Appendix F

Selection and Implementation of Alternatives Report for PVSC

SELECTION AND IMPLEMENTATION OF ALTERNATIVES REPORT

Passaic Valley Sewerage Commission (NJ 0021016)

Passaic Valley Sewerage Commission
Essex County
600 Wilson Avenue
Newark, New Jersey

"Protecting Public Health and the Environment"

September 2020

GREELEY AND HANSEN
CDM Smith

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SECTION A - INTRODUCTION

The Passaic Valley Sewerage Commission (PVSC) is a regional sewerage commission established in 1902 by an Act of the New Jersey State legislature. The PVSC provides wastewater treatment service to 48 municipalities within Bergen, Hudson, Essex, Passaic, and Union counties in the Passaic Valley Treatment District located in Northeast New Jersey. In total PVSC provides sewerage services to approximately 1.5 million people, 198 significant industrial users and 5,000 commercial customers. PVSC's Treatment District covers approximately 150 square miles from Newark Bay to regions of the Passaic River Basin upstream of the Great Falls in Paterson.

PVSC does not own or operate any of the combined sewer system outfalls as further described below. The extent of the PVSC Treatment District and the combined sewer areas within the study area are illustrated in **Figure A-1**.

Eight of the municipalities within the PVSC Treatment District have combined sewer systems (CSS) and have received authorization to discharge under their respective New Jersey Pollutant Discharge Elimination System (NJPDES) Permits for Combined Sewer Management. The eight PVSC CSS Permittees, referred from here on as the "Permittees," are:

- City of Paterson
- City of Newark
- Town of Kearny
- Town of Harrison
- Borough of East Newark
- City of Bayonne (Bayonne Municipal Utilities Authority was dissolved in 2016 and the City of Bayonne now owns the CSS)
- Jersey City Municipal Utilities Authority (JCMUA)
- Township of North Bergen Municipal Utilities Authority (NBMUA)

The Township of North Bergen has two combined sewer areas that are owned and operated by the NBMUA under two separate NJPDES permits: NBMUA and NBMUA (Woodcliff). The Woodcliff Sewage Treatment Plant (STP) service area is separate from the PVSC Treatment District. Any mention in this report of the infrastructure owned and operated (in part or in full) by NBMUA (Woodcliff) is only included where it is necessary in order to accurately reference the NBMUA system.

A general schematic of the PVSC sewer system with municipalities is shown on **Figure A-2**.

