR BROOK WETLANDS PILOT PROJECT	ONONDAGA COUNTY DEPT OF WATER ENVIRONMENT	CHA – CH2M-HILL JOINT Rich DeGuida, PE (CHA) 441 S Salina St. Syracuse, NY 13202 Office – 315-471-3920	Double 80-80, 44 cfs
2015	Taylorville, Illinois	City of Taylorville	Crawford, Murphy and Tilly Jeffery Large 217 572-1131	Single 70_70 with gravity underdrain
EUROPEAN INSTALLATIONS				
2005	LONDON	LONDON SEWER DEPT		PCS70_70; 450 l/sec
PACIFIC RIM				
1998	SYDNEY, AUSTRALIA		CDS TECHNOLOGIES PTY LTD.	PCS100_100; 1000 l/sec
2002	BRISBANE, AUSTRALIA		CDS TECHNOLOGIES PTY LTD.	PCS65_65; 400 l/sec
2002	SEOUL, S. KOREA, CHUNG GAE CSO FACILITY	SEOUL PUBLIC WORKS DEPT	KOGET ENVIRONMENTAL TECH.	6 each PCS100_100, 1,000 l/sec each

PWTech
PROCESS WASTEWATER TECHNOLOGIES LLC

Appendix F

ACTIFLO® Ballasted Flocculation Unit Installation List

(Source: Veolia Water Technologies)

KRÜGER

ACTIFLO Wet Weather Installation List

Jul-17

Installation Number	Name	Application	Location	Year Startup	Total Capacity	Number of Trains
1	St. Bernard, LA	ACTIFLO	At WWTP	2001	10	1
		BIOACTIFLO	At WWTP	2011	7.5	1
2	Bremerton, WA	ACTIFLO	Satellite	2001	10	1
3	Lawrence, KS	ACTIFLO	At WWTP	2003	40	2
4	Fort Smith, AR (P Street)	ACTIFLO	At WWTP	2004	31	1
5	Port Clinton, OH	Dual Mode ACTIFLO*	At WWTP	2004	24	2
6	Greenfield, IN	Dual Mode ACTIFLO*	At WWTP	2004	8	2
7	Fort Worth, TX	ACTIFLO	At WWTP	2005	110	2
8	Port Orchard, WA	ACTIFLO	At WWTP	2006	6.7	1
9	Cincinnati SSO 700, OH	ACTIFLO	Satellite	2006	15	1
10	Heart of the Valley (HOV) Kaukauna, WI	Dual Mode ACTIFLO*	At WWTP	2007	60	2
11	Salem, OR	ACTIFLO	Satellite	2007	50	2
12	Cincinnati, OH Sycamore Creek	ACTIFLO	At WWTP	2008	32	2
13	Tacoma, WA	ACTIFLO	At WWTP	2008	76	2
14	Geneva, NY	ACTIFLO	Satellite	2008	23	1
15	Nashua, NH	ACTIFLO	At WWTP	2008	60	2
16	Fort Smith, AR (Sunnymede Pump Station)	ACTIFLO	Satellite	2010	25	1
17	Newark, OH	ACTIFLO	At WWTP	2011	28	2
18	Wilson Creek, TX Phase 1	Dual Mode BIOACTIFLO*	At WWTP	2012	36	1
	Wilson Creek, TX Phase 2 (under construction)		At WWTP	2017	36	1
19	Lowell, IN	ACTIFLO	At WWTP	2013	10	1
20	Rock Creek, OR	Dual Mode ACTIFLO*	At WWTP	2013	30	2
21	Knoxville, TN	BIOACTIFLO	At WWTP	2013	11	2
22	Terra Haute, IN	ACTIFLO	Satellite	2016	16.5	1
23	Nappanee, IN (under construction)	ACTIFLO	Satellite	2017	5	1
24	Cox Creek, MD (under construction)	BIOACTIFLO	At WWTP	2017	12	1
25	McHenry, IL (under construction)	BIOACTIFLO	At WWTP	2017	10	1
26	DC Water (under construction)	ACTIFLO	At WWTP	2018	250	3

* Note: Dual mode means the ACTIFLO treatment train is used during dry weather flows for either primary or tertiary treatment.

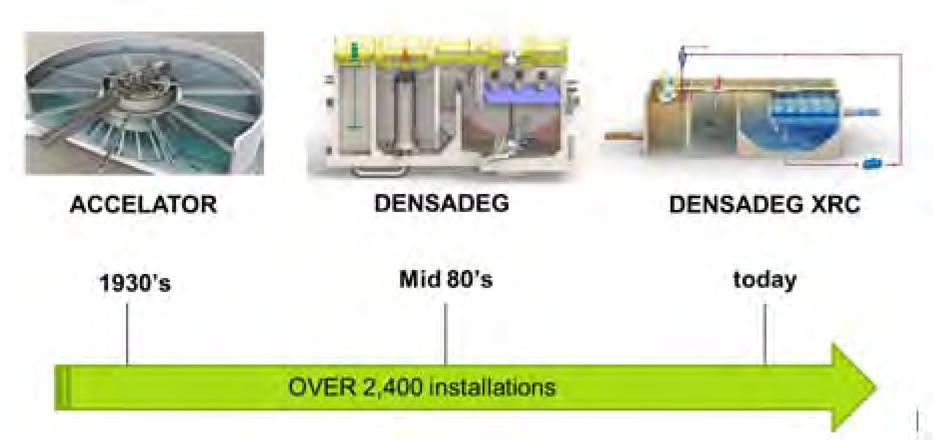
Appendix G

DensaDeg® Ballasted Flocculation Installation List

(Source: Suez)

DENSADEG CSO EXPERIENCE

SUEZ has been providing high rate solids contact system for over 85 years. The new DensaDeg XRC™ has been born out of decades of improvements, starting with the original solids-contact clarifier, the Accelator, which was the first to incorporated internal sludge recycling. In the late 1980's the original DensaDeg clarifier was introduced to the market and continues to lead the industry for high-rate sludge ballasted and solids recirculation systems. While the DensaDeg XRC™ is recently introduced in 2015, it is merely an improvement upon a history of existing installations and operating principles, including over 2,400 installations over this span.



DENSADEG XRC

A year-long pilot study was conducted at Petersburg WWTP, VA, which included testing of the primary influent and secondary effluent from the plant. A case study summary is provided in **Addendum 3** of this proposal.

CSO/SSO REFERENCES

Below you will find a list of select installations for the original DensaDeg in CSO/SSO applications.

1 – McLoughlin Point WWTP, British Columbia, Canada – 64.5 MGD, 2019
2 – Shreveport WWTP, Louisiana – 40 MGD, 2006
3 – Toledo WWTP, Ohio – 232 MGD, 2006
    Mr. Alan Ruffle, 419-727-2618
4 – Halifax WWTP, Nova Scotia, Canada – 92 MGD, 2005
5 – Edinborough, Scotland, UK -- 2002
6 – Aix-En-Provence (De La Pioline) WWTP, France – 25MGD, 2001
7 – Bourg-End-Bresse (De Majornas) WWTP, France – 22MGD, 2000
8 – Limoges WWTP, France – 23.8 / 33.6 MGD, 2000
9 – Meru (De L'Eau D'Amont) WWTP, France – 3.2MGD, 1999
10 – Saint-Chamond WWTP, France – 63.5MGD, 1999
11 – Colombes (Seine Centre) WWTP, France – 277MGD, 1998
12 – Bonneuil-En-France WWTP, France – 81.5 MGD, 1996
13 – Metz (Station Nord) WWTP, France – 68.5MGD, 1995

Appendix H

FlexFilter Installation List

(Source: WesTech Engineering, Inc.)

WWETCO FlexFilter™

Installation and Reference List

This partial list is composed of our key installations for this product. If you would like an expanded or more customized installation or reference list, please contact WesTech Engineering, Inc.

Plant Name	Location City/Sate	Quantity Size	Capacity Equipment Application	Contact Information
Springfield WWTP	Springfield, Ohio	11 30 ft. x 27 ft.	100 MGD Flex Filters CSO Treatment	Bill Young: Plant Superintendent, Springfield WWTP P: (937) 328.7626 E: byoung@springfieldohio.gov
Choctaw Pines	Dry Prong, Louisiana	2 2 ft. x 2 ft.	60 gpm FlexFilters Tertiary Treatment	Russell Turnage: Owner, Turnage Environmental Services P: (318) 447.5291 E: russellturnage@aol.com
Lamar WWTP	Lamar, Missouri	3 6 ft. x 6 ft.	2 MGD FlexFilter Lagoon Effluent Filtration	Rick Hornbeck: Water Plant Superintendent, City of Lamar P: 417-682-4480 E: rhornbeck@cityoflamar.org
Heard County	Franklin, Georgia	2 4 ft. x 4 ft.	0.75 MGD FlexFilters Tertiary Treatment	Jimmy Knight: Director, Heard County Water Authority P: (706) 594.2486 E: jknight@myhcwa.com
Weracoba Creek	Columbus, Georgia	3 6 ft. x 18 ft.	10 MGD FlexFilters Stormwater Treatment	Lynn Campbell: Vice President, Division of Water Resources, Operations, Columbus Waterworks P: (706) 649.3459 E: lcampbell@cwwga.org

WWETCO FlexFilter™

Installation List

This partial list is composed of our key installations for this product. If you would like an expanded or more customized installation or reference list, please contact WesTech Engineering, Inc.

Plant Name	Location City/Sate	Quantity Size	Capacity Equipment Application
Solvay Polymer	Marietta, Ohio	3 6 ft. Diameter	1.44 MGD, Flex Filters Tertiary Treatment
Hope East WWTP	Hope, Arkansas	3 6ft. x13 ft	1.6 MGD, Flex Filters Tertiary Treatment
Hope West WWTP	Hope, Arkansas	3 6ft. x16 ft	2 MGD, Flex Filters Tertiary Treatment
Upper Tuscarawas WWTP	Akron, Ohio	10 6 ft. x 10 ft.	100 MGD, Flex Filters CSO Treatment
Springfield WWTP	Springfield, Ohio	11 30 ft. x 27 ft.	100 MGD, Flex Filters CSO Treatment
Choctaw Pines	Dry Prong, Louisiana	2 2 ft. x 2 ft.	60 gpm, FlexFilters Tertiary Treatment
Lamar WWTP	Lamar, Missouri	3 6 ft. x 6 ft.	2 MGD, FlexFilter Lagoon Effluent Filtration
Heard County	Franklin, Georgia	2 4 ft. x 4 ft.	0.75, MGD FlexFilters Tertiary Treatment
Weracoba Creek	Columbus, Georgia	3 6 ft. x 18 ft.	10 MGD, FlexFilters Stormwater Treatment

Appendix I

Operation and Maintenance Cost Opinions/Guidelines for Storage Tanks, Tunnels and Green Infrastructure

(Source: Greeley and Hansen and CDM Smith)

O&M For Storage Tanks, Tunnels, and Green Infrastructure

	Item	Unit	Cost Basis (per year)
Operation	Pump Station*		
	Up to 100 MGD	COP	0.5 x $470K
	Over 100 MGD	COP	2.0 x $470K
	Storage	COP	0.5 x $470K
	Tunnels	COP	1.0 x $470K
Maintenance	Green Infrastructure	Per Impervious Acre Managed	$8,000
	Pump Station	% of construction cost	2.0%
	Storage	% of construction cost	3.0%
	Tunnels	% of construction cost	2.0%
	Conveyance Pipelines/ Sewer Separation	% of construction cost	2.0%

*Pump station operation for tunnels included in tunnel operation.
Only add pump station operation costs if standalone pump station.

O&M For Storage Tanks, Tunnels, and Green Infrastructure

Operation

- Labor costs and requirements for the various CSO Control Technologies were based on the average cost of maintaining a single operating post manned by one operator on a 24-hour, year round basis. Local operations labor is approximately $53.60/hour, including fringe benefits. Assuming an eight hour workday, with three shifts per day, for 365 days per year, the average cost for a Continuous Operating Post (COP) would be $470,000.

Maintenance

- Costs taken as a percentage of the construction cost.

O&M For Storage Tanks, Tunnels, and Green Infrastructure

To combine O&M and full capital costs for each control technology, present worth calculations have to be completed. For this, a discount rate of 2.75% is used (taken from the Rate for Federal Water Projects, NRCS Economics, Department of the Interior) with a life span of 20 years. The following equation is then utilized to calculate the present worth factor to convert from annual O&M costs to present worth.

$(P/A, i\%, n) = ((1+i)^n -1)/((i(1+i)^n)$

This is then multiplied by the annual O&M costs and then added to the construction costs to obtain the total life cycle cost. Salvage value is considered to be $0, as it is assumed no resale value will result from the Control Technologies utilized.

The life cycle cost can also simply utilize the cost curve developed from the referenced documents. Calculating the life cycle cost from escalating the capital cost and present worth is an alternative method to provide a check to the life cycle cost.

APPENDIX K

Response to Public Comments to PVSC Regional Development and Evaluation of Alternatives Report

Dated: November 2019

Appendix K

Response to Public Comments to

PVSC Regional Development and Evaluation of Alternatives Report

November 2019

Written comments for the Regional Development and Evaluation of Alternatives (DEAR) were received from public interest groups and members of the Supplemental CSO Team. For the reader's convenience, the comments are grouped into the general topics listed below. A common response is provided in bold for all of the comments that pertain to a topic.

Each entity that provided comments is listed herein and associated with a commenter number. The commenter numbers (eg. [1],[2]) are referenced throughout this Appendix.

Public Comments- General Topics

Topic 1: Climate Change and Selection of the Typical Year

Topic 2: Public Input & Outreach

Topic 3: Request for Executive Summary

Topic 4: Addressing Pollutants of Concern

Topic 5: Development and Implementation of Regional Alternatives

Topic 6: Regional Tunnels

Topic 7: Alternatives Evaluation Process

Topic 8: PAA Disinfection

Topic 9: Use of Receiving Waters

Topic 10: Green Infrastructure

Topic 11: Water Quality

Topic 12: DEAR Report Preparation

Topic 13: Construction and Community Impacts

Topic 14: Number of Overflows and Overflow Volume

Topic 15: Infiltration and Inflow

Topic 16: Sewer Separation

Topic 17: Financing

Topic 18: Modeling

Topic 19: Bayonne DEAR- Population and Redevelopment

Topic 20: Paterson DEAR- Projected Population Growth

Topic 21: Bayonne DEAR- Green Infrastructure

Topic 22: Paterson DEAR - Flooding in the Community

Topic 23: Paterson DEAR- Green Infrastructure

Topic 24: General Statements

Commenters:

[1] Sewage Free Streets and Rivers Partners

[2] JC START

[3] Paterson SMART

[4] Bayonne Water Guardians

[5] Drew Curtis on Behalf of NJEJA

[6] Sustainable Jersey City

Topic 1: Climate Change and Selection of the Typical Year

Comment 1

Projections on more intense storms that are predicted as a result of climate change or increase in annual rainfall totals should be included in the reports. **[1]**

Comment 2

Part D gives projected number of overflows and CSO volumes for the various alternatives, but the report seems to have no explanation of the technical methodology used to come up with those projections. For example, what assumptions were made about annual rainfall, or about dry weather flow (accounting for population growth), or any number of other critical assumptions involved in this sort of modeling? **[1]**

Comment 3

We were glad to see that the alternative analysis accounts for projected sea level rise and population growth. However, the alternative analysis does not appear to include an evaluation of more intense storms that are predicted as a result of climate change or increase in annual rainfall totals. Please provide some sensitivity analysis for a range of storm intensities and annual rainfall increases. **[2]**

Comment 4

The alternative analysis does include sea level rise and population growth, but it does not appear to include an evaluation of more intense storms that are predicted as a result of climate change or increase in annual rainfall totals. There should be some sensitivity analysis performed for range of storm intensities and annual rainfall increases. **[1]**

Comment 5

How was climate change considered? Picking a point in time to do the evaluation was necessary, however, that point should still be reviewed for efficacy of solutions given climate changes risks. Climatologists have studied weather patterns and have indicated the storms we should expect will be more significant on each occurrence. The increased intensity of storms will overwhelm storm sewers and cause devastating flooding as well as create CSO events which Paterson has already experienced. How will Paterson factor in the risk of climate change to ensure a reasonable factor of influence on the wet weather events and Alternatives proposed? **[3]**

Comment 6

Evaluation of more intense storms that are predicted as a result of climate change or increase in annual rainfall totals should also be included in these reports as this will impact CSOs. **[1]**

Comment 7

All of the appendices include projected growth and wastewater flow projections, evaluation of more intense storms that are predicted as a result of climate change or increase in annual rainfall totals should also be included. **[1]**

Response to Comments (1 through 7)

The typical year used for modeling does account for the relatively recent increase in rainfall intensity based on historic rainfall data of a 70-year period showing an increasing trend in the last few decades. The NJDEP's letter for the "Review of the Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Overflows- Regional Report," dated September 25, 2019, further indicates that while a long term precipitation data set (i.e. greater than 30 years) was considered as part of the Typical Year analysis, "a more recent period was used in the ultimate selection of 2004 in order to consider local climate change."

Topic 2: Public Input & Outreach

Comment 8

What engagement and outreach will take place over the next year and how will additional public comments be incorporated into the final plan? **[2]**

Comment 9

The "Community Benefits" column was developed using general knowledge about each of the technologies and several resources. The Supplemental CSO Team and public could have also provided feedback on the community benefits associated with each technology given the knowledge they have of their communities. **[1]**

Comment 10

The report states that public input has been solicited but does not include a summary of public input or who provided the input. What is the content of the public input gathered? **[1]**

Comment 11

How would communities be impacted? And has public input been gathered from the impacted communities? **[1]**

<u>Comment 12</u>

This says that the “criteria, rating, and ranking method” for selection of a preferred alternative will be determined through discussion with permittees. There’s no mention of discussion with the public. Will the public have input in selecting a preferred alternative? **[1]**

<u>Comment 13</u>

The reports describe the public outreach activities but do not summarize public input gathered. A summary of public input and who submitted the input on the alternatives should be included. **[1]**

<u>Comment 14</u>

This says that the preferred alternative will be identified following conversation with DEP and the permittees. What is the process for input from the public? **[1]**

<u>Comment 15</u>

The report states that the “screening of CSO technologies has also been presented to the public at the PVSC Regional Supplemental CSO Team meetings. Public input received on the screening of CSO control technologies has been reviewed and considered in the evaluation.”