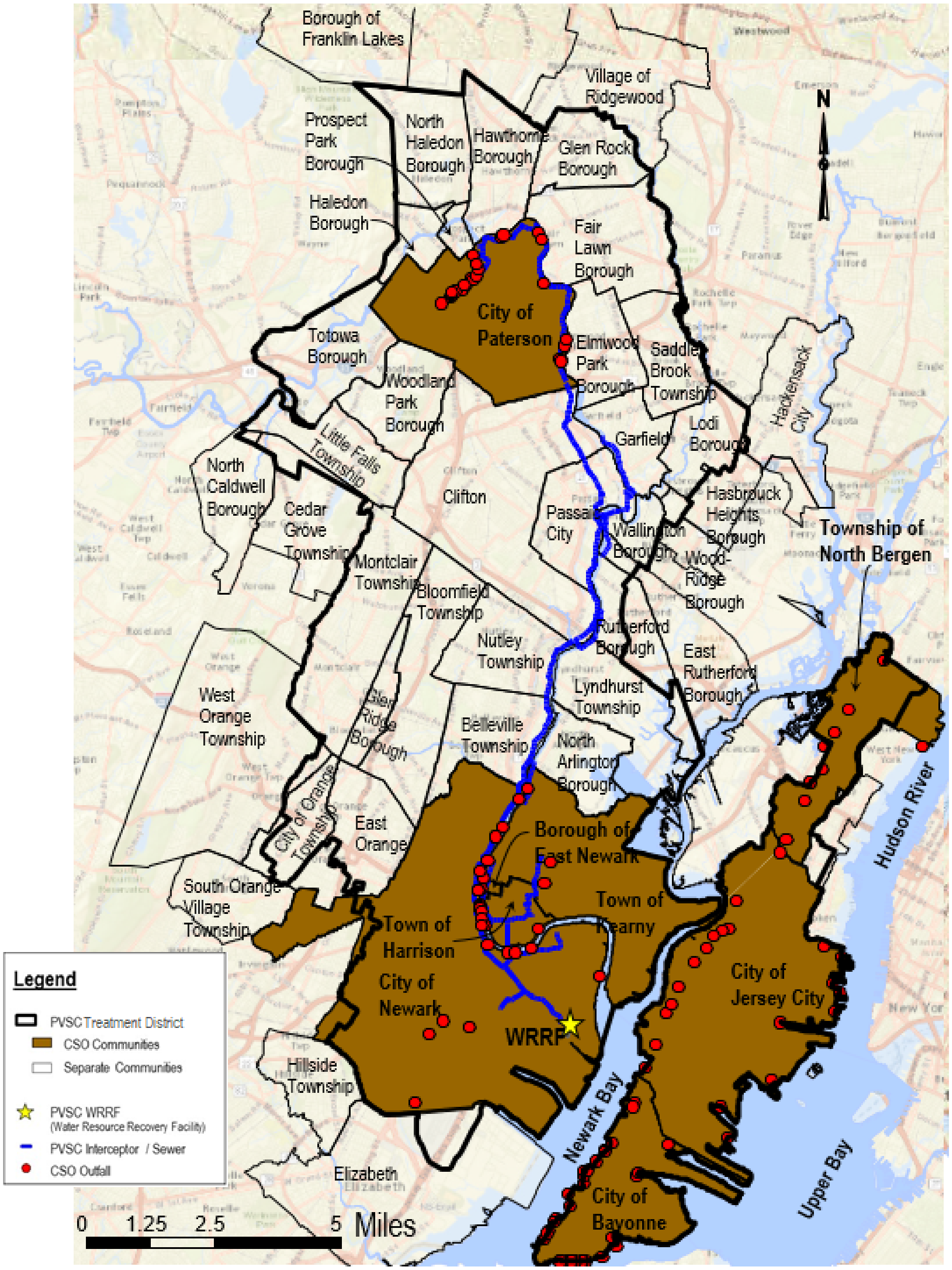


Figure A-1: PVSC Treatment District with CSO Outfalls

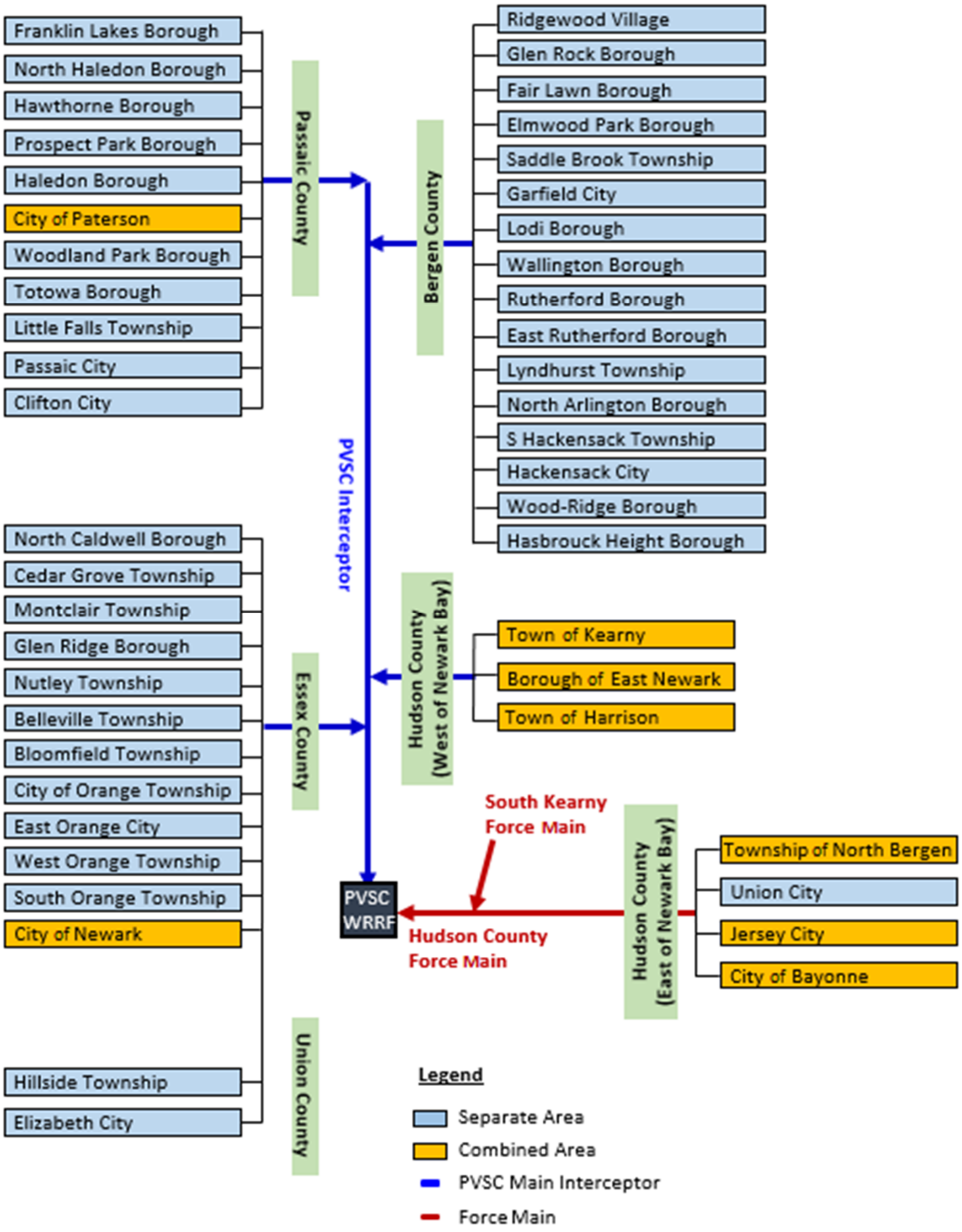


Figure A-2: PVSC Municipalities

A.1 PURPOSE OF THIS REPORT

Part IV, Combined Sewer Management, Section D.3.b.vi of the PVSC NJPDES Permit indicates that as part of the Long Term Control Plan (LTCP) requirements a Selection and Implementation of Alternatives (SIAR) Report must be submitted within 59 months from the effective date of the permit. This report constitutes the PVSC SIAR, and has been developed to meet the permit requirements for PVSC.

A.2 REGULATORY REQUIREMENTS

A.2.1 NJPDES LTCP Permit Requirements

Under its NJPDES Permit No. NJ0021016, issued in the year 2015 and administered by the New Jersey Department of Environmental Protection (NJDEP), PVSC is required to submit a SIAR in the Final LTCP by June 1, 2020. Due to the impacts of the COVID-19 Pandemic, the NJDEP has granted an extension for submittal of this report to October 1, 2020.

Part IV Sections G.2 and G.6 through G.9 of the PVSC NJPDES Permit Number NJ0021016 outlines the requirements of the SIAR. The objective of the SIAR is to provide the NJDEP, PVSC, and the municipalities with selected alternatives and implementation plans necessary to *"ensure the CSO controls will meet the water quality-based requirements of the Clean Water Act (CWA), will be protective of the existing and designated uses in accordance with N.J.A.C. 7:9B, give the highest priority to controlling CSOs to sensitive areas, and address minimizing impacts from SIU discharges.*"

The NJPDES permits issued to PVSC and each of the eight Permittees within the PVSC Treatment District, also include requirements for PVSC and the Permittees to cooperatively develop a CSO LTCP given they have a hydraulically connected system. This regional approach to a LTCP is addressed in the *Selection and Implementation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Repor*t subsequently referred to as the "Regional LTCP", to which this PVSC SIAR is appended.

PVSC NJDEP Permit Part IV.G Section 10 requires the Permittee to be "responsible for submitting a LTCP that addresses all nine elements in Part IV.G". The nine elements required by the Permit are listed in **Table A-1** below, with specific notation provided for which Sections of the NJPDES Permit this SIAR addresses:

Table A-1: Review of Major Requirements of the SIAR

Permit Section	Permit Requirement	SIAR Section Reference
Part IV G1	Characterization Monitoring and Modeling of the Combined Sewer System	Presented in the Regional LTCP as Appendix A
Part IV.G2	Public Participation Process	Presented in the Regional LTCP as Appendix E
Part IV G3	Consideration of Sensitive Area	Presented in the Regional LTCP as Appendix C
Part IV G4	Evaluation of Alternatives	Presented in the Regional LTCP as Appendix D and summarized in Section C of this SIAR
Part IV G5	Cost/Performance Considerations	See Section D.3 of this SIAR
Part IV G6	Operational Plan	See Section F.6 of this SIAR
Part IV G7	Maximizing Treatment at the Existing STP	See Appendix A of this SIAR
Part IV G8	Implementation Schedule	See Section F.5 of this SIAR
Part IV G9	Compliance Monitoring Program	Presented in Section K of the Regional LTCP

A.2.2 USEPA CSO Control Policy Requirements

The USEPA issued a national policy statement entitled *Combined Sewer Overflow (CSO) Control Policy* in April 1994 that established a consistent national approach for controlling CSO discharges to the Nation's waters through the National Pollutant Discharge Elimination System (NPDES) permit program. In 2000, the CSO Control Policy was incorporated into the Clean Water Act (CWA) by reference. This policy provides guidance to Permittees with CSOs and other parties on coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the CWA and allow for public involvement during the decision-making process.

The USEPA's *Combined Sewer Overflows Guidance for Long-Term Control Plan,* dated September 1995, provides guidance to CSO communities to assist them in developing appropriate, site-specific programs to control CSOs in compliance with documented NPDES permit programs and Clean Water Act requirements.

The CSO Control Policy contains four key principles, incorporated as part of the development of this LTCP report, with the goal of providing CSO controls that are cost-effective and meet the requirements of the CWA:

- Provide clear levels of control that would be presumed to meet appropriate health and environmental objectives
- Provide sufficient flexibility to municipalities, especially those that are financially disadvantaged, to consider the site-specific nature of CSOs and to determine the most

cost-effective means of reducing pollutants and meeting CWA objectives and requirements

- Allow a phased approach for implementation of CSO controls considering a community's financial capability
- Review and revise, as appropriate, WQS and their implementation procedures when developing long-term CSO control plans to reflect the site-specific wet weather impacts of CSOs.

A.2.3 Long Term Control Plan Approach

The USEPA's CSO Control Policy and the NJPDES Permit expect that a CSO Control Plan will develop a "reasonable range" of alternatives and should adopt one of the following approaches: the "Presumption" approach, or the "Demonstration" approach for each group of hydraulically connected CSOs.

- Under the "Presumption" approach a CSO LTCP is presumed to meet water quality provided one of the three following criteria is satisfied:
    i. "No more than an average of four overflow events per year… as the result of a precipitation event that does not receive the minimum treatment specified below; or
    ii. The elimination of the capture for treatment of no less than 85% by volume of the combined sewage volume collected in the CSS during precipitation events on a system-wide annual average basis; or
    iii. The elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under paragraph ii. above."
- Under the "Demonstration" approach a Permittee may demonstrate that a selected control program though not meeting the criteria specified in II.C.4.a. [Presumption Approach], "…is adequate to meet the water quality-based requirements of the CWA. To be a successful demonstration, the Permittee should demonstrate each of the following:
    i. The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;
    ii. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment. Where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation, or other means should be used to apportion pollutant loads;
    iii. The planned control program will provide the maximum pollution reduction benefits reasonably attainable; and
    iv. The planned control program is designated to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses."

Given that PVSC does not own or operate any CSO discharge outfalls, accurate measurement of the effectiveness of a CSO control program through the Demonstration Approach, specifically the effects of the program on water quality, may not be feasible. This renders the Presumption Approach a better tool to measure effectiveness of the program to be implemented by PVSC, under which CSO volume capture can be assessed through modeling and metering of increased wet weather flow conveyed for treatment at the WRRF. Selection of the Presumption Approach to evaluate the PVSC selected alternative is also consistent with the approach applied at the regional level as well as by each Permittee at the municipal level. Due to the various CSO discharge locations to several water bodies with significantly different background conditions related to non-CSO sources, the Presumption Approach was determined to be a better tool to evaluate the effectiveness of the control programs, both at the municipal and regional level.