Can PVSC include more information on the input that was gathered? Is there a summary of the public input gathered? Not just that input was gathered and taken into consideration but what the input actually was and who provided the input? **[1]**

<u>Comment 16</u>

Two members going to a SUEZ workshop is also noted. While the two members are to be commended, how does the reach the public at large? **[1]**

<u>Comment 17</u>

"Alternatives that .. were developed based on a broad range of considerations [including]... social impacts, public acceptance,etc.,...". Please show indications of evaluation of public input with documentation of comments received and methodology of soliciting and collecting public input. [1]

<u>Comment 18</u>

What is the process for Supplemental CSO Team members to review and to state their preferences for these alternatives? There has not been a formal review process. **[1]**

<u>Comment 19</u>

What is the process or mechanism for, and expectation of, opportunity for the public to offer broader commentary and input over the next year as perspective evolve on these preliminary alternative suggestions before finalized? **[1], [6]**

<u>Comment 20</u>

If this is public outreach please show the date collected at these regional meetings. **[1]**

Comment 21

The report states that public outreach to educate citizens about the CSS's and to encourage people to do their part to "reduce the grease, toxic chemicals, and floatables from entering local waterways. This is currently accomplished through Supplemental CSO Team Meetings (public meetings). Information presented in meetings is available as handouts." The need for public outreach is extensive and is not being met by the current regional meetings. This statement essentially allows for municipalities to rely on regional meetings that do not reach the majority of the public to do outreach and is insufficient. **[1]**

Comment 22

Public outreach was ruled out by most permit holders for further consideration by most permit holder other than a few who are evaluating water conservation. Public outreach should be evaluated and including in the LTCPs. **[1]**

Comment 23

PVSC has been an active member in several of the MAT's but to date has not been active with the Kearny AWAKE group and minimally with the Bayonne group. Both of these groups could use additional support. **[1]**

Comment 24

C1 – Control technology screening table:

Public outreach other than water conservation was not recommended for further evaluation. I would recommend public outreach be further evaluated. **[1]**

Comment 25

Quarterly Supplemental regional meeting should NOT be considered as adequate public meetings. Very few people in the public are aware of them or attend. **[1]**

Comment 26

Public outreach

None of the practices related to public outreach will be evaluated further. There is a tremendous opportunity for public outreach that have not been optimally pursued. I recommend further evaluation. **[1]**

Comment 27

What engagement and outreach will take place over the next year and how will additional public comment be incorporated into the final plan? **[2]**

Comment 28

Who really knows about this project in their respective communities? Why not have direct outreach in print and/or email via sewer billings, for example. Have a Healthy Waterways, Healthy Neighborhoods flyer/insert with a bill or via email. Social media and website are good for those who want to locate information on a topic, but it has to be initiated by a citizen. And frankly that cannot happen if you don't even know what is in the works! Initial public consciousness must be done directly to the public, so that they know who, what, when, why and how the CSO must be improved. This is needed before they can venture to comment on alternatives. Public outreach must be dynamic and not confined to the town engineer answering inquiries. **[1]**

Response to Comments 8 through 28

The "Public Participation Process Report," which has been reviewed and approved by the NJDEP on March 29, 2019, outlines the public participation and outreach activities that have occurred as of the date of the NJDEP approval and also notes what future public participation and outreach activities will occur. Additionally, based on public comments as provided by the Supplemental CSO Team, community benefits have been added to the screening of CSO technologies and the results of this screening have been included in this Development of Evaluations and Alternatives Report (DEAR). A draft copy of this DEAR has also been distributed to the Supplemental CSO Team, as well as members of the public, for purposes of soliciting public input. The public input/comments received, as well as responses to the public input/comments have been included in this Appendix. To date, 13 Supplemental CSO Team Meetings have been held and future Supplemental CSO Team Meetings are anticipated to be held. Presentations that were delivered at these meetings by the permittees are publicly available for review on the "Clean Waterways, Healthy Neighborhoods" website (www.njcleanwaterways.com). This website also serves as a platform for the public and the Supplemental CSO Team to provide input at any time. Social media outreach, an informational website, meetings with existing groups, both Rutgers University and Stevens Institute of Technology courses, ad hoc meetings with the public, and meetings with Mayors and City Council/Commissioners have been held and will continue to be held, as needed.

Various other public participation and outreach activities have occurred and will continue to occur as noted in the "Public Participation Process Report," which has been approved by the NJDEP on March 29, 2019.

Topic 3: Request for Executive Summary

Comment 29

A public facing executive summary would also assist with review of the reports. Executive summaries would contain a summary of the results of the evaluation of alternatives, the methodology and process moving forward. **[1]**

Comment 30

A public facing executive summary for the report is needed? **[1]**

Comment 31

An executive summary would contain some of the information in the introduction but summarized and written in terms that could be understood by a broader audience, include the recommendations, methodology used to evaluate the alternatives and the decision making process involved in narrowing down the alternatives and steps that will taken over the next year. **[1]**

Response to Comments 29 through 31

A report summary of the Development and Evaluation of Alternatives Report (DEAR) was prepared and issued to the Supplemental CSO Team and other members of the public to facilitate

review by the public of the DEAR. Additionally, the Regional DEAR is an executive summary of the individual permittee DEARs.

Topic 4: Addressing Pollutants of Concern

Comment 32

The "pollutants of concern" identified is only bacteria. But CSOs include other pollutants that likely have water quality standards (WQS) for the receiving waters, such as floatables (i.e., trash/litter), dissolved oxygen, oil and grease, etc. The permittees also have an obligation to reduce CSOs to address those pollutants. By omitting those pollutants an important factor in screening the CSO control technologies has been left out. This has resulted in the elimination of technologies that reduce floatables. **[1]**

Comment 33

The report states that the technologies were evaluated based on the "pollutants of concern" and the CSO "discharge volume." Has the Supplemental CSO Team provided input on the "Pollutants of Concern" and expanding to other pollutants that are caused by floatables? **[1]**

Response to Comments 32 and 33

Bacteria as the Pollutant of Concern has been reported to and approved by the NJDEP.

Topic 5: Development and Implementation of Regional Alternatives

Comment 34

Regional alternatives do not show the reduction of CSOs by City. Can this be added? **[1]**

Comment 35

The LTCP should optimize CSO reductions within each city, not just at a regional level. How does the regional plan help to reach maximum CSO reduction in each city, if at all? **[2]**

Comment 36

Will there be a hybrid plan (city & regional) to reach that maximum CSO reduction? Currently it appears that the choices of alternatives are all at the city level or all the regional level; a combination of the two do not seem to be offered. Please include a hybrid plan in the alternatives that would maximize regional as well as local objectives. **[2]**

Comment 37

How will regional agreements be negotiated? **[1]**

Comment 38

How were the longer list of "regional alternatives" from Appendix A, Part D, pared down to generate the short list of regional alternatives here? **[1]**

Comment 39

Is PVSC looking at an 85% capture scenario across the whole PVSC service area, rather than 85% for each permittee individually? **[1]**

Comment 40

Is the "knee of the curve" graph (cost vs performance) still valid at the regional level? Does the regional plan have [the] ability to kick in at some point to move the knee of the curve in a more cost effective direction? **[1]**

Comment 41

The LTCP should optimize CSO reductions within each city, not just at a regional level. How does the regional plan help to reach maximum CSO reduction in each city, if at all? **[2]**

Comment 42

Regional alternatives do not show the reduction of CSOs by City. Can this be added? **[1]**

Comment 43

Is the "knee of the curve" graph (cost vs performance) still valid at the regional level? Does the regional plan have the ability to kick in at some point to move the knee of the curve in a more cost-effective direction? **[2]**

Comment 44

Did DEP say that the presumption approach can be met on a regional basis, rather than each permittee having to meet the presumption approach targets within their own area? **[1]**

Comment 45

Will there be a hybrid plan (city & regional) to reach that maximum CSO reduction? Currently it appears that the choices of alternatives are all at the city level or all the regional level; a combination of the two do not seem to be offered. Please include a hybrid plan in the alternatives that would maximize regional as well as local objectives. **[2]**

Comment 46

Can you elaborate on why alternative 3 was only evaluated for 85% CSO volume capture? [1]

Response to Comments 34 through 46

The Regional Development and Evaluation of Alternatives Report (DEAR) identifies alternatives to meet CSO reduction targets at the regional level, and the individual DEARs included in the appendices identify the same for each Permittee at the city-wide level. Each Permittee is responsible for meeting permit requirements as outlined in their NJPDES Permit. A regional approach if selected, must also meet the individual permittee's permit requirements. A "knee of the curve" analysis is among the considerations that could be used to help guide the selection of controls.

Topic 6: Regional Tunnels

Comment 47

GI was not evaluated on a regional basis because PVSC does not own the land but wouldn't this also be true for a regional tunnel? **[1]**

Comment 48

Would construction of a regional tunnel require acquiring private property for construction? **[1]**

Comment 49

Are all of the regional alternatives being located on [PVSC owned land]?

Response to Comments 47 through 49

The regional tunnels that are being evaluated would be located across multiple municipalities and may require land acquisition or easements. The regional alternatives that are being evaluated are not necessarily on PVSC owned land.

Topic 7: Alternatives Evaluation Process

Comment 50

Ordinances and zoning changes that could have a significant impact on combined sewer overflows were not included. **[1]**

Comment 51

Ordinance Enforcement – This is also an area that could use further analysis as well as changes to zoning and passage of ordinances that could be support CSO reduction and would be a lower cost solutions. **[1]**

Comment 52

Alternatives were ruled out for further evaluation because they are already being implemented. This assumes that they are being implemented for their maximum benefits. Low cost solutions like I/I and ordinance enforcement should be evaluated further. **[1]**

Comment 53

The report states that community benefits will be considered but it is unclear how this factors into the decision making process. How do we know that technologies like that are already being implemented are being implemented to the maximum extent. Technologies like I/I reduction can have significant lower cost solutions. Could this be evaluated further? **[1]**

Comment 54

Operation and Maintenance – This is a low-cost solution that should be further evaluated. **[1]**

Comment 55

Only four alternatives have been presented for additional review and consideration: PAA Disinfectant, Sewer Separation, Offline Storage, and Offline Storage Tunnels. There were several other alternatives during the evaluation process that had a "medium" rating for volume reduction. I would like to see additional exploration to include Green Infrastructure within the suggested alternatives...I think the presented alternatives that are being pursued by the City of Bayonne are a tad bit limited in scope. I would like to see more of an aggressive mixture of alternatives that are being pursued with an increase in green infrastructure as one of the listed alternatives. **[4]**

Response to Comments 50 through 55

The Development and Evaluation of Alternatives Report (DEAR) considers a variety of alternatives at varying levels of CSO control, which includes a screening of CSO controls that are already being implemented. Additionally, based on public comments as provided by the Supplemental CSO Team, community benefits have been added to the screening of CSO technologies and the results of this screening have been included in this Development of Evaluations and Alternatives Report (DEAR).

Topic 8: PAA Disinfection

Comment 56

PAA disinfection is listed as either the sole low cost solution for Paterson, North Bergen, Newark and East Newark or one of several solutions for Bayonne and Kearny.

1) Has the Supplemental CSO Team provided input on this alternative?

2) Has this been used by any other cities to reduce CSOs?

3) What studies have been conducted?

4) What are the impacts on water quality and ecosystem?

Residual toxicity of PAA not fully known.." Should not more research be done before considering this for "primary technology? **[1]**

Comment 57

"Residual toxicity of PAA not fully known.." Should not more research be done before considering this for "primary technology? **[1]**

Comment 58

According to the report “Bayonne intends considering disinfection without suspended solids removal.” How would this impact the water quality? **[1]**

Comment 59

Also, which sites would be above ground and which considered for below grade? **[1]**

Comment 60

Has PAA been used for more than a few years by any city to reduce sewage overflows? **[1]**

Comment 61

It states that despite a 2017 study conducted in Bayonne "it is understood that the residual toxicity and PAA disinfection operations at CSO facilities is not fully known". PAA disinfection has been identified as a primary technology to consider in the alternatives evaluation.

1. This technique has only been in use for 2-3 years for waste water treatment. There isn't enough comprehensive data on its effectiveness.

2. Currently there aren't any peer review white papers on this product as it relates to its effectiveness in addition to long term effects and by-products released into the atmosphere.

3. For maximum effectiveness, treated water must be placed in the peracetic acid for 3-5 minutes for the disinfectant to be effective. Therefore additional holding tanks will be required at each of the disinfectant sites (in order to treat and hold the water before it is released at the Output location).

4. What happens when there is an occurrence of temperature fluctuation with the water during the treatment process. What are the parameters that the City of Bayonne will implement during warmer weather time periods as well as extreme cold weather seasons? PAA has water temperature requirements for effective wastewater treatment. **[4]**

Comment 62

What impact analysis is being done to consider the '[Peracetic] acid' application re: control alternatives, to the surrounding waterways? **[1], [6]**

Comment 63

How will water treatment be evaluated? What studies will be done prior to using PPA? What continuing studies will be done to ensure PPA is a eco-friendly alternative? If PPA is used, how will backward flow of stormwater be treated as it flows back into the streets of Paterson from the outflows that will be shut down during storm flow? How will flooding impact the mechanical functionality of the pumps? **[3]**

Comment 64

Treatment By Disinfection: The report mentions a pilot program at one of the outfalls. How would you be able to determine the longterm effects of treatment disinfection? **[1]**

Comment 65

Sites are indicated but again no mention of the one planned and being developed for the city park in the middle of the city (not near an outfall). Why is that? **[1]**

Response to Comments 56 through 65

PAA has been used in wastewater treatment applications, including for CSO treatment.

Details concerning the analysis of PAA as an alternative as a CSO control element are noted in the Development and Evaluation of Alternatives Report (DEAR).

Topic 9: Use of Receiving Waters

Comment 66

Newark Bay, Upper Newark Bay and Kill Van Kull and Hudson River are only being evaluated for secondary contact. Is this reflected in how these water bodies are actually used?

Response to Comment 66

The designation of the Newark Bay, Upper Newark Bay and Kill Van Kull and Hudson River was indicated in the Sensitive Areas Report, which has been approved by the NJDEP on April 8, 2019.

Topic 10 : Green Infrastructure

Comment 67

Was private land considered in the evaluation of GI? As well as programs like Rain Check that incentivizes homeowners to implement GI? **[1]**

Comment 68

Planting trees and enhanced tree pits were not included in the collection system technologies screening table and therefore not included any of the plans other than the JCMUA's and Kearny's. Given that increasing tree canopy's is already a goal of many urban cities and can have an impact on CSO's this should be evaluated further? **[1]**

Comment 69

There was no green infrastructure in the regional alternatives other than the JCMUA lowest cost alternative proposed. How were the regional solutions paired down from the list in the appendix? **[1]**

Comment 70

The regional alternatives do not include any GI (except for one scenario with some GI in Jersey City). Several of the regional alternatives in Appendix A include GI what was the decision-making process to not include any GI in the narrowed down regional alternatives? **[1]**

Comment 71

GI – Could a summary of the overflows reduced [be] included in addition to the tables? **[2]**

Comment 72

We were happy to see that trees have been called out as a specific green infrastructure method within section C.2.1 and in Table C.91. However, Jersey City's goals for increasing its tree canopy for other benefits such as health, aesthetics, and the reduction of the urban heat island effect do not appear to have been considered in the analysis of planting trees as an alternative. This is one instance where taking a TBL approach when analyzing alternatives would be especially beneficial. Please consider taking this approach. **[2]**

Comment 73

This might include perspectives on private sector partnership reflecting Developer Projects that would attribute to GI outcomes (upcoming Stormwater Management Ordinance Changes). The current scenario in the Alternatives Report presented, points to GI only being implemented on public land, so assumption would be that private property GI implementation can in fact leverage the underlying investment and outcomes made by the municipality. Is there a way to measure that contribution from the private sector? **[1],[6]**

Comment 74

Does public land include streetscapes? **[1],[6]**

Comment 75

It does not appear that the categories of Green Infrastructure considered in Section C2.5 of the PVSA Regional Eval of Alternatives Report specifically highlight Urban Forestry / Trees as a category and given this is being considered as a specific initiative in Jersey City, can the greater 3BL impacts of the targeted 30K Trees for Jersey City (Tree Canopy Study / JCEC Commitment) be calculated as additional GI commitment to leverage the outcomes being targeted ? **[1],[6]**

Comment 76

How does the various scenario analyses and recommendations map to the new Flood Overlay plan being developed by City Planning re: 37% of city parcels – is there a specific opportunity to leverage GI in these corridors? **[6]**

Comment 77

Why is green infrastructure only being considered on public lands? Are right [of] way plantings included in the definition of public land? **[2]**

Comment 78

Jersey City currently requires green infrastructure in some Redevelopment Plans and is working on adding additional green infrastructure requirements for developers within the Stormwater Management Ordinance and a proposed Flood Overlay Zone. Is it possible to measure the impact of contributions from the private sector (on private land) and include these numbers in the analysis of alternatives? **[2]**

Comment 79

Is it possible to map the alternatives analyses along with the new Flood Overlay plan being developed by the Planning Division in order to see if there are opportunities to leverage green infrastructure in these corridors? **[2]**

Comment 80

Has there been consideration of the impact of Jersey City's projected scheduled tree plantings and any investments already committed by the City towards urban forestry? **[2]**

Comment 81

Does the 7[-]10% of GI being targeted for in the Alternatives Report equate to 7 [-]10% of the budget expenditure? **[2]**

Comment 82

Can there be a scenario analysis done that could increment Green Infrastructure (GI) from 7 – 10%, quantifying triple bottom line (3BL) analysis similar to what was used by Philadelphia Water Dept (PWD) to understand if GI solutions were modeled into the mix of alternatives at 20% or 30%, what the outcomes might be ? **[1],[6]**

Comment 83

We were encouraged to see that green infrastructure was given a “very good” rating in the alternative analysis. However, we would like to see an analysis of higher percentages of green infrastructure (15%, 20% and 30%) and more analysis of specific green infrastructure approaches. Why aren’t permeable pavements recommended for Alternative Evaluation [?]. **[2]**

Comment 84

Recommend permeable pavement for further evaluation. There is an opportunity for permeable pavement to be used in Jersey City. Not using permeable pavement would limit GI implementation in Jersey City. **[1]**

Comment 85

Alternative 4 – GI

Has PVSC considered higher percentages of GI 15% or 20%? Is there a threshold at which GI becomes more impactful? **[2]**

Comment 86

On both the regional tables and the [Bayonne] specific version of the tables they didn't even seem to bother to evaluate trees, tree pits or tree trenches. Please evaluate trees and Urban Forestry and include them as an alternative. Tree planting is flexible, requires less land that some alternatives and has added and immense benefits socially and environmentally. **[1]**

Comment 87

For Bayonne only "verbal comments" on GI were even noted. The content of the comments was not even recorded. **[1]**

Comment 88

Budget Related-Does 7 [-] 10% GI being targeted for JC in Alternatives Report, equate to 7[-]10% of the budget expenditure? **[1],[6]**

Comment 89

As we have already communicated to JCMUA executive staff, we would like a Triple Bottom Line (TBL) approach that considers social, environmental and financial aspects, to be used to evaluate each alternative included in JCMUA’s Long Term Control Plan. This approach is especially useful in calculating the benefits of green infrastructure. **[2]**

Comment 90

Recommend evaluating GI at 5% and 10% and considering private and public land as well as areas where you can remove impervious surfaces. Recommend evaluating GI based on additional community benefits and how it can help Paterson reach its sustainability goals. **[1]**

Comment 91

Although this is considered a major issue, there is no indication of the fact anywhere in the report that Bayonne is working to site a cistern in at least one public park, removing a considerable amount of trees and replacing green space with hardscape. The city is well along in this process, yet there has been little, to no, public input or even notification. If a storage tank will be located under parks it should be indicated, not hidden in the language "city owned property" Why is private property not considered?