A range of alternatives were identified as part of the Development and Evaluation of Alternatives Report (DEAR). The PVSC DEAR was submitted to NJDEP in June 2019, and revised in November 2019, as Appendix A to the Regional DEAR, developed for the CSS PVSC Treatment District. The PVSC DEAR was approved by the NJDEP on January 2020.The alternatives in the DEAR were evaluated for effectiveness to reduce CSO at varying levels of control (0, 4, 8, 12, and 20 overflow events per year, and 85% CSO volume capture) at the regional and municipal levels. Given that PVSC does not own or operate any CSO outfalls, the PVSC Recommended Alternative could not be evaluated for the reduction of yearly CSO overflow events or percent capture. Thus, PVSC applied the Presumption Approach of achieving a minimum of 85% capture by volume on an annual average (typical year), consistent with the approach selected by Permittees for their individual plans. However, since PVSC does not own or operate any CSO outfalls, it is noted that the PVSC Recommended Alternative as discussed in Section F of this Report is intended to complement the implementation of alternatives that are being proposed by the Permittees within the PVSC Treatment District. Therefore, the placement into operation of the PVSC Recommended Alternative shall be the performance criteria that will be used for the PVSC Recommended LTCP capital project since the implementation of the capital projects by the other Permittees are required to collectively achieve 85% capture by volume.

A.2.4 NJPDES Discharge Requirements

PVSC is authorized by the NJDEP to discharge to the Upper New York Bay through Outfall 001A under the NJPDES permit number NJ0021016. Discharges to the Upper Newark Bay through Outfall 002A are allowed when the hydraulic capacity of Outfall 001A to Upper New York Bay is exceeded during periods of heavy precipitation. All effluent discharged to the Upper Newark Bay is required under PVSC’s NJPDES Permit to receive the same treatment as effluent discharged to the Upper New York Bay. There is no bypassing of any treatment steps in the current operation.

The stream classifications for the receiving waters (Upper Newark Bay and Upper New York Bay) according to the New Jersey Administrative Code (N.J.A.C) are detailed in **Table A-2** and **Table A-3** respectively.

Table A-2: N.J.A.C for the Newark Bay

Classification	Designated Use(s)	Indicator Bacteria	Criteria (cfu per 100mL)
SE3	Secondary Contact	Fecal Coliform	1500 GM

Table A-3: N.J.A.C for the New York Bay

Classification	Designated Use(s)	Indicator Bacteria	Criteria (cfu per 100mL)
SE2	Secondary Contact	Fecal Coliform	770 GM

A.3 OVERVIEW OF PVSC FACILITIES

PVSC owns and operates one of the nation's largest wastewater treatment facilities located in Newark, NJ on a 162-acre plant site. The PVSC Water Resources Recovery Facility (WRRF) is permitted for treatment of an annual average design flow of 330 million gallons per day (MGD). During wet weather, PVSC treats up to 400 MGD as required by its NJPDES Permit. Long term sustained treatment of wet weather flows in excess of 400 MGD is currently not feasible due to limitations in the current treatment capacity at the final clarifiers. However, on December 10, 2019, PVSC's NJPDES Permit was modified for interim bypass authorization which will allow the acceptance of additional wet weather flows that are currently untreated and discharged as CSOs.

Figure A-3 provides a site aerial of the PVSC WRRF**.**

Figure A-3: Aerial of the PVSC WRRF (*Source: Hazen and Sawyer, NPA 2019*)

Upon entering the PVSC WRRF, wastewater is screened, de-gritted, and conveyed through a channel to the Influent Pumping Station and the Wet Weather Pumping Station. Flow is then lifted by a combination of six (6) Archimedes screw pumps and three centrifugal pumps to the Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen, and South Kearny, enters the WRRF at the afterbay of the Influent

Pumping Station just before the Primary Clarifiers. Following primary clarification, the combined flows then enter secondary treatment consisting of Aeration Tanks which utilize a pure oxygen activated sludge process and Final Clarifiers. Treated wastewater is disinfected with sodium hypochlorite upon entering the Effluent Pumping Station and is pumped to one of two outfalls. The main outfall (001A) discharges to the Upper New York Bay, and flow in excess of the capacity of the main outfall is conveyed to a chlorine contact tank. This excess flow will then be dechlorinated using sodium bisulfite prior to discharging to Newark Bay via secondary outfall (002A).

Solids from the Primary Clarifiers and Waste Sludge from the Aeration Tanks are collected and thickened at the gravity Sludge Thickeners. Thickened sludge is then processed through the Thickening Centrifuges to reduce the liquid volume. A wet-air oxidation process known as Zimpro is applied to stabilize and condition the sludge for dewatering before it is further reduced in volume in Decant Tanks. Sludge is then dewatered in filter presses and is then stored in cake silos prior to beneficially being used as landfill daily cover.

A.3.1 Combined Sewer System

Combined sewer systems are legacy systems of the country's early wastewater infrastructure when communities built sewer systems to collect both storm water and sanitary sewage in the same piping system. During dry periods, the CSS conveys the wastewater typically to a wastewater treatment facility (or WRRF) for treatment prior to discharge to receiving water bodies. However, during wet weather, stormwater is combined with wastewater and the volume of combined sewage can sometimes exceed the capacity of the CSS or WRRF. When the capacity of the CSS or WRRF is exceeded, regulator structures exist along local collector sewers in the CSS to relieve excess combined sewer volume through a combined sewer outfall (CSO) and into receiving waters. CSOs are equipped with solid and floatables controls (e.g. netting facilities and screens) to reduce solid waste prior to discharge.

PVSC provides wastewater treatment service to 48 municipalities within Bergen, Hudson, Essex, Passaic, and Union counties in the Passaic Valley Treatment District located in Northeast New Jersey. The PVSC WRRF receives combined sewer flow from three sources:

1. the Main Interceptor Sewer,
2. the South Side Interceptor, and the
3. Hudson County Force Main (HCFM).

PVSC owns, operates and maintains parts of the system that convey wastewater, such as the Main Interceptor, various branch interceptor sewers, and several pumping stations. The Main Interceptor begins at Prospect Street in Paterson and generally follows the alignment of the Passaic River to the PVSC WRRF. The Main Interceptor is approximately 22 miles long and ranges from 3.75 to 12.5 feet in diameter.

PVSC does not own, operate, or maintain any of the CSO outfalls within the PVSC Treatment District, the South Side Interceptor service area, or the Hudson County Force Main service area. The South Side Interceptor is located entirely within the City of Newark. The Hudson County

Force Main receives combined sewer flow from the cities of Jersey City, Bayonne, North Bergen, and South Kearny. The extent of the PVSC Treatment District and the CSO outfalls within the study area are illustrated in **Figure A-4**.

A.4 CONTENTS OF THIS REPORT

This SIAR evaluates a range of CSO control alternatives intended to meet the requirements of the 1994 EPA CSO Policy and Federal Water Pollution Control Act, CWA of 1972, as well as the NJPDES Permit, effective October 9, 2015 and last modified on December 10, 2019. As required by the NJPDES Permit Part IV Section G.4.e, this SIAR utilizes models to simulate the existing conditions and the expected conditions after the construction and operation of the chosen alternative. The SIAR evaluates the practical and technical feasibility of the proposed CSO control alternative, with the goal of achieving the water quality-based requirements of the CWA through the construction and implementation of various remedial controls and the combination of such controls and activities.

An overview of the organization and contents of this SIAR is provided in **Table A-4**.

Table A-4: Selection and Implementation of Alternatives Report Contents and Organization

Section		Topics Covered
A	Introduction and Background	Documents the problem, definition, background, project description, summary and table of contents
B	Screening of CSO Control Technologies	Describes the technology screening process used to determine the CSO control technologies advanced for analysis in Section D
C	Evaluation of Alternatives	Describes the process used to develop and evaluate alternatives from the technologies advanced from Section B
D	Selection of Recommended LTCP	Describes the selected alternative for the recommended LTCP and the selection process
E	Financial Capability	Describes the affordability of the selected PVSC alternative
F	Recommended Long Term Control Plan	Describes the recommended plan for PVSC's LTCP efforts