<u>Comment 92</u>

"Adequate geologic data for the subsurface conditions is not currently available at Bayonne,.."

It has been noted in public meetings that Green Infrastructure is not effective/workable because of the geology in Bayonne and yet here, the report indicates that data was not considered in repeatedly making this assertion? Please clarify.

<u>Comment 93</u>

"This analysis assumed no change in effective ground surface imperviousness associated with new developments." Why is this assumed [in the Bayonne DEAR]? Many of the current sites have no setbacks and no green space and are seemingly nearly 100% impervious, whereas some of the sites they are building on formally had yards, trees, etc.

<u>Comment 94</u>

Also please note, "operability" for offline storage in the Jersey City report indicated that ongoing maintenance, etc., would require "highly skilled labor", whereas Green infrastructure, for example, would not. As these issues are part of the consideration of alternatives why are they not elucidated in Bayonne's report?

Response to Comments 67 through 94

The evaluation of Green Infrastructure technologies has been evaluated as a CSO control element by the Permittees at the city level and the regional level. Details of this analysis have been included in the Development and Evaluation of Alternatives Report (DEAR).

Topic 11: Water Quality

<u>Comment 95</u>

Page 86 – “85% capture” presumption approach which equates to 20+ overflows per year. Will this meet WQS standards? **[1]**

<u>Comment 96</u>

What are the impacts on water quality? **[1]**

<u>Comment 97</u>

Reducing sewer overflows will have impacts on water quality so the statement that “sewer optimization would have no impact on water quality but could reduce sewer overflows” seems inaccurate. And should be considered for further evaluation. **[1]**

Response to Comments 95 through 97

Various levels of CSO control have been evaluated as they relate to water quality in accordance with the requirements of the National CSO Policy and the NJPDES Permits.

Topic 12: DEAR Report Preparation

Comment 98

How was input on the screening table gathered? Who filled out the table for each municipality? **[1]**

Comment 99

Who did the reviews in respective municipalities? And based on what credentials? Town engineer? Governing body? **[1]**

Comment 100

Could you provide tables that show the projected results per individual outfall – not just in the aggregate for the whole system, or even in the aggregate for any given permittees' outfalls. **[1]**

Comment 101

The screening of technologies matrix [in the Regional DEAR] was referenced but not included in the report. It would be helpful to include the matrix in the report so that the public can understand what was recommended for further evaluation and what is already being implemented. **[1]**

Comment 102

More information on how these alternatives have been reviewed and will be reviewing them? **[1]**

Response to Comments 98 through 102

The preliminary screening table was developed by the Permittees. The preliminary screening table was presented to the public at various Supplemental CSO Team Meetings in order to solicit public input. For instance, the addition of a "community benefits" column to the preliminary screenings table was incorporated based on input received by the public.

Topic 13: Construction and Community Impacts

Comment 103

There is no clear explanation of tank dimensions (except to note capacity in MG). This again is clarified in Jersey City's report with, for example a 4.5 MG tank being described as 80' in diameter and 120' in depth. This is important for "public acceptance" and "siting". This should be made more clear. **[1]**

Comment 104

The report did not contain the size of the facility. **[1]**

Comment 105

What construction would be involved? How would Newark be impacted? **[1]**

Comment 106

What are the community impacts of these plans? **[1]**

Comment 107

What are the community benefits of these plans? **[1]**

Comment 108

Alternative 2 Storage Tanks. What would the impact be for the communities where the tanks are being proposed? Both Paterson and Newark are environmental justice communities already burdened by a disproportionate amount of industry? **[1]**

Comment 109

Alternative 3 – Newark regulator modification. How would this impact Newark communities? **[1]**

Comment 110

"The following are some of the key implementability issues that have been part of preliminary considerations in the alternatives evaluation, but they have not been reviewed or analyzed in depth. The considerations made in this evaluation are solely based on the available information obtained from various sources." [Bayonne DEAR]

What are these sources? Why weren't the important issues analyzed in depth? When will this be done? Is this just being neglected? This is unacceptable. Jersey City analyzed these issues under "Constructability"

Response to Comments 103 through 110

Community impacts/benefits and considerations for each control technology are available in Section C and D for each Permittee's DEAR and is included Appendices A through I. The impacts/benefits will depend on the final CSO control alternative that is selected. Construction impacts will vary based on the final selection of CSO control technologies.

Topic 14: Number of Overflows and Overflow Volume

Comment 111

Table doesn't directly give the baseline CSO volumes. Without that, there's no context for understanding the CSO volume reductions shown on the table. I guess the "0 overflow" row effectively tells what the baseline is (since zero overflow would mean all existing CSO is captured), but that could be made more explicit. (Or, maybe zero overflow doesn't actually capture all volume – see comment below on p. 88, Table D4.)

Comment 112

How does zero overflows result in 641 million gallons of overflow volume?

Response to Comments 111 and 112

Details relative to overflow volumes can be found in the Regional DEAR, last revised November 2019.

Topic 15: Infiltration/Inflow

Comment 113

I/I reduction was not recommended based on being a regional solution. But the PVSC report states that I/I is not a regional practice. **[1]**

Comment 114

Paterson ruled out I/I reduction because it did not meet the threshold for excessive infiltration of 120 gallons per capita. Recommend further consideration because this is a low cost solution and could help reduce sewage overflows. **[1]**

Comment 115

PVSC is continuing to evaluate GI as a screening technology even though PVSC does not own the land. Could PVSC continue to evaluate I/I as a screening technology? **[1]**

Comment 116

The report states that PVSC has done outreach to the MS4 permit holders in the region to request them to do an I/I program and that several of the CSO permit holders are analyzing I/I. Given that this is a low cost solution that could have a tremendous benefit to the region. What is PVSC planning to do moving forward? And is there anything else that could be done? **[1]**

Response to Comments 113 through 116

The individual combined sewer systems and separate sanitary sewers are owned by the individual municipalities. Therefore, any I/I reduction considerations would need to be considered by each individual municipality. The outreach activities concerning the potential evaluation of I/I is included in the "Public Participation Process Report," which has been approved by the NJDEP on March 29, 2019.

Topic 16: Sewer Separation

Comment 117

For sewer separation, it does not appear that the cost analysis includes any level of stormwater treatment. According to NJDEP, some level of stormwater treatment would be required for all storm sewer separated outfalls. **[1]**

Comment 118

For sewer separation, it does not appear that the cost analysis includes any level of stormwater treatment. According to NJDEP, some level of stormwater treatment would be required for all storm sewer separated outfalls. Please adjust the cost analysis of this alternative to include the cost of required stormwater treatment. **[2]**

Response to Comments 117 and 118

The lifecycle costs for sewer separation, if evaluated, have been included in the Development and Evaluation of Alternatives Report (DEAR).

Topic 17: Financing

Comment 119

Is there consideration in the [Jersey City] budget that attributes already committed investment toward urban forestry / trees (over x period of years / annually) toward this stormwater management alternatives evaluation investment profile? **[1], [6]**

Comment 120

Newark included existing financing programs in their cost analysis. All of the permittees should include, where feasible, available financing programs to ensure an accurate cost estimate. **[1]**

Comment 121

Life cycle costs go up 20 years? How was this determined as the number of years for this projection? **[1]**

Response to Comments 119 through 121

Funding considerations for LTCP implementation are reported in the DEAR by each Permittee and are ongoing. A 20-year life span for a financial life cycle cost analysis is typical for this type of analysis.

Topic 18: Modeling

Comment 122

Can you explain the modeling that was used? And assumptions that were made? **[1]**

Comment 123

The annual overflow percent reduction in the table is different from what permittees reported from their models? Can you explain why municipal models are different from the PVSC projections? **[1]**

Comment 124

The percentages of flow reduction and CSOs managed [In Bayonne] is lower than in the other PVSC municipalities and much lower than the PVSC projections?

Response to Comments 122 through 124

Please refer to the "Service Area System Characterization Report," which has been approved by the NJDEP on April 18, 2019, for additional discussion about the hydrologic and hydraulic modeling methodologies.

Topic 19: Bayonne DEAR- Population and Redevelopment

Comment 125

Population Projection

Seems inaccurate considering the rate of redevelopment in Bayonne. The projected population in 2045 is set to 70,939 (an increase from 2017 of 3,753) Redevelopment charts in report show 4, 618 units approved or in the process of being approved as of now. When these are occupied, even if only an average of one person occupied each of the units, you already would exceed the population projection for 2045, 25 years from now. Please explain or revisit. **[1]**

Response to Comment 125

The population projection used in the alternatives evaluation is based on published records as noted in the report.

Topic 20: Paterson DEAR- Projected Population Growth

Comment 126

How was projected growth measured? Population growth is projected to be 157,079 for 2050. Presently population is 146,199. DOT has projected population to be 178,907 in 2045. That is a difference of almost 22,000 people. While water usage may be lower due to conservation and such, the potential of a transformed Paterson may make the population grow even more. With a more positive, greener environment, a return to a more balanced urban environment may increase the population more than is projected in the Alternatives Plan submitted. How will Paterson address this disparity? Paterson also has upstream water flow passing through the city, how will NJDEP address upstream waterflow influences from population and development

Response to Comment 126

The City of Paterson's projected population total can be rationalized by the technologies proposed across the lots available for development. Lots that can be used for greywater storage tanks, as well as GI like parks and trees, would no longer be tenable by residential units (save for green/blue roofs on new construction). Under our current siting study, the City has opportunities to reclaim "green" land by clearing currently abandoned residential structures and other impervious cover on blocks/lots that are presently or soon-to-be city-owned. Proposing GI like gardens, parks or tree pits on lots that could otherwise hold residential units influences the future population.

It must also be noted that, for more than 15 years, Paterson has had an ordinance for no-net-increase in impervious cover. This favors the LTCP, as it reduces the burden on sewer capacities. Any new developments or alterations (i.e. population moving into Paterson) must comply with this ordinance.

As it stands, the LTCP only accounts for the upstream water flow currently received from nearby communities (Haledon, Prospect Park, etc.). It may be in Paterson's interest to monitor for any increase in upstream flow, but coming to terms on contribution limits or compensation from these communities would be a legal challenge.

Topic 21: Bayonne DEAR- Green Infrastructure

Comment 127

Please explain how the numbers were calculated in Table D2 [in the Bayonne DEAR]?

Response to Comment 127

The process used to calculate the data shown in Table D2 is explained in detail in Section D.2.2 of the Bayonne DEAR.

Topic 22: Paterson DEAR - Flooding in the Community

Comment 128

Public Wet Weather experiences in Paterson.

Prior to 2010, the City of Paterson had been experiencing street and basement flooding issues in the V2 flow area during rain events upstream of the V2-1 Regulator, which is located at the intersection of Vreeland Avenue and East 36th Street. The most severe flooding typically occurs on 18th Avenue between East 28th Street and East 31st Street; on 19th Avenue between East 32th Street and East 36st Street; on 20th Avenue between East 19th Street and East 22st Street; and around the St. Joseph's University Medical Center. Area Flooding remains a significant concern for the community. Paterson residents at 33rd Street and 14th Avenue have also recently experienced flooding. How will areas beyond the above noted locations be handled?

Response to Comment 128

The 19th Avenue relief sewer (proposed in Alternatives 2-9) aims to provide substantial street and basement flood relief to many, if not all, of the affected areas listed above. A conceptual route is shown in Appendix C of the Paterson DEAR. Once an Alternative has been selected in June 2020, and the corresponding CSO reduction technologies are implemented in the City thereafter, incremental benefits of these technologies can be measured. This will determine if the technologies are working to reduce flooding as intended, as well as identify what areas may still need to be addressed as the LTCP continues in future CSO permit renewals.

Topic 23: Paterson DEAR – Green Infrastructure

Comment 129

How was Green Infrastructure (GI) evaluated? As Paterson is a poorer city with low income and many ethnicities and race, it is hard to quantify at this time if everyone will benefit in some way, but, if GI planned with a vision, there is opportunity for a Paterson transformation. By involving local labor, green job opportunities would be created which Paterson SMART would be willing to help facilitate the job training. Former industrial areas along the river which are very blighted at this time, will offer a place for underground storage tanks which can be converted above ground into public open green space particularly for a riverfront greenway which the community is in support of. This may initiate a revitalization of new neighborhoods. Using school areas will also provide improved recreational space. GI delivers a broad range of benefits beyond reducing the flow of water. By mimicking a more naturalized system, GI can deliver a broad range of ecosystem services or benefits to people, some of which include: improvements to community livability (aesthetics and property values), human health, air quality, water quality, groundwater recharge, wildlife habitats and connectivity, reduced heat island effects, reduced energy use, increased green jobs, and more recreational opportunities (USEPA, 2014).

Paterson has approached this in a very balanced way in the Alternatives focus on public lands. Paterson also has many vacant lots. Is it possible to convert some vacant lots into green space and incorporate GI to manage stormwater?

SWIM model, which was used in Syracuse, proved effective in optimizing GI results. Did Paterson use one of the identified models to identify areas where the GI will have the most significant impact in order to maximize the GI impact? And if not, will Paterson consider including these evaluations to determine the most infiltration opportunities on public land and a thorough evaluation on flooding? GI is a viable solution if it is done right.

In section D.1.1, Paterson selected the lowest level of GI at 2.5% versus most other cities who have evaluated and modeled at 5-10%. GI will help more with mitigation and in the longer term will have a greater potential benefit on the community as a whole. Will Paterson consider a higher level of GI? Why did Paterson model so much lower than other similar cities? **[3]**

Response to Comment 129

The City of Paterson appreciates the insight into opportunities of further GI implementation within the City. Similarly, our response to Comment #126 elaborates on ways that green space can be reclaimed through converting vacant lots.

The City did not employ an explicit GI optimization model like USEPA's SUSTAIN to plan for GI. Instead, the various land uses and zones were analyzed to assess available impervious areas that would be amenable to GI. Federal, state, county and local roadways are significant contributors of runoff within Paterson, and potential stormwater controls were explored that could be funded through collaboration with the respective government entities. As described in our systematic evaluation of GI opportunities, the highway corridor, schools, government buildings and even some non-governmental lands offer tremendous education and employment opportunities besides stormwater management.

Flooding has been a major factor in the city's decision-making towards maintenance of its connected system, and the city has historically pursued sewer separation as the best means to address flooding, from a neighborhood to a regional scale (e.g. the CSO028 drainage area). Paterson did engage in a citywide survey of available GI sites, which can facilitate the investigation of the impacts of GI construction in drainage areas that flood often.

Paterson also recognizes that other municipalities have presented studies within their DEARs at percent controls higher than 2.5% GI. Early iterations of the Paterson model did measure up to 10% GI implementation in efforts to quantify the benefits. This was done through a ground-up evaluation that assessed GI feasibility in different zones & land uses. However, high costs and feasibility constraints from this assessment led to the informed decision of only presenting GI measures at 2.5% in this DEAR.

Ultimately, the objective was to keep GI implementation in the City as relatively feasible as possible for the City's ratepayers. As one of the first CSO alternative technologies introduced after the baseline conditions, a scenario was proposed that would balance the functionality of reducing/eliminating overflows at some regulators with the costs of installing rain gardens, bioswales, and more. This study was then followed with sizing the optimal greywater storage controls necessary to meet the overflow and percent capture targets, as required by the CSO Permit.

It is worth noting, however, that the 2.5% GI level is only part of a preliminary feasibility analysis. As the City undergoes geotechnical investigations in collaboration with groups interested in implementing GI, the City may pursue additional GI beyond 2.5% to mitigate flooding and improve its water quality. Yet, GI alone will likely not reduce the need to construct the grey infrastructure required for disinfection or CSO storage.

Topic 24: Community Engagement- Paterson DEAR

Comment 130

How will the community be engaged in the decision process?

Paterson has many green grassroots organizations looking to improve the quality of life in their communities.

Camden County Municipal Authority was very successful in creating a chart based on community priorities, a triple bottom line looking at social, environmental, and costs – resulted in prioritizing GI. For example, flooding in Paterson could be a driving factor in the rating system in terms of identifying where the GI should go. For GI to be optimized, GI is more about community prioritizing and that means the community needs to be involved to have the impact it deserves.

Paterson SMART and CSO supplemental team representation from the city was not mentioned in the report. Are there city representatives actively participating in the meetings? Will their inputs be included in the report? Will Paterson have timely public meetings to incorporate community feedback? How will Paterson summarize and share the community input gathered? How will Paterson ensure the solutions are equitable to all races, ethnicities, and socio-economic statuses equally? How will public education and water conservation initiatives be introduced to the community?

All of the technologies that become part of the LTCP will have to function for not only the improvement of the City's combined sewer flows, but also for the best interest of the city's residents. The residents care to be involved. **[3]**

Response to Comment 130

The City of Paterson acknowledges that members of the Supplemental CSO Team and groups such as Paterson SMART desire continuous and thorough interaction with the public, especially regarding the implementation of green infrastructure. The Development and Evaluation of Alternatives Report (DEAR) is intended to be an introductory study of what CSO alternative technologies are feasible within a municipality. To that end, the DEAR concludes that GI is not only feasible, but recommended for further analysis and development. As we progress towards selection of an alternative plan in the June 2020 Selection Report, the City will expand on the preliminary nature of the studies in its DEAR. It is acknowledged that the public would like input with regards to locations that optimize effects of GI, water conservation initiatives, and equitable solutions for the most residents.