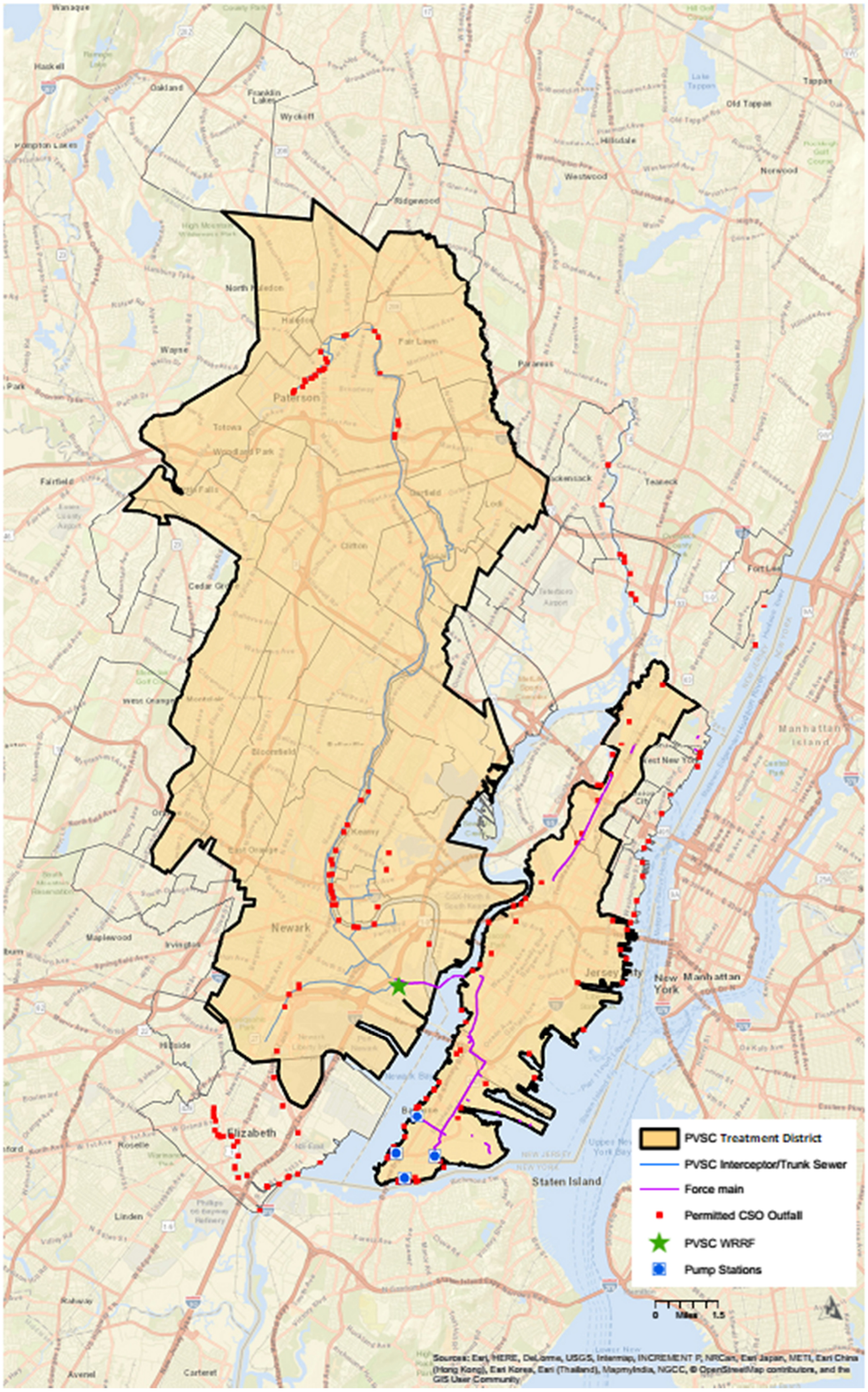


Figure A-4: PVSC Treatment District and CSO Outfalls

SECTION B - SCREENING OF CSO CONTROL TECHNOLOGIES

B.1 INTRODUCTION

This section of the SIAR summarizes the CSO control technology screening process performed in the Development and Evaluation of Alternatives Report (DEAR). The PVSC DEAR was submitted to NJDEP in June 2019, and revised in November 2019, as Appendix A to the Regional DEAR, developed for the CSS PVSC Treatment District. The PVSC DEAR was approved by the NJDEP on January 2020. The Regional and PVSC DEARs were developed in compliance with the requirements of NJPDES Permit No. NJ0021016 issued to PVSC. As part of the PVSC DEAR, PVSC screened various CSO technologies in order to determine the CSO control technologies with the greatest potential to meet the requirements of the NJPDES Permit, the CSOs Control Policy Section II.C.4, and the United States Environmental Protection Agency's (USEPA) "Guidance for Long Term Control Plan".

The CSO control technology screening process considered only those technologies applicable to PVSC-owned infrastructure with regards to CSO control technology feasibility, implementation, and design, without consideration of cost or cost effectiveness. The screening analysis utilized CSO control levels to determine technology effectiveness of up to 0, 4, 8, 12, and 20 overflow events per year, and 85% CSO volume capture. The purpose of screening is to exclude those CSO control technologies that are not technically or physically feasible for application by PVSC. The summary tables in Section B.2 identify the CSO control technologies screened in the PVSC DEAR, and considered feasible for further evaluation.

For the complete screening of CSO control technologies refer to the PVSC DEAR, part of the Regional DEAR. The latter is included as Appendix D of the Regional LTCP.

B.1.1 Water Quality and Primary CSO Control Goals

CSO control technologies were screened for their effectiveness on reducing pollutants of concern (POC) and reducing CSO discharge volume in support of water quality standards and CWA compliance. As such, the CSO control technologies were screened based on the following primary CSO Control goals.

- Reducing the pathogen loads from remaining CSO discharges
- Reducing CSO discharge volume and frequency

B.1.2 Evaluation Methodology Used for this Study

Each CSO control technology evaluated in this section was assigned a value based on its effectiveness at achieving the primary goals defined above. The categories used to assign goal effectiveness are as follows:

- High: These CSO control technologies are highly effective and are among the best technologies to achieve primary CSO control goals. For this reason, these technologies are highly likely to be considered for further evaluation.
- Medium: These CSO control technologies are moderately effective at achieving the primary CSO control goals, but are not considered among the most effective technologies to achieve those goals. These technologies may or may not be considered for further evaluation.

- Low: These CSO control technologies are projected to have a minor impact on achieving the primary CSO control goals. These technologies will need other positive attributes to support achieving CSO control measures to be considered for further evaluation.
- None: The CSO control technology will have no impact or a negative impact on the primary CSO control goals. It is unlikely that these technologies will be considered for further evaluation.

Additionally, the positive impacts that each of the technologies would have on the community beyond achieving the primary goals described above were evaluated. The community benefits were identified using, as a reference the NJDEP Division of Water Quality's report entitled "Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans," and the New Jersey Green Infrastructure Municipal Toolkit website. Community benefits identified include aesthetic improvements, improvements to water quality, reduction of flooding potential, and alignment with sustainable community principles, among others.

CSO control technologies were recommended for further evaluation based on multiple factors.

- The first factor was the goal-effectiveness value that generally quantifies the effectiveness a technology would have towards achieving a CSO control goal. These goal-effectiveness values are described above.
- The second factor depended upon the CSO control technology requiring further evaluation pursuant to the NJPDES Permit. The permit identifies certain technologies that must be evaluated further before approval.
- The third factor in determining whether a technology would be evaluated further was the current or future implementation and operation of that technology. If the technology is currently in place, will be implemented, or is mandated by the Nine Minimum Controls, then further evaluation was not required.
- The fourth and final factor was the feasibility of implementation, particularly in terms of land/infrastructure ownership.

The community benefits identified for each technology also played an important role in determining whether implementation of the technology would be beneficial and recommended to be moved forward for further analysis.

CSO technologies found to be highly effective in one or all evaluation factors were recommended for further investigation. A CSO technology that would not achieve a "medium" effectiveness for water quality goals would not be recommended for further evaluation. This screening methodology was presented to the public at the October 2018 PVSC Regional Supplemental CSO Meeting. Input was requested from the public and the public feedback was considered in this evaluation.