Topic 25: General Statements

Comment 131

Sewage Free Streets and Rivers Partners who contributed comments to this review include Larry Levine, Natural Resources Defense Council, Laurie Howard, Passaic River Coalition, Nicole Miller, Jill Scipione, Morris Park Neighborhood Association, Deb Italiano Sustainable Jersey City and Mo Kinberg New Jersey Future. **[1]**

Comment 132

Supplemental CSO Team members were given two weeks to review the reports and collect input from community stakeholders. Given that the reports are over 1,000 pages and highly technical, 30 days would ensure a more robust review. **[1]**

Comment 133

The report should provide more explanation of the additional analysis that will be performed over the next year. **[1]**

Comment 134

Only major comment is that I would like to see Newark's amazing community engagement efforts included in the report and an outline of how the community's feedback on the different alternatives were used. I am attaching a copy of the report I sent to Newark last month. I've copied the Newark team as well, for their reference. Newark has been such a leader in this work that it should be referenced and it is very important to ensure that resident feedback is used in the analysis. **[5]**

Response to Comments 131 through 134

Thank you for your comments and suggestions.

APPENDIX L

NJDEP Comment Letters for the Development and Evaluation of Alternatives Reports for PVSC and Permittees

Dated: September 25, 2019

State of New Jersey

PHIL MURPHY
Governor

SHEILA OLIVER
Lt. Governor

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CATHERINE R. McCABE
Commissioner

September 25, 2019

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North Bergen Municipal Utilities Authority
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North Bergen, NJ 07047

Frederick Margron, Town Engineer
City of Paterson
111 Broadway
Paterson, NJ 07505

Re: Review of Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report
Passaic Valley Sewerage Commissioners, NJPDES Permit No. NJ0021016
Bayonne City Municipal Utilities Authority, NJPDES Permit No. NJ0109240
Borough of East Newark, NJPDES Permit No. NJ0117846
Town of Harrison, NJPDES Permit No. NJ0108871
Jersey City Municipal Utilities Authority, NJPDES Permit No. NJ0108723
Town of Kearny, NJPDES Permit No. NJ0111244
City of Newark, NJPDES Permit No. NJ0108758
North Bergen Municipal Utilities Authority, NJPDES Permit No. NJ0108898
City of Paterson, NJPDES Permit No. NJ0108880

Dear Permittees:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" (hereafter "the regional report") dated June 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP). The regional report was submitted in a timely manner and was prepared in accordance with Part IV.D.3.b.v of the above referenced NJPDES permits. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements which is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" whereas responses to the individual appendices is provided under separate covers.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject regional report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

A sub list of alternatives have been identified as part of the development of the CSO control alternatives that are applicable to the PVSC, i.e., "alternatives that can be implemented for PVSC-owned infrastructure and/or implemented for CSO outfalls (that are owned by other Permittees) but are associated with PVSC-owned and operated regulators." PVSC provides for regional collection, conveyance, and treatment of sewage where a range of alternatives were developed to evaluate each of the screened and preselected technologies, both individually and in combination with other technologies on a regional scale. The PVSC Water Resource Recovery Facility ("WWRF") as located in Newark receives flow from three sources: the

Main Interceptor Sewer, the South Side Interceptor, and the Hudson County Force Main ("HCFM"). A general overview of the information provided for the CSO control alternatives, can be summarized below where the Department's comments follow:

- As described in each of the permittees' individual reports (i.e., Appendices), various alternatives were evaluated alone and in combination with each other for those alternatives identified in Part IV.G.4.e.i - vii. Alternatives were found to have varying applicability, effectiveness, and cost, with some alternatives being more effective in combination with others. **Alternative 1** as described in Section Section D.2.1 (Regional Alternative 1) of the regional report includes those alternatives for each of the 8 permittees that were found to be the most cost effective for each permittee to meet the yearly CSO frequencies and 85% capture scenario. Comments on the individual appendices are provided under separate covers as addressed to each of the individual 8 permittees.

- **Alternative 2**, as described in Section D.2.2 (Regional Alternative 2) of the regional report, was created as a regional approach in order to improve capture and treatment using regional tunnels to meet the yearly CSO frequencies and the 85% capture scenario. The regional tunnels would include the Paterson Citywide Tunnel, McCarter Highway Tunnel, and the NJ440 Tunnel, as depicted in Figure D-1 (Map of Regional Tunnels Locations NJ440). This alternative would require dedicated surface level piping leading to the drop shafts and microtunneling to connect the drop shafts to McCarter Highway Tunnel which would be needed in Harrison, East Newark, and Kearny.

- **Alternative 3**, as described in Section D.2.3 (Regional Alternative 3) of the regional report, evaluates a combination of Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant Expansion (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM) to meet the yearly CSO frequencies and the 85% capture scenario. Modifications to the 11 PVSC-owned and operated CSO regulators to maximize flow into the PVSC Main interceptor and PVSC WWTP is evaluated along with a parallel interceptor which would run from the WRRF to outfall regulator NE002. Regulator flows or upstream flows would be redirected to this new interceptor to reduce overflow and make use of an expanded 720 MGD treatment capacity at the WRRF. Additionally, the HCFM, which receives flow from Jersey City, City of Bayonne, North Bergen, and South Kearny, would be maximized to 146 MGD.

- **Alternative 4**, as described in Section D.2.4 (Regional Alternative 4) of the regional report, evaluates a combination of Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant Expansion (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM) + Tunnels, to meet the yearly CSO frequencies and the 85% capture scenario.

Specific Comments

Comment 1

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. These alternatives are briefly discussed in Section D.1.1 (Alternatives Evaluation Approach) and the regional report evaluates various CSO control technologies to provide varying levels of control (i.e., 0, 4, 8, 12, and 20 CSO events per year, and 85% CSO volume capture). A target of 85% capture and four overflows or less are two alternatives for the Presumption Approach; however, a specific approach has not been selected within the regional report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020.

Baseline percent capture is discussed in the regional report at Section C.1.1 (Water Quality and CSO Control Goals) where values of 83.7% capture for the PVSC Interceptor Communities and 65.3% for the Hudson County Force Main Communities are identified in Table C-8 (Typical Year % Capture). For report completeness the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be provided.

Comment 2

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." A justification for the hydraulically connected systems, namely the segmentation of the interceptor communities as well as the segmentation of those communities that pump to the Hudson County Force Main, must be provided.

Comment 3

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long-term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 4

Expansion is included in the header of Section C.6 (Sewage Treatment Plant Expansion or Storage at the Plant) where wet weather blending is described within. Specifically, throughout the regional report, the use of "bypassing" to reach flows up to 720 MGD are referenced as "expansion". Please note that the Department does not consider bypassing as a form of expansion and references to bypass should be stated as such.

Comment 5

A discussion of public participation is included in Section D.1.5 (Public Input). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. As stated in Section D.1.5 (Public Input) of the regional report, “The implementation of the LTCP PPP is an ongoing process that includes hosting quarterly public meetings with the Clean Waterways Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, participating as an active member of the PVSC Treatment District Communities GI Programs, including Newark DIG, Jersey City START, Paterson SMART, Bayonne Water Guardians, Harrison Tide, and Kearny AWAKE and partnering with Rutgers University in a GI municipal outreach program, … attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways Healthy Neighborhoods website and social media platforms.”

Moving forward, public participation is a required element of the ‘Selection and Implementation of Alternatives’ for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 6

Alternative 2 of the regional report details the usage of tunnel storage in Section D.2.2 (Regional Alternative 2) including the Paterson Citywide Tunnel, McCarter Highway Tunnel, and the NJ440 Tunnel. However, Appendix A (Development & Evaluation of Alternatives Report, PVSC) only includes two tunnels and does not include the NJ440 Tunnel. Similarly, the City of Bayonne looked at the feasibility of the NJ440 tunnel and determined that no further evaluation on this alternative was warranted, as noted in Section D.2.9 (Storage Tunnels) of Appendix B (Development & Evaluation of Alternatives, The City of Bayonne). Please explain these discrepancies.

Comment 7

Regarding Alternatives 2, 3 and 4, the use of tunnels, additional pumped capacity through the Hudson County Force Main Pump Expansion and incorporation of a new parallel interceptor would all allow additional flows to be conveyed to the PVSC WRRF. Please confirm that these flows would be sent PVSC, whether PVSC could accept these stored flows, or if there are any conveyance limitations that would prevent such. In addition, please verify the current capacity of the PVSC main interceptor; current capacity of the HCFM; and current flows of the HCFM.

Comment 8

In Section D.2.3 (Regional Alternative 3) it is stated that “Regional Alternative 3 is the same as Alternative 5a that was evaluated by PVSC (See Appendix A) and includes Newark Regular Modifications & Rehabilitation + Parallel Interceptor + Plant Expansion (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM).” However, based on Table D-1 (PVSC Alternatives) as included in Appendix A, Alternative No. 6.a.1 is Newark Regular Modifications & Rehabilitation + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Expansion (720 MGD) + JC Pipe (146 MGD HCFM).

In addition, in Section D.2.4 (Regional Alternative 4) it is stated that “Regional Alternative 4 is the same as Alternative 6 that was evaluated by PVSC (See Appendix A). However, based on Table D-1 (PVSC Alternatives), Alternative No. 7.a1 is Newark Regular Modifications & Rehabilitation + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Expansion (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels. Please revise or clarify.

Comment 9

While cost analyses are provided throughout the regional report, particularly in Section D.1.7 (Cost) as well as for each alternative evaluated in Section D, please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Please incorporate these changes and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Robert Hall, Bureau of Surface Water Permitting
Marzooq Alebus, Bureau of Surface Water Permitting
Susan Rosenwinkel, Bureau of Surface Water Permitting
Teresa Guloy, Bureau of Surface Water Permitting

State of New Jersey

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CATHERINE R. McCABE
Commissioner

September 25, 2019

Bridget M. McKenna, Chief Operating Officer
Passaic Valley Sewage Commissioners
600 Wilson Avenue
Newark, NJ 07105

Re: Review of Development & Evaluation of Alternatives Report
Passaic Valley Sewerage Commission (PVSC), NJPDES Permit No. NJ0021016

Dear Ms. McKenna:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated June 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of Alternatives Report" (hereafter "the report") for PVSC. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix A is specific to PVSC. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives Report" specific to the PVSC (Appendix A) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

PVSC provides for regional collection, conveyance, and treatment of sewage; however, PVSC does not own or operate any outfalls or any portion of the CSS of the municipalities that it serves. PVSC's alternatives, as included in the subject report, focus on increasing the volume capture and/or reducing the frequency of overflow events of CSOs throughout the collection system to varying levels of control, by analyzing alternatives designed for CSO outfalls associated with PVSC-owned and operated regulators. Control technologies evaluated include GI, PVSC-owned regulator modifications (Newark Regulators), parallel interceptor, storage tanks, tunnels, and expansion of plant treatment capacity via bypass. A range of alternatives were developed to evaluate each of the screened and preselected technologies, both individually and in combination with other technologies. The resulting alternatives are presented in Table D-1 (PVSC Alternatives). A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- Increasing **in-line storage** in the conveyance system is addressed throughout the report. Specifically, Section C.4.1.2 (Regulator Modifications) evaluates modifications to regulators owned and operated by PVSC as an alternative. Section D.2 (Preliminary Control Program Alternatives) considers regulator modifications as a singular alternative and in combination with other alternatives. However, Section D.2.3 (Alternative 3 – Newark Regulator Modifications) states, "Regulators alone provide minimal CSO reduction relative to other alternatives."

  The report evaluated **storage** alternatives for increasing storage capacity of the conveyance system, individually and in combination, including regulator modifications, new parallel interceptors next to the existing interceptors in Newark and Harrison, storage tunnels (Paterson Citywide Tunnel, McCarter Highway Tunnel, NJ440 Tunnel), and eleven storage tanks for PVSC owned regulators in Paterson, Newark, Kearny, and Harrison.

- **STP expansion** and **bypass** are evaluated and discussed within the report and in the Appendix entitled, "Passaic Valley Sewerage Commission, New Jersey – WWTP No Feasible Alternatives (NFA) Analysis Report". A bypass would incorporate the acceptance of up to 720 MGD of wet weather flows at the treatment plant. Other technologies can make use of this increased treatment capacity by conveying more flow to the plant.

- **Sewer separation** is discussed in Section C.7 (Sewer Separation) but is not considered a feasible technology for PVSC implementation. Sewer separation was not considered for further evaluation as a CSO control alternative since PVSC does not own or operate the combined sewer system.

- **Inflow and infiltration (I/I)** is discussed in Section C.3 (Infiltration and Inflow Control). Since PVSC does not own or operate any of the combined sewer systems, the report states that PVSC has limited influence on I/I reduction and will not be evaluated as a control alternative.

- **Treatment of the CSO discharge** is discussed in Section C.8 (Treatment of CSO Discharge). As PVSC does not own or operate any of the CSS and/or CSO outfalls, treatment of CSO discharge is not considered a feasible technology and will not be evaluated as a control alternative.

- **Green Infrastructure** (GI) technologies are evaluated in Section C.2 (Source Control) and D.2.4 (Alternative 4 – GI). Section C.2.1 (Green Infrastructure) explains that GI's benefits extend beyond reducing the flow of water into CSSs during wet weather events. GI performs a range of ecosystem services and benefits to people.

Specific Comments

Comment 1

Section B.4 (Projected Future Wastewater Flows) states that despite increase in population within the PVSC Sewer District, dry weather flows have decreased over the previous decades due to water conservation measures. The report states, "Based on the continued application of water conservation measures, PVSC expects this trend to continue; however, there is uncertainty in whether the flows to the PVSC WRRF are going to increase proportional to population growth. Therefore, the wastewater flows used for existing and future conditions are the same for the purpose of this study." Given a projected population growth increase of roughly 20% by 2045 (as stated on page 10), please provide additional information as to how water conservation measures supports this assertion.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. These alternatives are briefly discussed in Section D.1.1 (Alternatives Evaluation Approach) and 85% capture is identified in many of the alternative performance tables throughout the report as a CSO Event Target where percent capture is one of the alternatives for the Presumption Approach. However, a specific approach has not been selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 3

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." A justification for the hydraulically connected systems, namely the segmentation of the interceptor communities as well as the segmentation of those communities that pump to the Hudson County Force Main, must be provided.

Comment 4

Section C.2.1 (Green Infrastructure) details the derivation of estimated GI and it is assumed that for 1.4 to 2 gallons of runoff treated by GI, 1 gallon of CSO reduction can be achieved depending on the hydraulic conditions in the system. Please provide justification for this figure.

Section D.2.4 (Alternative 4 – GI) considers three levels of GI implementation (2.5%, 5%, and 10%) to be applied to the entire PVSC Treatment District. Figure D-4 (Alternative 4 – Green Infrastructure) in Section D.2.5 depicts the PVSC Treatment District area to which GI is proposed to be applied at the various percentages whereas Table D-6 (Alternative 4 Performance and Cost) depicts the results utilizing the hydrologic and hydraulic model. However, the report contains limited information and discussion of possible specific locations for GI opportunities in the PVSC district area that would be needed to attain the impervious surface targets of 2.5%, 5%, or 10%. Please elaborate.

In addition, as GI implementation continues to be assessed any percentage must be equated to a reduction in CSO volume, frequency and duration in order to attain these targets and show any changes from the baseline. The inclusion of this quantitative metric for GI is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the volumes referenced in order to quantify any decrease in CSO flow from GI measures referenced in Table D-6 (Alternative 4 Performance and Cost).

Comment 5

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an “average” or “typical” rainfall year. As stated within the May 2018 report entitled “Typical Hydrological Year Report”, 2004 was selected as the typical hydrological year. While a long-term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 6

Section C.6 (WRRF Expansion and or Storage at the Plant) states that based on a No Feasible Alternatives Analysis, there was no feasible way to expand the capacity of the WRRF other than bypass of secondary treatment. Throughout the report, the use of bypassing to reach flows up to 720 MGD are referenced as “expansion”. Please note that the Department does not consider bypassing as a form of expansion and references to bypass should be stated as such.

Comment 7

A discussion of public participation is included in Section D.1.5 (Public Input). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. As stated in Section D.1.5 (Public Input) of the report, "The implementation of the LTCP PPP is an ongoing process that includes hosting quarterly public meetings with the Clean Waterways Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, participating as an active member of the PVSC Treatment District Communities GI Programs, including Newark DIG, Jersey City START, Paterson SMART, Bayonne Water Guardians, Harrison Tide, and Kearny AWAKE and partnering with Rutgers University in a GI municipal outreach program, … attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways Healthy Neighborhoods website and social media platforms."

Moving forward, public participation is a required element of the 'Selection and Implementation of Alternatives' for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 8

In Section D.2 (Preliminary Control Program Alternatives), Table D-1 (PVSC Alternatives) cites alternatives which include "JC Pipe (146 MGD HCFM)", "JC Pipe (185 MGD HCFM)", and "JC Pipe (235 MGD HCFM)". Please verify the current capacity of the HCFM, current flows.

Comment 9

In Section D.2.5 (Alternative 5 – Newark Regulator Modifications + Plant Expansion (720 MGD) + Jersey City Pipe (235 MGD HCFM)), Table D-7 considers inflow from the HCFM at 235 MGD and states that this alternative would capture 603 million gallons of CSO flow, resulting in a reduction of 29.5%. However, Table D-8 (Alternative 5a Performance and Cost) in Section D.2.6 (Alternative 5.a – Newark Regulator Modifications + Plant Expansion (720 MGD) + Jersey City Pipe (146 MGD HCFM)) only considers 146 MGD from the HCFM, but would capture 618 million gallons of CSO flow, resulting in a slightly larger reduction of 30.3%. Please explain how accepting more flow (235 MGD) from the HCFM would result in a lower volume of CSO flow capture than accepting a smaller flow (146 MGD).

Comment 10

Section C.5 (Storage) and in Section D (Alternatives Analysis) discuss various storage alternatives. Siting information has been included for tunnels in Figure D-1 (Alternative 1 – Tunnels) and grouped storage tanks in Figure D-2 (Alternative 2 – Storage Tanks) and Table D-3 (Alternative 2 – Tank Locations and Associated Outfalls). This resulted in 2 tunnels in Paterson and Newark and 11 reinforced concrete storage tanks throughout Paterson, Newark, Harrison, and Kearny. Necessary storage capacity of the tunnels and tanks were given in Tables C-5 and C-6 in Section C.5.1.1 (Tunnels), and Table C-8 in Section C.5.2.1 (Tanks). Please supplement this section with additional discussion as to whether or not these areas could sustain the needed volume of storage infrastructure. Please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please confirm as to whether or not this stored flow would be sent PVSC, whether PVSC could accept stored tank flow, or if there are any conveyance limitations that would prevent such.

Comment 11

Regarding Alternative 2, there is a discrepancy between Figure D-2 (Alternative 2 - Storage Tanks) in Section D.2.2 (Alternative 2 – Tanks) and Table C-8 (Storage Tanks Analysis) in Section C.5.2.1 (Tanks). Table C-8 shows 4 storage tanks located in the Paterson, 5 storage tanks in Newark, 2 storage tanks in Harrison, and 1 storage tank in Kearny. In contrast, the Figure D-2 shows only 3 storage tanks in Paterson. Also, there are only 9 tanks shown in the figure, while 11 tanks are shown in Table C-8. In addition, there are 11 tanks listed in Table D-3 (Alternative 2 – Tank Locations and Associated Outfalls), but it appears there is only one tank in Harrison. Please correct or explain the discrepancies between Figure D-2 and Tables C-8 and D-3.

Comment 12

While cost analyses are provided throughout the report, particularly in Section D.1.7 (Cost) as well as for each alternative evaluated in Section D, please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Please incorporate these changes to the report and submit a revised version to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Robert Hall, Bureau of Surface Water Permitting
Marzooq Alebus, Bureau of Surface Water Permitting
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CATHERINE R. MCCABE
Commissioner

September 25, 2019

Tim Boyle, Superintendent
City of Bayonne
610 Avenue C, Room 11
Bayonne, NJ 07002

Re: Review of Development and Evaluation of Alternatives
City of Bayonne, NJPDES Permit No. NJ0109240

Dear Mr. Boyle:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated June 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of Alternatives" (hereafter "the report") for the City of Bayonne. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual DEARs developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix B is specific to the City of Bayonne. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives" report specific to the City of Bayonne (Appendix B) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green infrastructure** (GI) technologies are described in Section C.2.1 (Green Infrastructure) where this section also includes a description of the ancillary environmental, social and economic benefits of GI to the community. It is stated within this section on page 12 that GI "…is being evaluated in conjunction with other primary alternatives that are necessary to achieve volume and bacteria reduction goals for CSO control." It is further stated that GI will be refined and evaluated further and that the "City's citizen education and support services will continue to promote localized GI on a homeowner scale." More specific GI information is included in Section D.2.2 (Green Infrastructure).

- **STP Expansion** is discussed in Section C.6 (STP Expansion or Storage). It is explained on page 16 that the expansion of the STP is a possible alternative; however, due to local and regional hydraulic constraints, the amount of CSO flow that can be conveyed to PVSC is limited. Presently, the contracted flow rate to PVSC is 17.6 MGD and any flow above 20 MGD would require an increase in the capacity of the force main that is jointly owned by Jersey City MUA and Kearny MUA. It is then concluded that "Since Bayonne currently neither owns nor operates a wastewater treatment facility, STP expansion or modification for wet weather flow treatment or storage would not apply…" The report includes an analysis of increasing the capacity of the force main in Section D.2.7.

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.4 (Sewer System Optimization) including conveyance, regulator modifications, and outfall consolidation/relocation as primary technologies whereas real time control is identified as a complementary technology to be reviewed in combination with primary technologies. Findings for the primary technologies are as follows:

  a) As described on page 14, improved or additional conveyance can be gained through either modification to flow control or by adding additional capacities to existing force mains or sewers. Conveyance factors for the Oak Street Pumping Station and force main are described further on page 40 of the report.

b) In Section D.2.5 (Regulator Modifications) it is stated on page 39 that "…model results show raising regulator weirs did not change CSO-event counts and only slightly changed the CSO volume (~0.1%), primarily re-distributing CSO to other outfalls. More importantly, raising weirs increased water levels within the CSS, which in turn can increase the possibility of flooding basements or streets." It was then concluded that regulator modifications for in-line storage would not be further evaluated.

c) Outfall consolidation/relocation is discussed on page 14 where it is explained that combining and relocating outfalls can minimize the number of CSO control facilities which works best for outfalls that are in close proximity to each other to minimize conveyance modifications. It is then concluded that outfall consolidation will be considered further as a viable primary CSO control technology in order to minimize the number of required satellite disinfection facilities and to reduce high frequency, low volume CSOs.

Various **storage** technologies are described in Section C.5 (Storage) with a more detailed analysis in Section D.2.8 (Storage Tunnels at Consolidated Locations) and D.2.9 (Storage Tunnels). Storage allows for CSOs to be captured, stored, and eventually pumped to a wastewater facility for treatment where off-line storage (tunnel, tanks) is considered to be a feasible alternative. Conceptual off-line storage tank facilities have been developed for each of the 28 individual CSO outfalls and for 9 consolidated facilities. Regional and local tunnels are also evaluated since tunnels provide more storage volume than pipelines and underground construction techniques result in minimal disruption to ground surface.

- **Inflow and infiltration (I/I) reduction** is described in Section C.3 (Infiltration and Inflow Control). Infiltration control is found to be not cost-effective based on a March 2007 report entitled "CSO Long Term Control Plan Cost & Performance Analysis Report, Vol. 1" by Hatch Mott MacDonald (2007, HMM) where these findings are supported by dry-weather flow measurements conducted in 2016 and 2017. Inflow is also discussed in this section where it is stated that because Bayonne's sewer system is mostly combined, inflow control would primarily focus on tidal impacts and "…investigation and control of tidal inflow will be retained as a program enhancement to protect against future increases of CSO."

- **Sewer separation** is described in Section C.7 (Sewer Separation) and Section D.2.4 (Sewer Separation). Section C.7 discusses the process of sewer separation and includes a reference to the previous cost evaluation (2007, HMM). Section C.7 further states that since Bayonne is an urban community, sewer separation would be disruptive to the neighborhood and the City has concerns regarding future permit requirements on stormwater discharges. However, as stated on page 16, sewer separation would completely eliminate CSOs and therefore sewer separation will be given further consideration and will be compared to the other alternatives.

- The report includes an evaluation of disinfection technologies for **satellite treatment** (i.e., treatment of the CSO discharge) in Section C.8 (Treatment of CSO Discharge and in Section D.2.10 (Disinfection Technologies). Peracetic Acid (PAA) is described as having significant potential advantages over other CSO technologies. See **Comment 8** for additional detail.

Specific Comments

Comment 1

A discussion of public participation and the CSO supplemental team is included in Section D.1.4 (Public Acceptance). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. Section D.1.4 includes a brief discussion of public participation on the local level through the Bayonne Water Guardians. The Department acknowledges that a list of meetings and agendas for the regional PVSC CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. However, please amend Section D.1.4 of this subject report with a brief summary of subsequent public participation activities as well as meeting dates specific to the development and evaluation of alternatives including a general overview of feedback on any alternatives presented that are specific to the City of Bayonne.

Moving forward, public participation is a required element of the 'Selection and Implementation of Alternatives' for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team and the Bayonne Water Guardians be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. These alternatives are discussed in Section D.1.5 (Performance Considerations) and targets of 85 percent capture as well as 85 percent removal of pollutants of concern are identified as alternatives for the Presumption Approach. However, a specific approach has not been selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020.

Section D.1.5 includes a reference to a memorandum "Evaluation of Alternatives Process (Memorandum)," Greeley and Hansen, January 7, 2019. In this memo it states that "Bayonne and the other Hudson County communities of North Bergen and Jersey City must reduce CSO volume by 59% in order to achieve the 85% volume capture performance metric." Please provide a copy of the memorandum and specifically the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system.

Comment 3

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." If it is your intention to define a hydraulically connected system together with the other municipalities that convey flow through the Hudson County Force Main, as referenced in Section D.1.5, a justification for the segmentation of those communities that pump to the Hudson County Force Main must be provided. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 4

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 5

Green Infrastructure is described in Section C.2 (Source Control) as well as in Section D.2.2 (Green Infrastructure (GI)). As stated on page 34 modeling analyses were applied to quantify the reduction from Baseline of CSO count and volume resulting from two levels of GI implementation. The first level of GI implementation involves elimination of runoff from the first inch of rainfall falling on 5% of the impervious surfaces in Bayonne, and the second involves elimination of runoff from the first inch of rainfall on 10% of the impervious surfaces. Both alternatives are equated to the number of approximate acres on page 34 to attain these targets and the CSO events and volume changes from the baseline are depicted in Table D-2 (Impacts on CSO Discharges of GI to Control Runoff from First Inch of Rain on 5% and 10% of Impervious Area). The Department notes that a quantitative metric such as acres is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the acreage values referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

While the report includes a reference to the Rutgers study "Green Infrastructure Feasibility Study, Bayonne," on page 12 for possible locations for GI opportunities in Bayonne, there is limited specific information regarding the siting of potential GI projects. Additional discussion should be added regarding possible locations for GI opportunities in the City that would be needed to attain the impervious surface targets of 5% or 10% or if any of the locations within the Rutgers report are available.

Comment 6

Tanks can be used to capture the most concentrated first flush and provide storage until conveyance and treatment capacity becomes available. On page 15 it is stated that Bayonne has an abandoned primary treatment tank with a capacity of 3.5 million gallons which could be used in conjunction with additional tankage to meet CSO control goals. The Department acknowledges that the use of this existing tank could assist as a pragmatic means of addressing a portion of CSO flow and the Department encourages use of such in the short term.

However, a significant limitation to the storage alternative is the capacity of the Oak Street Pump Station as well as the hydraulic limitations of the force main. As stated on page 40:

> "According to an existing agreement with PVSC, the City can send wastewater to PVSC's treatment Facilities at a peak rate of no more than 17.6 MGD (1986, PVSC). Based on its diameter, the existing Bayonne force main is hydraulically limited to approximately 20 MGD. Replacement of approximately 6,000 linear feet of the force main would be required to bring its entire length up to a consistent diameter of 36 inches, as necessary to hydraulically convey up to about 40 MGD."

Storage is further described in Section D.2.7 (Storage) where Table D-5 (Off-Line Storage Tank Sizes Required at Individual Outfalls to Achieve CSO Frequency Goals) shows the tank volumes that would be required at the 28 individual outfalls without considering any capacity limitations for dewatering of any particular tank. It is then stated on page 41, "…only the 20 CSO-event/yr performance objective can be met on a City-wide basis with the current pumping limitation of 17.6 MGD at the Oak Street Pump Station… More stringent performance objectives, such as the 8- and 4 CSO events/yr targets, would require a conveyance capacity of 40 MGD from the Oak Street pump station and its force main, with a possible need for capacity improvement within other portions of the collection system."

Based on the above, the conveyance capacity at the force main must be increased in order to consider storage as an alternative control.

Regarding the siting locations shown, please provide a brief description as to whether or not these locations have been explored regarding land ownership, availability etc. In addition, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. Finally, given the hydraulic limitations, please describe whether any analysis has been conducted as to whether or not tanks could be used in concert with satellite treatment.

Comment 7

While cost analyses are provided within the report, particularly in Section D.2.11 (Summary of Cost Opinions) and Section D.3 (Preliminary Selection of Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Comment 8

Table D-26 (Example Plan Alternatives for CSO-Frequency Targets Control Alternative) includes different alternatives for various untreated CSO event counts/year including PAA Disinfection with FlexFilter Pretreatment as well as Consolidated Tank with Additional Conveyance. Prior to this reference within this table there is limited discussion of pretreatment technologies or the FlexFilter within the report. In fact, it is stated on page 48 that "…PAA disinfection facilities can be implemented upstream of each CSO outfall, at a location between the existing regulator and the existing netting facility. Recognizing the fact that Bayonne already meets the water quality standards for pathogens and that smaller space requirements and significant (~75%) cost savings could be realized if the disinfection facility is not provided with suspended solids removal. Therefore, Bayonne may consider disinfection without solids removal." Please clarify the intentions for primary clarification and settleable solids removal.

In addition, in Table D-10 (Impacts of Disinfection for Range of CSO-Control Objective), footnote 2 states "In this context, "Untreated CSO Volume" is defined as the sum of discharged volumes during any 5-

minute period that exceed the design flow rate for 3-log pathogen removal." Please provide documentation and supporting analysis to justify the 3-log reduction.

Comment 9

In Section D.3.3 (Selection of Preliminary Alternatives), the following is stated on page 65 with respect to ambient water quality:

> "As noted above, Bayonne's receiving waters already meet applicable water-quality standards and designated uses, including pathogen levels. Disinfection of CSO discharges would provide significant reductions of pathogens, which have been identified as the pollutant of concern."

It is premature and outside of the scope of this report to include this conclusion regarding compliance with water quality standards. Please revise this statement as well as other similar statements within the report.

Comment 10

There is limited discussion within the report in section C.6 (STP Expansion or Storage at the Plant) with some additional discussion in section D.2.3. (Additional Conveyance of Wastewater) regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that Bayonne City does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. In addition, additional documentation regarding coordination with the other communities that share the force main is needed. For example, please identify the current conveyance capacity of the force main, as well as if there is adequate conveyance capacity to divert additional CSO flow to PVSC. Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky

Dwayne Kobesky
CSO Team Leader
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CATHERINE R. MCCABE
Commissioner

September 25, 2019

Bridgite Goncalves, Chief Financial Officer
Borough of East Newark
34 Sherman Avenue
East Newark, NJ 07029

Re: Review of Development and Evaluation of Alternatives Report
Borough of East Newark, NJPDES Permit No. NJ0117846

Dear Ms. Goncalves:

Thank you for your submission of the “Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report” dated June 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the “Development and Evaluation of Alternatives Report” (hereafter “the report”) for the Borough of East Newark. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

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The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 “System Characterization Report” (approved by the Department on April 12, 2019); the June 2018 “Public Participation Process Report” (approved by the Department on March 29, 2019); the June 30, 2018 “NJCSO Group Compliance Monitoring Program Report” (approved by the Department on March 1, 2019; and the June 2018 “Identification of Sensitive Areas Report” (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green infrastructure** (GI) technologies are described in Section C.2.1 (Green Infrastructure) where this section also includes a description of the ancillary environmental, social and economic benefits of GI to the community. As stated on page 3 "GI is being evaluated in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control."

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.4 (Sewer System Optimization) including regulator modifications, conveyance, outfall consolidation/relocation and real time control. Specific information is included in Section D.2.1 (Controls) where it is shown in Table D-2 (Overflow Volumes and Frequencies with Regulator Modifications) that regulator modifications to increase the weir height by 6 inches could result in an overall volume reduction of 9% from the baseline. It is then concluded that if this alternative were to be considered that additional investigation would be needed in order to ensure that this alternative would not cause street or basement flooding.

  As discussed in Section C.5 (Storage), various **storage** technologies were evaluated including pipeline storage, tunnel storage and tank storage. Section D.2.1 (Controls) focuses on the storage tank option where it is stated that "only one storage tank would be needed" and "It is assumed that a storage tank would be located near the existing outfall and it would below the ground."

- **STP Expansion** is discussed in Section C.6 (Sewage Treatment Plant (STP) Expansion or Storage) where it is explained that the Borough of East Newark transports their combined sewer flows to PVSC through the main interceptor and that "STP expansion or modification for wet weather flow could only be done by PVSC." It is then stated that due to local and regional hydraulic constraints as well as the involvement of Kearny and Harrison who share the conveyance lines, "it would likely be less intricate and more cost effective if local storage (e.g., tunnel, tank) is considered, rather than conveying the full peak flow of the Borough of East Newark to PVSC for treatment."

- **Inflow and infiltration (I/I) reduction** is described in Section C.3 (Infiltration and Inflow Control). It is stated that "Infiltration control in the Borough of East Newark CSS is not a cost-effective method of CSO control for achieving the requires CSO reductions." Regarding inflow control, it is explained that "Inflow control…would focus primarily on potential tidal inflows, as the separated catchments do not contribute storm water to the CSS, and there are no known or suspected stream inflows to the CSS." It is then concluded that investigation and control of I/I via identification and control of tidal inflow will be retained as a program enhancement to protect against future increases of CSO.

- **Sewer separation** is described in Section C.7 (Sewer Separation) whereas partial sewer separation is discussed in Section D.2.1. On page 21 it is explained that sewer separation could be conducted at the former BASF Clark Thread Mill manufacturing site and that this "area could be separated from the combined sewer area and inflows produced from this manufacturing industry could be removed from the combined sewer system." Table D-3 (Overflow Volumes and Frequencies with Partial Sewer Separation without GI) shows a potential volume reduction of 27% from baseline.

- The report evaluates **satellite treatment** (i.e., treatment of the CSO discharge) namely PAA Disinfection in Section D.2.1. It is concluded that "this alternative was assessed with partial sewer separation and GI at the Clark Thread Mill manufacturing site."

Specific Comments

Comment 1

Section B.3 (Planned Projects) describes the redevelopment of the BASF property (former Clark Thread Mill), as a means to reduce the CSO drainage area by about 14 acres through sewer separation as well as a potential location for the implementation of GI. However, there is limited discussion as to the status of that project, the commitment of the owners of that property, and whether or not there is certainty for sewer separation and GI on that parcel. Please provide additional details on the level of commitment for the use of this property for these control measures as well as the status of any remediation or redevelopment of the property.

There is also discussion later in the report regarding the construction of a storage tank near the outfall which is in close proximity to the BASF property. It is unclear if the BASF property is being considered as potential location for a storage tank and if this property could sustain the needed tank sizes referenced in Table D-5, Storage Tank Size (MG). If storage is being considered at this property or at any other locations, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please elaborate as to whether or not PVSC could accept stored tank flow given the statement in Section C.6 (Sewage Treatment Plant (STP) Expansion or Storage) that "local and regional hydraulic constraints would limit the amount of additional flows that could be conveyed for treatment."

Comment 2

There is limited discussion within the report in section C.6 (Sewage Treatment Plant (STP) Expansion or Storage) regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that the Borough of East Newark does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. In addition, additional documentation regarding coordination with the other communities that share the force main is needed. For example, please identify the current conveyance capacity of the force main, as well as if there is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 3

A discussion of public participation and the CSO supplemental team is included in Section D.1.4 (Public Acceptance). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a list of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. Please amend Section D.1.4 of this subject report with a brief summary of subsequent public participation activities as well as meeting dates specific to the development and evaluation of alternatives including a general overview of feedback on any alternatives presented that are specific to the Borough of East Newark.