B.2 SCREENING OF CONTROL TECHNOLOGIES

Table B-1 through **Table B-3** provide a summary of the comprehensive screening of CSO control technologies process from the PVSC DEAR. The CSO control technologies summarized in this section present assigned values based on their effectiveness at reaching primary CSO control goals. CSO control technologies recommended for further evaluation are shaded in these summary tables. CSO control technologies not shaded or designated for further evaluation but that were being already implemented at the time of the screening process, are identified in the second to last column in each of the tables. Descriptions of the goal effectiveness categories and the evaluation methodology are located in Subsection **B.1.2.**

Table B-1, **Table B-2** and **Table B-3** also contain a brief description of the implementation and operation factors for the different CSO technologies and provide a summary of those CSO control technologies moving forward in alternatives evaluation in Section C.

Table B-1: Source Control Technologies

Source Control Technologies (Summary from PVSC DEAR)								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	▪ Reduced surface flooding	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	No	No
	Catch Basin Modification (for Floatables Control)	Low	None	▪ Water quality improvements ▪ Reduced surface flooding	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
	Catch Basin Modification (Leaching)	Low	Low	▪ Water quality improvements ▪ Reduced surface flooding	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
Public Education and Outreach	Water Conservation	None	Low	▪ Reduced surface flooding ▪ 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.	No	Yes	No
	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 input and understanding of the message. Public outreach programs would have a more effective result.	No	Yes	No
	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	No
	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 Nine Minimum Controls (NMC).	Yes	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
	Hazardous Waste Collection	Low	None	▪ Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	No	Yes	No
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	▪ 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-	No	Yes	No

Source Control Technologies (Summary from PVSC DEAR)

Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
					day notification (if Permittee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.			
	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.	No	Yes	No
	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.	No	Yes	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.	No	Yes	No
	Illicit Connection Control	Low	Low	▪ Water quality improvements ▪ Align with goals for 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.	No	Yes	No
Good Housekeeping	Street Sweeping/Flushing	Low	None	▪ Reduced surface flooding	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.	No	Yes	No
	Leaf Collection	Low	None	▪ Reduced surface flooding ▪ Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	No	Yes	No
	Recycling Programs	None	None	▪ Align with goals for sustainable community	Most Cities have an ongoing recycling program.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
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.	No	Yes	Yes
	Blue Roofs	None	Medium	▪ Reduced heat island effect ▪ Property value uplift ▪ Local jobs ▪ Reduced surface flooding	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.	No	Yes	Yes

Source Control Technologies (Summary from PVSC DEAR)

Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Green Infrastructure Buildings				▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community				
	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.	No	Yes	Yes
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ 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.	No	Yes	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, infiltrating and evapotranspiring 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.	No	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	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.	No	Yes	Yes

Source Control Technologies (Summary from PVSC DEAR)								
Technology Group	**Practice**	**Primary Goals**		**Community Benefits**	**Implementation & Operation Factors**	**Consider Combining w/ Other Technologies**	**Being Implemented**	**Recommendation for Alternatives Evaluation**
		Bacteria Reduction	**Volume Reduction**					
				improvements ▪ Reduced crime ▪ Align with goals for a sustainable community ▪ Increased pedestrian safety through curb retrofits				
	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, infiltrating and evapotranspiring 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.	No	Yes	Yes

Table B-2: Collection System Technologies

Collection System Technologies (Summary from PVSC DEAR)								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
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.	No	Yes	No
	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.	No	Yes	No
	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	No
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	No	Yes
	Regulator Modifications	Medium	Medium	▪ Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls will require O&M. May increase risk of upstream flooding. Permittees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	No	Yes	Yes
	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.	No	Yes	No
	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.	No	Yes	No

Table B-3: Storage and Treatment Technologies

Storage and Treatment Technologies (Summary from PVSC DEAR)								
Technology Group	**Practice**	**Primary Goals**		**Community Benefits**	**Implementation & Operation Factors**	**Consider Combining w/ Other Technologies**	**Being Implemented**	**Recommendation for Alternatives Evaluation**
		Bacteria Reduction	**Volume Reduction**					
Linear Storage	Pipeline	High	High	▪ Water quality improvements ▪ Reduced surface flooding ▪ 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	No	Yes
	Tunnel	High	High	▪ Water quality improvements ▪ Reduced surface flooding	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes
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	No	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.	No	Yes	No
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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No
	Contaminant Booms	None	None	▪ Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	No	Yes	No
	Baffles	None	None	▪ Water quality improvements	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	No	Yes	No
	Disinfection & Satellite Treatment	High	None	▪ 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.	No	Yes	No
	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.	No	Yes	No
	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.	No	Yes	No

Storage and Treatment Technologies (Summary from PVSC DEAR)								
Technology Group	**Practice**	**Primary Goals**		**Community Benefits**	**Implementation & Operation Factors**	**Consider Combining w/ Other Technologies**	**Being Implemented**	**Recommendation for Alternatives Evaluation**
		Bacteria Reduction	**Volume Reduction**					
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.	No	Yes	Yes
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	Yes	No

SECTION C - EVALUATION OF ALTERNATIVES

C.1 INTRODUCTION

In accordance with the requirements of Part IV Section G.4 of the PVSC NJPDES Permit NJ0021016, PVSC evaluated a reasonable range of CSO control alternatives predicted to meet the water quality-based requirements of the CWA. The alternatives developed and evaluated were submitted as part of the PVSC DEAR and the Regional DEAR.