Moving forward, public participation is a required element of the ‘Selection and Implementation of Alternatives’ for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 4

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. These alternatives are briefly discussed in Section D.1.5 (Performance Considerations) and 85 percent capture is identified in Table D-10 (CSO Control Alternatives Costs Summary) as a CSO Event Target where percent capture is one of the alternatives for the Presumption Approach. However, a specific approach has not been selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the ‘Selection and Implementation of Alternatives’ report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 5

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as “The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…” The definition of hydraulically connected system allows the permittee to “segment a larger hydraulically connected system into a series of smaller inter-connected systems.” As depicted in Table D-10 85% capture is calculated, however it is unclear if this applies specifically to the Borough of East Newark or to a larger system. Please provide a justification for the segmentation of this portion as a hydraulically connected system. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 6

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 7

In Section D.2.1 (Controls) the use of GI as a complementary CSO control technology is described where it is stated that two different control levels of GI were assessed. Specifically, an assessment is included of the management of 1" of storm water runoff generated from 5% of impervious surface as well as the management of 1" of storm water runoff generated from 10% of impervious surface. Both scenarios are equated to the number of acres that would be needed to attain these percentages, as shown in Table D-4 (Overflow Volumes and Frequencies with Partial Sewer Separation and GI), along with the associated volume reduction for each scenario and the baseline value. The Department acknowledges the inclusion of this quantitative metric for GI which is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the volumes reductions referenced from GI measures.

However, the report contains limited information regarding the siting of potential GI projects. While there is a reference within Section C.2.1 to the "Green Infrastructure Feasibility Study, East Newark," as prepared by Rutgers University, there is limited discussion of possible locations for GI opportunities in the Borough beyond the general reference to the BASF site. Please elaborate.

Comment 8

While cost analyses are provided within the report, particularly in Section D.2 (Preliminary Control Program Alternatives) and Section D.3 (Preliminary Selection of Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Comment 9

In Section D.2.1 (Controls) the use of disinfection by Peracetic Acid (PAA) is discussed. It is stated that "This preliminary disinfection alternative assumes that PAA disinfection will be implemented at locations between the existing regulators and existing outfalls.” Based on this statement, it is unclear if it is the Borough’s intention to include pretreatment technology to provide primary clarification and reduce settleable solids. Please clarify.

Table D-10 includes different alternatives for various CSO Event Target/year. The Alternative IDs for each of the CSO Event Targets include 1) Partial SS, 5% GI, PAA, FlexFilter; 2) Partial SS, 5% GI, Tank; 3) Partial SS, 10% GI, PAA, FlexFilter; and 4) Partial SS, 10% GI, Tank. Prior to this reference within this table there is no discussion of the FlexFilter within the report. Please clarify if FlexFilter or other pretreatment technologies are being considered and, if so, provide a description of such.

Finally, on page 24 under “6) Treatment – PAA Disinfection” states that “When full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens (a “3-log kill.”). Please provide documentation and supporting analysis to justify the 3-log reduction.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
Shaza Rizvi, Bureau of Surface Water Permitting
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CATHERINE R. MCCABE
Commissioner

September 25, 2019

Rocco Russomanno, Town Engineer
Town of Harrison
318 Harrison Avenue
Harrison, NJ 07029

Re: Review of Development and Evaluation of Alternatives Report
Town of Harrison, NJPDES Permit No. NJ0108871

Dear Mr. Russomanno:

Thank you for your submission of the “Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report” dated July 1, 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the “Development and Evaluation of Alternatives Report” (hereafter “the report”) for the Town of Harrison. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The “Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report” includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix D is specific to the Town of Harrison. This subject letter serves to provide a response to the “Development and Evaluation of Alternatives Report” specific to the Town of Harrison (Appendix D) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 “System Characterization Report” (approved by the Department on April 12, 2019); the June 2018 “Public Participation Process Report” (approved by the Department on March 29, 2019); the June 30, 2018 “NJCSO Group Compliance Monitoring Program Report” (approved by the Department on March 1, 2019; and the June 2018 “Identification of Sensitive Areas Report” (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit as well as inclusion of several control programs. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green Infrastructure** (GI) technologies are described in Section C.2.5 (Green Infrastructure) where the report includes a description of the ancillary environmental, social and economic benefits of GI to the community. GI is also described in Section D.2.7 (Green Infrastructure) where it explained on page 116 that bioswales and permeable pavement have been selected for further analysis for inclusion in the LTCP where the breakdown between the two technologies will depend on field conditions.

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.4 (Sewer System Optimization) including additional conveyance, regulator modifications, outfall consolidation/relocation and real time controls. As discussed on pages 35-38, these control alternatives will not be considered further based on a number of site-specific factors.

  As discussed in Section C.5 (Storage), various **storage** technologies were evaluated including pipeline storage, tunnel storage and tank storage. Section D.2.1-3 further analyzes these alternatives and includes detailed siting information particularly around the outfall location.

- **Sewage Treatment Plant (STP) Expansion** is discussed in Section C.6 (STP Expansion or Storage at the Plant) where it is explained on page 41 that the Town of Harrison transports their combined sewer flows to PVSC and that "Expansion of the treatment plant and storage at the treatment plant are the responsibility of PVSC and has not been evaluated by Harrison." There is also a referenced to the PVSC main report (i.e. regional report) within this section.

- **Inflow and infiltration (I/I) reduction** is described in Section C.3 (Infiltration and Inflow Control) as well as a description of advanced sewer inspection and maintenance in subsection C.3.2. It is stated on page 34 that "Harrison has no control over the other communities tributary to PVSC, so it is not feasible for the Town of Harrison to implement I/I controls across the entire system." The report also indicates that it may be beneficial to incorporate I/I measures into other control alternatives.

- **Sewer separation** is described in Sections C.7 (Sewer Separation) and D.2.6 (Control Program 6 Sewer Separation) with additional specific discussion in Section B.3.1 (Sewer Separation in Redevelopment Area) regarding the ongoing separation of the H-05 basin.

- The report evaluates **satellite treatment** (i.e., treatment of the CSO discharge) namely PAA Disinfection in Section C.8 (Treatment of CSO Discharge) as well as in Section D.2.4 (Control Program 4 End-of-Pipe Treatment) and Section D.2.5 (Control Program 5 Consolidated End of Pipe Treatment). This alternative was analyzed at the end of the each outfall pipe, as consolidated treatment, and as part of the storage alternatives. A description of the treatment train, including screening, primary treatment and PAA is included in Section D.2.4.1 (Control Program 4 Description) on page 97.

Specific Comments

Comment 1

A robust discussion of public participation and the CSO supplemental team is included in Section A.5 (Public Outreach Summary) and Section D (Preliminary Control Program Alternatives) includes a subsection for public acceptance within each control program description. As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a list of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. The involvement of a local community group, Harrison TIDE (Transforming Infrastructure and Defending our Environment) is referenced in this section on pages 6 & 7 regarding their involvement with CSO issues.

Moving forward, public participation is a required element of the ‘Selection and Implementation of Alternatives’ for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team and Harrison TIDE members be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. Performance objectives are discussed in Section D.1.7 (Performance Objectives – Systemwide Level of Control) where the frequency of CSO events is described within this section and in other sections of the report. Two of the alternatives for the Presumption Approach, namely the attainment of 85% percent capture and 4 overflows or less, are referenced throughout the report. While this information is included, neither the Presumption of Demonstration Approach have been specifically selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the ‘Selection and Implementation of Alternatives’ report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 3

The following excerpt is included in Section B.5 (Modeling of Future Baseline Conditions) on page 18:

> "The PVSC CSO Group estimated that a 7% reduction in overflow volume by the interceptor communities would be required to achieve a systemwide 85% capture of wet weather flows as per the presumptive approach. The 30% reduction achieved between the 2015 baseline and 2050 future baseline exceeds this reduction goal. Thus, all alternatives evaluated would achieve the 85% capture level of control, through the separation of basin H-005."

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." Please provide a justification for the segmentation of the interceptor communities as a hydraulically connected system for report completeness. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 4

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 5

In Section C.2.5 (Green Infrastructure) and Section D.2.7 (Control Program 7 Green Infrastructure) Green Infrastructure is discussed. Detailed information is included regarding the siting of potential GI projects, a maps as Figure 51 (Harrison Land Use Map) as well as through land use information. It is further stated on page 116 that "…the anticipated green infrastructure is expected to consist primarily of bioswales and permeable pavement, but the breakdown between the two technologies will depend on field conditions." In addition, the direction of 2.5%, 5%, 7.5% and 10% of the impervious area through GI were assessed. All percentages are equated to a reduction in CSO volume, frequency and duration in order to attain these targets and the changes from the baseline are depicted in Tables 61-67. The Department acknowledges the inclusion of this quantitative metric for GI which is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the gallons referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

Comment 6

There is limited discussion within the report in Section C.6 (STP Expansion or Storage at the Plant) regarding the required evaluation of the alternatives concerning STP Expansion and no discussion of CSO-related bypass. The Department acknowledges that the Town of Harrison does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. For example, is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 7

Linear storage (pipelines and tunnels) and point source storage (tanks and industrial discharge detention) are discussed in Section C.5 (Storage) and more detailed discussion is provided in Sections D.2.1 (Control Program 1: Point Storage at Individual Outfalls), D.2.2 (Control Program 2: Consolidated Tank Storage), and D.2.3 (Control Program 3: Tunnel Storage). While siting information has been included through a description of each area near the outfall as well as of maps of the areas, please supplement with additional discussion as to whether or not these areas could sustain the needed volume of the estimated tank sizes referenced in Table D-5. If storage is being considered at any available properties near the outfalls, please describe whether or not any potential storage tanks would be surface or subsurface and, if subsurface, whether or consideration has been given to any amenities such as parks, parking lots or GI. In addition, please elaborate as to whether or not PVSC could accept stored tank flow or if there are any conveyance limitations that would prevent such.

Comment 8

While cost analyses are provided within the report, particularly in Section D.2 (Preliminary Control Program Alternatives) and Section D.3 (Preliminary Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Comment 9

Section D.2 includes a robust discussion of the seven control program alternatives with individual subsections for each including description, analysis, institutional issues, implementability, public acceptance, performance summary and cost summary. In addition, a summary rating with weighted scores is provided as Table 5 (Summary Rating of Control Programs) on page xviii along with additional general discussion in Section D.3.

While it is acknowledged that the benefits of these control program are analyzed in concert with the effects of sewer separation at H-005, generally these alternatives show a singular approach through the implementation of one alternative as opposed to a mix of various alternatives. Please expand on whether or not a mixed approach has been considered to address each outfall.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
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CATHERINE R. MCCABE
Commissioner

September 25, 2019

Richard Haytas, Senior Engineer
Jersey City Municipal Utilities Authority
555 Route 440
Jersey City, NJ 07305

Re: Review of Development and Evaluation of Alternatives Report
Jersey City Municipal Utilities Authority, NJPDES Permit No. NJ0108723

Dear Mr. Haytas:

Thank you for your submission of the “Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report” dated July 1, 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the “Development and Evaluation of Alternatives Report” (hereafter “the report”) for Jersey City MUA. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The “Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report” includes individual DEARs developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix E is specific to the Jersey City. This subject letter serves to provide a response to the “Development and Evaluation of Alternatives Report” specific to Jersey City (Appendix E) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 “System Characterization Report” (approved by the Department on April 12, 2019); the June 2018 “Public Participation Process Report” (approved by the Department on March 29, 2019); the June 30, 2018 “NJCSO Group Compliance Monitoring Program Report” (approved by the Department on March 1, 2019; and the June 2018 “Identification of Sensitive Areas Report” (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit as well as inclusion of several control programs. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green Infrastructure** (GI) is evaluated, among other possible source reduction technologies available to Jersey City. The selection criteria for GI technologies focused on the ability to retain at least one inch of rain, design flexibility, and visual appeal. The GI technologies that were chosen for further evaluation are roadside rain gardens, bioswales, and tree pits.

- In Section C.4 (Sewer System Optimization), the report describes the **Sewer System Optimization** program implemented by the City to repair and optimize the storage capacity of the Jersey City collection system. This work was started as a result of the "JCMUA CSO Correction Project, 1999" and addressed regulator modifications (raise weir elevations) and the installation and repair of tide gates. Page 7 of the Report states that "further raising the weir elevations would exacerbate street flooding." JCMUA has chosen not to further consider inline storage as a CSO control technology.

- JCMUA evaluated both tanks and tunnels as **offline storage** alternatives. JCMUA analyzed the possibility of an east and west side tunnel which would be connected by drop shafts to the east and west side outfalls in the City, as stated on page 8 of the Report. As described in Section D.1.5.5 (Performance for Off-line Storage with Tunnels), tunnels were sized for 4, 8, 12, and 20 CSO overflows and 85 percent capture, based on existing east and west side pump station capacities. Each tunnel would be approximately 27,000 feet in length with diameters of the tunnels ranging from 6.5 feet to 12 feet. Section D.3.3 of the Report lists the following possible alternatives for offline storage: storage tanks/treatment shafts for the W1 and W2 subdrainage areas, if necessary, additional storage tanks for W3 to W13 subdrainage areas, addition of storage tanks at E18 and E19 subdrainage areas, or solely a tunnel on the west side alone if storage tanks are deemed less favorable.

- In Section C.6. of the Report, JCMUA evaluated two options of **STP expansion:** either upgrading the East and West Side Pump Stations while using the existing 6 ft diameter force main or upgrading the pump stations and constructing a new 12,000 linear foot, 9 foot diameter force main.

The report explains that reduction of CSOs through STP expansion is limited by the capacity of the interceptors that convey flow to the east and west side pump stations. However, increasing the capacity of the east and west side pump station in combination with other technologies will be evaluated further.

- Jersey City has ongoing operations to reduce excessive **infiltration and inflow** (I/I). As described in Section D.1.1.1, approximately 67% of the sewer pipes (6,926 pipe segments) in Jersey City were inspected to identify defects. Based on the inspection, 87,896 feet (805 pipe segments) need to be replaced or rehabilitated as shown in Figure D.1-1. Table D.1-1 shows the implementation of I/I for each subdrainage area. This report concludes that 0.88 MGD of total flow rate can be eliminated through I/I pipe replacement or rehabilitation.

- The report discusses the current **sewer separation** projects in Jersey City, as well as plans for future projects. Jersey City has undertaken sewer separation in Washington and Essex Streets. Additional sewer separation is recommended in the Bates Street Redevelopment Area to alleviate combined sewage flooding, as explained in Section D.1.1.2 of the Report. Appendix B contains the design drawing for this sewer separation project.

- The report includes an evaluation of the following **CSO treatment** technologies: screening, pretreatment, and disinfection. Jersey City evaluated several disinfection technologies including chlorine dioxide, sodium hypochlorite, and peracetic acid (PAA). Since the efficiency of disinfection is improved by reducing the total suspended solids concentration, the treatment process requires screening and pretreatment. On page 10 of the Report, it is concluded that this alternative was not given further consideration due to the high costs of treatment and disinfection.

Specific Comments

Comment 1

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long-term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. Throughout the Report and particularly in Section D.3.2 (Regulatory Compliance) the attainment of 85% percent capture as an alternative under the Presumption Approach is described as is the Demonstration Approach for certain outfalls. However, neither the Presumption or Demonstration Approach have been specifically selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020.

Baseline percent capture is discussed throughout the report in multiple sections such as in Section D.1.5 (Performance Considerations) where a value of "…72.4% for the baseline scenario" is identified. For report completeness the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be provided. Specifically, the permittee shall provide the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system.

Comment 3

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." If it is your intention to define a hydraulically connected system together with the other municipalities that convey flow through the Hudson County Force Main, a justification for the segmentation of those communities that pump to the Hudson County Force Main must be provided. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 4

In Section C.2.1 (Green Infrastructure), Section D.1.1.3 (Siting for Green Infrastructure Source Controls), Green Infrastructure is discussed. Section D.1.1.3 of the Report states that, based on boring data, there are 297 acres of Jersey City that are optimal sites for GI. This equates to 7% of the City's impervious area as shown in Figure D.1-2. Less optimal locations are available that can increase GI to 10% of impervious area, which are presented in Figure D.1-3.

As GI implementation continues to be assessed any percentage must be equated to a reduction in CSO volume, frequency and duration in order to attain these targets and show any changes from the baseline. The inclusion of this quantitative metric for GI is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the acreage values referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

Comment 5

There is limited discussion within the report in Section C.6 (STP Expansion or Storage at the Plant) with some additional discussion in Section D.1.1.4 (Siting for Maximizing Flow to the POTW) regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that JCMUA does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. In addition, additional documentation regarding coordination with the other communities that share the force main is needed. For example, please identify the current conveyance capacity of the force main, as well as if there is adequate conveyance capacity to divert additional CSO flow to PVSC. Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 6

Storage is discussed in Section C.5 (Storage) and in Section D (Alternatives Analysis). Siting information has been included for tunnels and in Figure D.1-4 (Proposed Jersey City Tunnel Alignment) and grouped storage tanks in Figure D.1-5 (Grouped Storage Tank Locations). The preliminary locations for the nine grouped storage tanks are shown in Figure D.1-5. Page 19 of the Report states that this alternative would require seven miles of new combined sewer pipes to connect the existing outfalls. Please supplement this section with additional discussion as to whether or not these areas could sustain the needed volume of the estimated tank sizes. If storage is being considered at any available properties near the outfalls, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please confirm as to whether or not this stored flow would be sent PVSC, whether PVSC could accept stored tank flow, or if there are any conveyance limitations that would prevent such.

Comment 7

A discussion of public participation and the CSO supplemental team was not provided in the report specific to the Development and Evaluation of Alternatives; however, some discussion of public acceptance is included as Section D.1.4 (Public Acceptance) as broken down for each preliminary alternative. As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a listing of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. Please supplement Section D.1.4 of this subject report with a brief summary of subsequent public participation activities as well as meeting dates specific to the development and evaluation of alternatives including a general overview of feedback on any alternatives presented that are specific to Jersey City.

Moving forward, public participation is a required element of the ‘Selection and Implementation of Alternatives’ for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 8

In Section D.3.2 (Regulatory Compliance), Jersey City has stated on pages 29 and 30 that the demonstration approach may be utilized for the waterbodies they claim are meeting water quality criteria for fecal coliform and Enterococci. For the outfalls that discharge to Penhorn Creek, the presumptive approach with the target goal of 20 overflows may be proposed since this would result in a percent capture of 93% during the 2004 typical year. It is premature and outside of the scope of this report to include this conclusion regarding compliance with water quality standards. Please revise this statement as well as other similar statements within the report.

Comment 9

Section D.1 includes a discussion of the seven control program alternatives with individual subsections for each including siting, implementability, public acceptance and performance. In addition, a summary rating with weighted scores is provided as Table D.2-1 (Alternatives Evaluation Matrix) along with additional discussion in Section D.3.

Generally, these alternatives show a singular approach through the implementation of one alternative as opposed to a mix of various alternatives. Please expand on whether or not a mixed approach has been considered to address each outfall.

Comment 10

While cost analyses are provided within the report, particularly in Section D.3 (Summary of Cost Opinions), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
Josie Castaldo, Bureau of Surface Water Permitting
Susan Rosenwinkel, Bureau of Surface Water Permitting

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CATHERINE R. McCABE
Commissioner

September 25, 2019

Robert J. Smith, Town Administrator
Town of Kearny
402 Kearny Avenue
Kearny, NJ 07032

Re: Review of Development and Evaluation of Alternatives Report
Town of Kearny, NJPDES Permit No. NJ0111244

Dear Mr. Smith:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated July 1, 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of Alternatives Report" (hereafter "the report") for the Town of Kearny. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix F is specific to the Town of Kearny. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives Report" specific to the Town of Kearny (Appendix F) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit as well as inclusion of several control programs. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green Infrastructure** (GI) technologies are described in Section C.2.5 (Green Infrastructure) with a more detailed description of individual sites is included in Section C.2.5.5 (Site Evaluation). For those sites that remain in consideration based on an analysis of site-specific factors, it is concluded that further soil testing is needed to determine the suitability of existing soils for GI implementation.

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.5 (Sewer System Optimization) including additional sewer construction (i.e. sewer separation), regulator modifications, outfall consolidation/relocation and real time controls. As described on page 21, regulator modifications and real time controls were not considered feasible and were eliminated from consideration. However, outfall consolidation/relocation will be investigated further for the consolidation of Outfalls 004A (Nairn Avenue) and 006A (Johnson Avenue) as part of the LTCP.

  As discussed in Section C.6 (Storage), various **storage** technologies were evaluated including inline storage (CSO tunnel), offline storage (tanks) and industrial discharge detention. Section D.1 (Development and Evaluation of Alternatives) further analyzes these alternatives and includes detailed siting information particularly around the outfall location.

- **Sewage Treatment Plant (STP) Expansion** and **CSO Related Bypass** is discussed in Section C.7 (STP Expansion or Secondary Bypass). It is explained on page 23 that PVSC owns and operates the treatment plant which treats the flows from the Town of Kearny and that "Any modifications to the PVSC treatment plant to mitigate CSO volume and frequency, or any increased treatment capacity, will be addressed by PVSC and its consultants."

- **Inflow and infiltration (I/I) reduction** is described in Section C.4 (Reduction in Base Flow) where it is explained that a reduction in base flow can be accomplished through measures such as water conservation or I/I reduction; however, "I/I reduction is expected to have little impact on the number and volume of CSOs, as the majority of the CSO volume is not coming through leaks in the sewer piping, but from sanitary flow and precipitation." It then further stated on page 21 that "A 10 percent reduction in base flow resulted in a 1.6 percent reduction in overall Town wide CSO frequency, and a 1.4 percent reduction in overall Town wide volume." For these reasons base flow reduction was eliminated from further consideration.

- **Sewer separation** is described in Sections C.3 (Combined Sewer Separation) and D (Alternatives Analysis) where the report evaluates two levels of sewer separation namely total sewer separation for the entire town and partial sewer separation in Drainage Area 010 only. As described on page 20, "The Town is committed to achieving complete separation of sewers in all of Drainage Area 010. A project is currently in design and will go into construction in the near future, which will achieve this goal."

- The report evaluates **satellite treatment** (i.e., treatment of the CSO discharge) in Section C.8 (Treatment of CSO Discharge) as well as in Section D (Alternatives Analysis). Peracetic acid disinfection at the end of each outfall is also included in the preliminary control program alternatives as described in Section D.2 which cover all the various levels of control (i.e. 0, 4, 8, 12, and 20 CSO events per year, and the 85% capture goal).

Specific Comments

Comment 1

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. Performance objectives are described throughout various alternatives where analysis is included for targeted frequencies for 0, 4, 8, 12 and 20 CSO events per year as well as for 85% systemwide capture where the attainment of 4 overflows or less and 85% capture are two of the alternatives for the Presumption Approach. However, while this information is included, neither the Presumption of Demonstration Approach have been specifically selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 2

A detailed analysis is included in Section D.3 (Reduction in CSO Volume and Frequency) which depicts the Baseline B alternative where it is stated that this alternative achieves the 85% capture target for PVSC interceptor communities as shown in footnote (1) in Table D-3 (Annual Untreated Overflow Frequency by Outfall). This section also includes a reference to percent reduction on a Town-wide basis. The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plant (STP)…". The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." Please provide a justification for the segmentation of the interceptor communities or on a Town-wide basis as a hydraulically connected system for report completeness. See also **Comment 1** above regarding the evaluation of percent capture.

Comment 3

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 4

A discussion of public participation and the CSO supplemental team is included in Section C.2.2 (Public Education and Outreach) and Section C.2.5.3 (Public Participation Process Report). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a list of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. In addition, the involvement of public participation through a local community group, Kearny AWAKE (Association of Water, Agriculture and Kearny's Environment) regarding CSO issues and the public participation process is described within Section C.2.2 where public input specific to localized flooding as part of Kearny AWAKE is described on page 20 in Section C.2.5 (Green Infrastructure).

Moving forward, public participation is a required element of the "Selection and Implementation of Alternatives" for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team and Kearny AWAKE members be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 5

Green Infrastructure is discussed at length in Section C.2.5 (Green Infrastructure) and Section D.5 (Green Infrastructure). Detailed information is included regarding the siting of potential GI projects in Section C.2.5.5 (Site Evaluation) as well as a map as Figure 4 (Green Infrastructure). In addition, an analysis is included in Section D.5 regarding the portion of impervious area controlled by green infrastructure as 5% and 10% including the required number of acres to attain this target. The Department acknowledges the inclusion of this quantitative metric for GI which is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the acreage values referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

Comment 6

There is limited discussion within the report in Section C.7 (STP Expansion and Secondary Bypass) regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that the Town of Kearny does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. For example, is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 7

Inline Storage (CSO Tunnel), offline storage (Tanks) and Industrial Discharge Detention are described in Section C.6 (Storage) with more detailed discussion in Section D (Alternatives Analysis). While siting information has been included through a description of each area near the outfall as well as of maps of the areas, please supplement with additional discussion as to whether or not these areas could sustain the needed volume of the estimated tank sizes referenced in Table C-1 (Tunnel Storage) and Table C-2 (Tank Storage). If storage is being considered at any available properties near the outfalls, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please elaborate as to whether or not PVSC could accept stored tank flow or if there are any conveyance limitations that would prevent such.

Comment 8

In Section D.2. (Preliminary Control Program Alternatives) the use of disinfection by Peracetic Acid (PAA) is discussed. On page 33 it is stated, “Where full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens, or a 3-log kill.” Similarly, on page 33 footnote 6 states “(6) In this context, “Untreated CSO Volume” is defined as the sum of discharged volumes during any 5-minute period that exceed the design flow rate for 3-log pathogen removal.”

Please provide documentation and supporting analysis to justify the 3-log reduction. In addition, in the report there is no discussion regarding the use of some type of solids removal in conjunction with PAA. Based on this, it appears that there will be no pretreatment technology to provide primary clarification and reduce settleable solids. Please clarify.

Comment 9

While cost analyses are provided within the report, particularly in Section D.4 (Evaluation of Costs) and Section D.6 (Discussion of Costs), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
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CATHERINE R. McCABE
Commissioner

September 25, 2019

Kareem Adeem, Assistant Director of Public Works
City of Newark
239 Central Avenue
Newark, NJ 07102

Re: Review of Development and Evaluation of Alternatives Report
City of Newark, NJPDES Permit No. NJ0108758

Dear Mr. Adeem:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated June 21, 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of CSO Alternatives Report" (hereafter "the report") for the City of Newark. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual DEARs developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix G is specific to the City of Newark. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives Report" specific to the City of Newark (Appendix G) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit as well as inclusion of several control programs. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green infrastructure** (GI) technologies are described in Section C.2.1 (Green Infrastructure) and states on page 7 "Evaluation of potential GI opportunities will be further refined in the next steps of the alternative evaluation." Section D.2.2 (Green Infrastructure) also includes a description of the ancillary environmental, social and economic benefits of GI to the community.

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.4 (Sewer System Optimization) including regulator modifications, conveyance, and real time control. Specific information is included in Section D.2.1 (Alternative 1 – Regulator Modification/Flow Maximization) where model simulations were conducted for 3 regulator modifications and CSO volume reduction results ranged from 0.7% to 5.3%. as shown in Table D-2 (Overflow Volumes and Frequencies with Regulator Modifications).

  As discussed in Section C.5 (Storage), various **storage** technologies were evaluated including pipeline storage, tunnel storage and tank storage. Section D.2.3 (Alternative 3 – CSO Storage) focuses on the storage tank option where it is stated on page 32 that "…an interative approach was used to estimate the volume required for 0, 4, 8, 12 and 20 overflows" and results are displayed in Table D-5 (Total CSO Storage Volumes and Reductions for 0, 4, 8, 12, and 20 Overflows). It is also stated on page 22 that "It is assumed that a storage tank would be located near the existing outfall and it would below the ground."

- **STP Expansion** is discussed in Section C.6 (STP Expansion or Storage) where it is explained on page 9 that "PVSC owns and operates the wastewater treatment plant that receives and treats flows from Newark." It is then further stated that "Any modifications to the treatment plant that would result in CSO volume and frequency reduction, or any increased treatment capacity, will be addressed by PVSC and its consultants."

- **Inflow and infiltration (I/I) reduction** is described in Section C.3 (Infiltration and Inflow Control) as well as in Section D.2.4 (Alternative 4 – Inflow and Infiltration Reduction). As stated on page 34, "The City of Newark has conducted sewer upgrade projects, including the lining of the brick sewers, and is expected to continue to upgrade the sewer system. This will control infiltration/inflow; however, these types of projects on their own will not attain the performance objectives…" Please refer to **Comment 7** below for additional information regarding inflow.

- **Sewer separation** is described in Section C.7 (Sewer Separation), in Section D.2.7 (Alternative 7 – Sewer Separation), and sewer separation areas are depicted in Table D-9 (City of Newark Sewer Separation Land Use Area by Ward). On page 40 it is concluded that "A sewer separation alternative may be investigated further if added benefits such as flood reduction or redevelopment in the areas warrants it."

- The report evaluates **satellite treatment** (i.e., treatment of the CSO discharge) namely PAA Disinfection in Section D.2.6 (Alternative 6 – Satellite Treatment). Frequency reduction and volume reduction are evaluated against the frequency targets of 0, 4, 8, 12, and 20 overflow events per year as shown in Table D-6 (Impacts of Disinfection for Range of CSO-Control Objectives).

Specific Comments

Comment 1

Some discussion of public participation and the CSO supplemental team is included in Section D.1.4 (Public Acceptance). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a list of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. Please amend Section D.1.4 of this subject report with a brief summary of subsequent public participation activities as well as meeting dates specific to the development and evaluation of alternatives including a general overview of feedback on any alternatives presented that are specific to the City of Newark. The Department notes that Newark DIG (Doing Infrastructure Green) (https://www.newarkdig.org/about) is a community group that meets on a routine basis where outreach and education on CSOs is one of their primary goals. It is suggested that summaries of these meetings be incorporated into the report.

Moving forward, public participation is a required element of the 'Selection and Implementation of Alternatives' for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. Performance considerations are discussed in Section D.1.5 (Performance Considerations) where the frequency of CSO events and 85 percent capture is described within this section and in other sections of the report. The attainment of percent capture or 4 overflows or less are two of the alternatives for the Presumption Approach. While this information is included, neither the Presumption of Demonstration Approach have been specifically selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 3

The following excerpt is included in Section D.1.5 (Performance Considerations) on page 21:

> "PVSC has indicated (2019, G&H) that for Newark, a 7% reduction of CSO volume (that is, a CSO discharge of no more than 93 MG) is required to achieve the 85% capture target."

As noted above, Section D.1.5 includes a reference to a memorandum "(2019, G&H)." Please provide a copy of the memorandum and specifically the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system.

In addition, the Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." Please provide a justification for the segmentation of Newark as a hydraulically connected system for report completeness. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 4

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long-term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 5

In Section D.2.2 (Alternative 2 – Green Infrastructure (GI)) the use of GI is described and there is a reference on page 7 within Section C.2.1 to the "Green Infrastructure Feasibility Study, Newark," as prepared by Rutgers University as well as a reference on page 28 within Section D.2.2 to the "Impervious Cover Reductions Action Plan for Newark, Essex County NJ" also prepared by Rutgers University. Section D.2.2 states that three different control levels of GI were assessed. The first alternative involves the implementation of GI identified in the latter Rutgers study; the second level includes "applying bio-detention modeling that detail and infiltrates runoff generated from 5% of the impervious surfaces in Newark; whereas the third level includes the "application on 10% of the impervious surfaces in Newark". All three alternatives are equated to the number of necessary acres on page 27 to attain these targets and the CSO volume and frequency changes from the baseline are depicted in Figure D.2-7 and Figure D.2-8, respectively. The Department acknowledges the inclusion of this quantitative metric for GI which is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you obtained the acreage values referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

However, the report contains limited information regarding the siting of potential GI projects. Beyond the reference to available city owned site in Section D.1.1 (Siting) as well as a reference to two Rutgers reports and the inclusion of the map as Figure D.2-6 (Rutgers GI Opportunities), there is limited discussion of possible locations for GI opportunities in the City that would be needed to attain the impervious surface targets of 5% or 10% or if any of the locations within the Rutgers report are available. Please elaborate.

Comment 6

There is limited discussion within the report regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that the City of Newark does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. For example, is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

In addition, on page 26 it is stated that Alt 1b, which entails delaying gate closure, "…provides a modest amount of reduction at little to no cost, and should continue to be considered as a CSO-control alternative." Since PVSC owns/operates the regulatory, please provide discussion as to whether or not PVSC is amenable to this change.

Comment 7

Storage tanks are further discussed in Section D.2.3 (Alternative 3 - Storage) where the report explains that "an iterative approach was used to estimate the volume required for 0, 4, 8, 12, and 20 overflows... For this planning level analysis it was assumed that tanks can be located near the regulators or outfalls." The total storage volume, approximate number of days to dewater, volume captured and percent CSO reduction is summarized in Table D-5 (Total CSO Storage Volumes and Reductions for 0, 4, 8, 12, and 20 Overflows) where Alt 3 (0 overflows) is determined to be infeasible.

Additional discussion needs to be included to explain if there is land available for storage and if any properties could sustain the cumulative total of the needed tank sizes referenced in Table D-5. If storage is being considered at any available properties near the outfalls, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please elaborate as to whether or not PVSC could accept stored tank flow or if there are any conveyance limitations that would prevent such.

Comment 8

Several alternatives for reducing I/I are described in Section D.2.4 (Alternative 4 – Inflow and Infiltration Reduction) including Alternative 4a, 4b and 4c. While information is provided for Alternative 4a on page 46, additional information is needed for Alt 4b and 4c to describe how these targeted reductions can be attained.

In addition, the report describes two significant sources of extraneous flow beginning on page 33 in Section D.2.4 where these sources tie directly into Newark's combined sewer system where elimination of such is described as Alt 4. This includes flow from Branch Brook Lake and flow from the lake in Weequahic Park which comprise the largest sources of inflow at an average flow of 0.84 MGD and 1.31 MGD, respectively. It is further stated on page 46 that the report entitled "Extraneous Flow Investigations" (Arcadis, July 2018) "calculated cost for various alternative for removing the park inflows." Several alternatives names are depicted in Table D-13 (Total Annual Cost Comparison Inflow Removal at Parks) for Weequahic Park namely the Meeker Avenue Alternative; NJ Transit Alternative; the Hollywood Avenue Alternative; and the Peddie Ditch Alternative as well as for Branch Brook Park namely the Branch Brook Park Road Alternative and the Lake Avenue Alternative. Please provide detail as to how these flows enter the system. In addition, please provide a description of the alternatives specified and how these alternatives would reduce or eliminate extraneous flows to the affected outfalls.

Comment 9

It is stated on page 34 in Section D.2.4 that "As part of the final alternative selection Newark will also investigate the removal or reduction of uncontrolled stormwater flows in the Jabez Interceptor and screenings wash water flows from floatables control facilities to the interceptor." Similar language is included on page 46 under Section D.2.7 (Alternative 7 – Sewer Separation). Please explain and elaborate on any issues associated with the Jabez Interceptor related to I/I reduction. In addition, please show the location of the Jabez Interceptor and any affected outfalls on Figure D.2.-9 (Newark Extraneous Flow Inventory).

Comment 10

In Section D.2.6 (Alternative 6 – Satellite Treatment) the use of disinfection by Peracetic Acid (PAA) is discussed and it is stated on page 38 that "…disinfection of CSO satisfies CSO-control objectives." It is also stated that "For the purposes of this analysis, disinfection facilities are designed to remove 99.9 percent ("3-log reduction") of pathogens for full treatment." Finally, it is further stated on page 38 that "PAA disinfection facilities can, in many cases, be sited upstream of each CSO outfall, at a location between the existing regulators and the existing screening/netting facility or collocated at a screening/netting facility." Satellite treatment is also discussed in Section D.2.3 (Preliminary Selection of Alternatives) where the Flexfilter system is referenced as a pretreatment technology.

Please provide documentation and supporting analysis to justify the 3-log reduction as cited on page 38. It is also unclear if it is the City's intention to include pretreatment technology to provide primary clarification and reduce settleable solids. Please clarify.

Comment 11

While cost analyses are provided within the report, particularly in Section D.2 (Preliminary Control Program Alternatives) and Section D.3 (Preliminary Selection of Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Comment 12

In Section D.3.2 (Regulatory Compliance) the report states that "The preliminary alternatives will result in full attainment of the existing pathogen water quality criteria providing the maximum bacterial reduction reasonably attainable." The Department maintains that it is premature to include this statement prior to an approved LTCP and the implementation of CSO control alternatives. Please revise accordingly.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
Susan Rosenwinkel, Chief, Bureau of Surface Water Permitting
Adam Sarafan, Bureau of Surface Water Permitting

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CATHERINE R. McCABE
Commissioner

September 25, 2019

Frank Pestana, Executive Director
North Bergen Municipal Utilities Authority
6200 Tonnelle Avenue
North Bergen, NJ 07047

Re: Review of Development and Evaluation of Alternatives Report
North Bergen Municipal Utilities Authority (MUA) - Central, NJPDES Permit No. NJ0108898

Dear Mr. Pestana:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated June 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of Alternatives Report" (hereafter "the report") for the Township of North Bergen. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix H is specific to the Township of North Bergen. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives Report" specific to the Township of North Bergen (Appendix H) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- **Green infrastructure** (GI) technologies are described in Section C.2.1 (Green Infrastructure) where this section also includes a description of the ancillary environmental, social and economic benefits of GI to the community. As stated on page 4 GI "will be considered for evaluation in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control."

- Regarding **increased storage capacity in the collection system**, the report evaluated sewer system optimization in Section C.4 (Sewer System Optimization) including regulator modifications, conveyance, outfall consolidation/relocation and real time control. Conveyance is identified as a primary technology that will be reviewed further for the development of CSO control alternatives whereas real time control is identified as a complementary technology to be reviewed in combination with primary storage.

  As discussed in Section C.5 (Storage), various **storage** technologies were evaluated including pipeline storage, tunnel storage and tank storage. Section D.2.1 (Controls) focuses on the storage tank option and storage tunnel option where sizes are shown in Table D-4 (Storage Tank Size (MG)) and Table D-7 (Storage Tunnel Size (MG)).

- **STP Expansion** is discussed in Section C.6 (Sewage Treatment Plant (STP) Expansion or Storage) where it is explained that the Township of North Bergen transports their combined sewer flows to PVSC through a force main shared with Jersey City Municipal Utilities Authority, the City of Bayonne, and Kearny MUA. It is also stated on page 6 that based on a contract with PVSC, the combined sewer flow from the Township of North Bergen is limited to a maximum of 18 MGD and that "STP expansion or modification for wet weather flow could only be done by PVSC." It is then stated that while negotiations have been initiated with Jersey City and Kearny MUAs to investigate joint facilities to serve all three municipalities, "it would likely be less intricate and more cost effective if local storage (e.g., tunnel, tank) is considered, rather than conveying the full peak flow of the Township of North Bergen to PVSC for treatment."

- **Inflow and infiltration (I/I) reduction** is described in Section C.3 (Infiltration and Inflow Control) and in Section D.2.1. It is concluded on page 19 that this control strategy will not be further considered "due to the fact that North Bergen's collection system is primarily a combined sewer system, inflow and infiltration cannot be eliminated without a significant investment."

- **Sewer separation** is described in Section C.7 (Sewer Separation) where it is stated that "Sewer separation at North Bergen was previously found to represent the most expensive CSO control alternative." It further states that because "sewer separation is a primary technology that would completely eliminate CSOs" and that "the previous cost evaluation will be used for a comparison with the tunnel and tank storage options."

- The report evaluates **satellite treatment** (i.e., treatment of the CSO discharge) namely PAA Disinfection in Section D.2.1 where disinfection facilities are sized "based on the maximum CSO discharge flow rate for each event to treat all but 4, 8, 12 and 20 CSO events.

Specific Comments

Comment 1

A discussion of public participation and the CSO supplemental team is included in Section D.1.4 (Public Acceptance). As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a list of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. Please amend Section D.1.4 of this subject report with a brief summary of subsequent public participation activities as well as meeting dates specific to the development and evaluation of alternatives including a general overview of feedback on any alternatives presented that are specific to the Township of North Bergen.

Moving forward, public participation is a required element of the 'Selection and Implementation of Alternatives' for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 2

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. These alternatives are briefly discussed in Section D.1.5 (Performance Considerations) and 85 percent capture is identified in Table D-12 (CSO Control Alternatives Costs Summary) as a CSO Event Target where percent capture is one of the alternatives for the Presumption Approach. However, a specific approach has not been selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 3

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." As depicted in Table D-12 85% capture is calculated, however it is unclear if this applies specifically to the North Bergen or to a larger system. Please provide a justification for the segmentation of this portion as a hydraulically connected system. If it is your intention to define a hydraulically connected system together with the other municipalities that convey flow through the Hudson County Force Main, a justification for the segmentation of those communities that pump to the Hudson County Force Main must be provided. See also **Comment 2** above regarding the evaluation of percent capture.

Comment 4

There is limited discussion within the report in section C.6 (Sewage Treatment Plant (STP) Expansion or Storage) regarding the required evaluation of the alternatives concerning STP Expansion and CSO-related bypass. The Department acknowledges that North Bergen MUA does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. In addition, additional documentation regarding coordination with the other communities that share the force main is needed. For example, please identify the current conveyance capacity of the force main, as well as if there is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 5

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long-term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 6

In Section D.2.1 the use of GI as a complementary CSO control technology is described where it is stated that two different control levels of GI were assessed. Specifically, an assessment is included of the management of 1" of storm water runoff generated from 5% of impervious surface as well as the management of 1" of storm water runoff generated from 10% of impervious surface. Both scenarios are as shown in Table D-3 (Overflow Volumes and Frequencies), along with the associated percent volume reduction and gallons of CSO reduction for each scenario from the baseline value. The Department notes that a quantitative metric for GI is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the volumes included in this table in order to quantify any volumetric decrease in CSO flow from GI measures.

In addition, the report contains limited information regarding the siting of potential GI projects. While there is a reference within Section C.2.1 (Green Infrastructure) to the "Green Infrastructure Feasibility Study, North Bergen," as prepared by Rutgers University, there is limited discussion of possible locations for GI opportunities in North Bergen Township. Please elaborate.

Comment 7

As stated on page 22 the "Storage tank alternative is considered as a primary solution for the CSO frequency control because other alternatives cannot reach the overflow events control target." Storage tank sizes are depicted in Table D-5 based on 0, 4, 8, 12 and 20 "CSO Event Target/yr" where storage tank sizes for 4 overflows a year ranges from 0.1 million gallons (MG) to 7.4 MG. Additional discussion needs to be included to explain if there is land available for storage and if any properties could sustain the needed tank sizes referenced in Table D-5. If storage is being considered at this property or at any other locations, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please elaborate as to whether or not PVSC could accept stored tank flow given the contractual limitations on the contractual limitation of 18 MGD.

Comment 8

In Section D.2.1 the use of disinfection by Peracetic Acid (PAA) is discussed. It is stated that "This preliminary disinfection alternative assumes that PAA disinfection will be implemented at locations between the existing regulators and existing outfalls." However, in Section D.3.3 (Selection of Preliminary Alternative) it is stated that "We may test PAA alone and with filtration." Based on this statement, it appears that there will be no pretreatment technology to provide primary clarification and reduce settleable solids. Please clarify.

In addition, on page 24 under "6) Treatment – PAA Disinfection" it is stated that "When full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens (a "3-log kill."). Please provide documentation and supporting analysis to justify the 3-log reduction.

Comment 9

While cost analyses are provided within the report, particularly in Section D.2 (Preliminary Control Program Alternatives) and Section D.3 (Preliminary Selection of Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Comment 10

Table D-12 (CSO Control Alternatives Cost Summary) includes different alternatives for various CSO Event Target/year. The Alternative identifications for each of the CSO Event Targets include 1) 85% Capture, PAA, FlexFilter; 2) Tank; 3) Tunnel; 4) PAA, FlexFilter; and 5) Sewer Separation. Generally, these alternatives show a singular approach through the implementation of one alternative as opposed to a mix of various alternatives. Please expand on whether or not a mixed approach has been considered to address each outfall.

Please incorporate these changes to the report and submit a revised version of the reginal report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
CSO Team Leader
Bureau of Surface Water Permitting

C: Marzooq Alebus, Bureau of Surface Water Permitting
John Lakhicharran, Bureau of Surface Water Permitting
Susan Rosenwinkel, Chief, Bureau of Surface Water Permitting

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CATHERINE R. MCCABE
Commissioner

September 25, 2019

Frederick Margron, Town Engineer
City of Paterson
111 Broadway
Paterson, NJ 07505

Re: Review of Development and Evaluation of Alternatives Report
City of Paterson, NJPDES Permit No. NJ0108880

Dear Mr. Margron:

Thank you for your submission of the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" dated July 1, 2019 as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP) which contains the "Development and Evaluation of Alternatives Report" (hereafter "the report") for the City of Paterson. The regional report was submitted in a timely manner and was prepared in response to Part IV.D.3.v of the above referenced NJPDES permit. The regional report is part of the development of the Long-Term Control Plan (LTCP) submittal requirements, of which the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices, where Appendix I is specific to the City of Paterson. This subject letter serves to provide a response to the "Development and Evaluation of Alternatives Report" specific to the City of Paterson (Appendix I) where a response to the overall regional report is provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

As per Part IV.G.4.e.i – vii of the above referenced NJPDES permits, the Development and Evaluation of Alternatives for the LTCP shall include, but not be limited to, an evaluation of the following CSO control alternatives:

i. Green infrastructure.
ii. Increased storage capacity in the collection system.
iii. Sewage Treatment Plant (STP) expansion and/or storage at the plant while maintaining compliance with all permit limits.
iv. Inflow and Infiltration (I/I) reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works.
v. Sewer separation.
vi. Treatment of the CSO discharge.
vii. CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7.

The Department finds that the report includes an analysis of a range of CSO control alternatives as identified in the NJPDES permit as well as inclusion of several control programs. A general overview of the information provided for the CSO control alternatives, as provided in response to Part IV.G.4.e, can be summarized below where the Department's comments follow:

- As discussed in Section C - Screening of CSO Control Technologies on page 17, the City of Paterson intends to factor in **green infrastructure (GI)** as an early alternative to reduce CSO discharges prior to considering grey infrastructure investments. Information is included regarding the siting of potential GI projects, as well as maps of property type classifications and city owned parcels. The City has opted to include implementation of GI as one of the early Alternatives towards achieving 85% capture (which is incorporated into Alternative 3).

- This report evaluates **in-line storage** in conjunction with other technologies in order to meet overflows reduction objectives. Page 18 of the report states that there are five locations (CSO 001, 005, 016, and 026) where existing upstream sewers are larger than 24 inches in diameter and potentially have available volume for storage to meet at least one of the overflow objectives (0, 4, 8, 12, 20 overflows). In all other cases, the CSO frequency target is either already attained, or in-line storage would not be sufficient to provide the required storage. Furthermore, as stated on page 23, additional conveyance pipelines would be designed to capture combined sewer flow during wet weather and then redirected to a regional tank or tunnel for storing which is factored into the costs and sizing for Alternatives 4-9.

  Offline storage is evaluated in a four-region grouping of CSO outfalls – Northern, Eastern, Western, and Exterior groups in the City of Paterson, which is shown in Figure 6 of Appendix E. Regarding potential sites for storage tanks, priority was given to land that was already city-owned in order to minimize land acquisition costs. Private properties closer to the outfall structures were then considered, especially those where lots were mostly vacant or otherwise abandoned. Appendix F further details siting of potential greywater storage. As stated in in-line storage, additional pipelines will be required as part of Alternatives 4-9 for greywater storage.

- The City of Paterson has chosen not to further evaluate **STP expansion** and/or storage at the plant and CSO related bypass. Page 19 of the report explains that since the City is at the northernmost (upstream) end of the PVSC CSS, its only connection to the PVSC Treatment Plant is by way of the PVSC-owned interceptor main, which connects multiple PVSC Districts moving downstream towards the plant.

- The City of Paterson has chosen not to pursue the alternative technology of **I/I reduction.** Page 17 of the report states that the citywide level of I/I of 7.5 MGD, or 50 gallons per capita based on the projected 2050 population, does not meet the threshold for excessive infiltration of 120 gallons per capita.

- **Sewer separation** projects have been ongoing in many parts of the City of Paterson since the early 2000s, specifically outfalls 028 and 029, which is included in the baseline scenario. Furthermore, partial sewer separation has been undertaken since 2006 in the drainage areas serving outfalls 002, 014, 015, 021, and 024. Additionally, outfall 023 is a potential site for future sewer separation. A total of 1,058.7 acres has already been separated or will be separated in the near future. Alternative 1 includes the baseline model and sewer separation projects completed since 2006. Alternative 2 expands on Alternative 1 to include the planned sewer separation for outfall 023.

- **Treatment of the CSO discharge** is evaluated both on its own and in conjunction with storage in Alternatives 4-8. Page 20 of the report states that treatment of CSO discharge with peracetic acid (PAA) is to be utilized where available land near outfall structures is limited, or when required storage volume exceeds the maximum size of a potential regional storage tank. The four-region grouping of storage tanks is also used for treatment facilities.

Specific Comments

Comment 1

In Section A (Introduction), the report includes a description of the City's combined sewer system areas as well as information regarding a number of completed and future projects. Please supplement this section with a table to show any active and inactive outfalls, and associated regulators. In addition, please provide information regarding dates for any outfall elimination, consolidation, sewer relief construction and sewer separation.

Comment 2

As per Part IV.G.2 of the NJPDES CSO permit, public participation shall actively involve the affected public throughout each of the three steps of the LTCP process including the Development and Evaluation of Alternatives phase. The Department acknowledges that a listing of meetings and agendas for the CSO Supplemental Team, as well as a discussion of other public outreach, is included in your Public Participation Process Report dated June 2018. Input from a local community group, Paterson SMART (Stormwater Management Resource Training) did provide comments and suggestions in a letter dated August 30, 2019 as signed by Sue Levine, Facilitator of Paterson SMART. These comments express an interest in the continued implementation of CSO alternatives and in providing input on behalf of the city residents. Paterson SMART also provides input on locations of street and basement flooding in its letter.

Moving forward, public participation is a required element of the 'Selection and Implementation of Alternatives' for the LTCP. Continued public participation must be provided to garner public input regarding CSO control alternatives where a description of such activities must be included in the LTCP. The discussion should include a description of the public participation activities that occurred during the development of these reports, the feedback opportunities provided, and how feedback was considered. It is also recommended that members of the CSO Supplemental Team and Paterson SMART be provided a copy of the LTCP in advance of the June 1, 2020 due date to the Department.

Comment 3

The NJPDES permit requires that the permittee select either the Presumption or Demonstration Approach as defined in the Federal CSO Control Policy as well as in the NJPDES permit. Throughout the Report and particularly in Section D.1 (Development and Evaluation of Alternatives), two of the alternatives for the Presumption Approach, namely the attainment of 85% percent capture and 4 overflows or less, are referenced as part of the design objectives. While this information is included, neither the Presumption of Demonstration Approach have been specifically selected within the report. While this comment does not necessitate a response at this time, a final selection is required to be made in the 'Selection and Implementation of Alternatives' report as part of the LTCP submission due on June 1, 2020. Note that if the Presumption Approach is selected, the percent capture equation utilized to calculate any baseline and other percent capture values for each hydraulically connected system must be included for report completeness.

Comment 4

The Department acknowledges that hydraulically connected system is defined within the notes and definitions in Part IV of the NJPDES permit as "The entire collection system that conveys flows to one Sewage Treatment Plan (STP)…" The definition of hydraulically connected system allows the permittee to "segment a larger hydraulically connected system into a series of smaller inter-connected systems." Please provide a justification for the segmentation of the City of Paterson as a hydraulically connected system, particularly as it relates to percent capture or number of overflows. See also **Comment 3** above regarding the evaluation of percent capture.

Comment 5

In accordance with the Federal CSO Control Policy, the assessment of system-wide CSO control alternatives is required to be based on an "average" or "typical" rainfall year. As stated within the May 2018 report entitled "Typical Hydrological Year Report", 2004 was selected as the typical hydrological year. While a long term precipitation data set (i.e. greater than 30 years) was considered as part of this analysis, a more recent period was used in the ultimate selection of 2004 in order to consider local climate change. While use of the year 2004 does consider climate change, please be sure to consider resiliency requirements in the design of any infrastructure (e.g., storage and satellite treatment). Specifically, in accordance with the provisions of Executive Order 11988, the USEPA and the New Jersey Water Bank require that funded infrastructure be located outside of floodplains or elevated above the 500-year flood elevation. Where such avoidance is not possible, the following hierarchy of protective measures has been established:

1. Elevation of critical infrastructure above the 500-year floodplain;
2. Flood-proofing of structures and critical infrastructure;
3. Flood-proofing of system components.

While this comment does not necessitate a response at this time, these protective measures should be a consideration in the LTCP.

Comment 6

In Section C.2.1 (Green Infrastructure), Section D.1.1 (Implementability), and Section D.1.2 (Siting), Green Infrastructure is discussed. In the 'Implementability' section beginning on page 22, the report states that the target GI implementation rate is established at 2.5% of the impervious cover in the combined sewer drainage area within Paterson, based on the "top-down" GI modeling results. Subsequently, a "bottom-down" approach was undertaken to characterize different land use types and identify potential properties within the combined sewer system. Appendix G of the report contains figures to illustrate this screening process. On page 24 of the report, it was determined that GI can be implemented on approximately 50 out or 160 acres in the city's combined drainage areas (excluding areas with any level of sewer separation).

As GI implementation continues to be assessed any percentage must be equated to a reduction in CSO volume, frequency and duration in order to attain these targets and show any changes from the baseline. The inclusion of this quantitative metric for GI is needed in order to establish that any volumetric credit is given towards overall CSO reduction goals. Please describe how you derived the acreage values referenced in order to quantify the volumetric decrease in CSO flow from GI measures.

Comment 7

Inline storage (pipelines and tunnels) and offline storage (tanks) are discussed in Section C.5 (Storage) and more detailed discussion is provided in Appendix F (Sizing of Potential Greywater Storage). Siting information has been included through a detailed description of the land parcel and a map of the area for storage tanks. Please supplement this section with additional discussion as to whether or not these areas could sustain the needed volume of the estimated tank sizes referenced in Appendix F. If storage is being considered at any available properties near the outfalls, please describe whether any potential storage tanks would be surface or subsurface and, if subsurface, whether consideration has been given to any amenities such as parks, parking lots or GI. In addition, please confirm as to whether or not this stored flow would be sent PVSC, whether PVSC could accept stored tank flow, or if there are any conveyance limitations that would prevent such.

It is stated on page 23 of the report, that the previous 2007 Schoor DePalma study references a grouping of outfalls into four regions for CSO storage and/or treatment. Appendix E includes a figure to demonstrate this regional grouping method. Please provide discussion and justification if a regional grouping is being considered.

Comment 8

There is limited discussion within the report in Section C.6 (STP Expansion or Storage at the Plant) regarding the required evaluation of the alternatives concerning STP Expansion and no discussion of CSO-related bypass. The Department acknowledges that the City of Paterson does not own/operate the PVSC treatment plant; however, documentation of coordination between the two parties is essential in order to evaluate whether or not this is a viable alternative. For example, is there adequate conveyance capacity to divert additional CSO flow to PVSC? Has there been discussion with PVSC about the acceptance of these flows? Please clarify.

Comment 9

While cost analyses are provided within the report, particularly in Section D.2 (Preliminary Control Program Alternatives), please note that the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission. This includes any conclusions regarding the selection of any preliminary CSO control alternatives, present value calculations, and the cost range of any CSO control alternatives.

Please incorporate these changes to the report and submit a revised version of the regional report to the Department no later than 60 days from the date of this letter. Thank you for your continued cooperation.

Sincerely,

Dwayne Kobesky
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Bureau of Surface Water Permitting

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