This Section summarizes PVSC's development and evaluation of alternatives submitted to NJDEP in 2019 as required by the Permit. Appendix D of the Regional LTCP includes the Regional DEAR and PVSC DEAR for additional detail. Section D presented later in this report will discuss how the alternative selection process evolved since submittal of the PVSC DEAR.

C.2 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

Development of CSO control alternatives included the CSO control technologies identified as feasible for implementation during the screening process in the PVSC DEAR, summarized in Section B of this report and listed below:

- Green Infrastructure (GI)
- Regulator Modifications
- Additional Conveyance (Parallel Interceptor)
- Linear Storage (Storage Tunnel)
- Point Storage (Storage Tanks)
- Wet Weather Blending (WRRF Bypass of Secondary Treatment)

The CSO control alternatives developed and evaluated utilized the typical control levels (i.e. up to 0, 4, 8, 12, and 20 overflow events per year, or 85% CSO volume capture) for effectiveness of CSO controls. The range of alternatives developed included alternatives that could be implemented independently by PVSC or at the regional level. Evaluation factors for the CSO control alternatives are detailed in the PVSC DEAR and include siting, institutional issues, implementability concerns, public input, performance considerations, and cost. The CSO control alternatives evaluated for implementation by PVSC are presented in **Table C-1** below.

Table C-1: PVSC CSO Control Alternatives

Alternative	Description[1]
No. 1	Tunnels
No. 2	Storage Tanks
No. 3	Newark Regulator Modifications
No. 4a	GI (2.5%)
No. 4b	GI (5%)
No. 4c	GI (10%)
No. 5	Newark Regulator Modifications + Plant Bypass (720 MGD) + JC Pipe (235 MGD HCFM)
No. 5.a	Newark Regulator Modifications + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 6.a	Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM)

Alternative	Description[1]
No. 6.a.1	Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 6.b	Newark Regulator Modifications + Parallel Interceptor (Newark only) + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM)
No. 6.b.1	Newark Regulator Modifications + Parallel Interceptor (Newark only) + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 7	Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels
No. 7.a	Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels
No. 8	Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels + Storage Tanks
No. 8.a	Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels + Storage Tanks
No. 9	Newark Regulator Modifications + Tunnels + Storage Tanks
No. 10	Tunnels + Storage Tanks
No. 11	5% GI + Newark Regulator Modifications
No. 12	5% GI + Newark Regulator Modifications + Plant Bypass (720 MGD) + JC Pipe (235 MGD HCFM)
No. 12.a	5% GI + Newark Regulator Modifications + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 13	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM)
No. 13.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 14	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels
No. 14.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels
No. 15	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels + Storage Tanks
No. 15.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels + Storage Tanks
No. 16	5% GI + Newark Regulator Modifications + Tunnels + Storage Tanks
No. 17	5% GI + Tunnels + Storage Tanks

[1] The term “JC Pipe” refers to pumping and force main capacity increase associated with Bayonne Infrastructure and ultimately conveyed through the HCFM to the PVSC WRRF.

C.3 CSO CONTROL ALTERNATIVES ADVANCED FOR EVALUATION

The CSO control alternatives advanced for evaluation included alternatives that could be implemented at the regional level, in order to facilitate collaboration with the Permittees, and analyze the impact of regional implementation encouraged by the permit. The alternatives advanced for further evaluation are listed below:

- Alternative 1: Tunnels
- Alternative 6.a.1: Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)
- Alternative 7.a: Newark Regulator Modifications + Parallel Interceptor + Plant Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels

Alternatives 1 and 7.a use tunnels as a CSO control technology. Tunnels are adaptable and their diameters and lengths were iteratively optimized to accommodate each of the levels of control evaluated (0, 4, 8, 12, 20, and 85%). In contrast, Alternative 6.a.1 was evaluated through a hydraulic model with a target of 85% CSO volume capture, which yielded the expected system capture when implementing the proposed CSO control technologies, instead of allowing for adjustment to achieve the various levels of control. Thus, analysis of Alternative 6.a.1 was limited to CSO volume capture and did not yield results for each of the various frequency of overflow based levels of control. **Table C-2** adapted from the PVSC DEAR summarizes the results of the alternatives evaluated at the time of submittal. These values do not constitute the current values for the selected alternative, which are discussed in Section D.

Table C-2: Performance and Cost Summary of PVSC DEAR Evaluated Alternatives

Level of Control[1]	System Volume Capture (%)	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
Alternative 1				
≤ 0	100%	$1.2B	$1.6B	$0.77
≤ 4	97.8%	$838	$1B	$0.59
≤ 8	96.8%	$743	$934	$0.57
≤ 12	94.8%	$680	$856	$0.62
≤ 20	89.9%	$512	$648	$0.83
85%	85.2%	$243	$308	$1.60
Alternative 6.a.1				
85%	93.9%	$460	$465	$0.36
Alternative 7.a				
≤ 0	100%	$1.3B	$1.6B	$0.77
≤ 4	98.9%	$1.1B	$1.3B	$0.68
≤ 8	97.1%	$980	$1.1B	$0.67
≤ 12	95.8%	$832	$940	$0.62

Level of Control[1]	System Volume Capture (%)	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 20	94.9%	$750	$838	$0.60
85%	93.9%	$460	$465	$0.38

[1] Expressed as number of CSO overflow events per year or 85% CSO volume capture

SECTION D - SELECTION OF RECOMMENDED LTCP

D.1 INTRODUCTION

The NJPDES Permit issued to PVSC and each of the eight Permittees includes requirements for PVSC and the Permittees to cooperatively develop a CSO LTCP. As discussed in Section C, to facilitate collaboration among the Permittees, PVSC developed and evaluated alternatives that could be implemented at the regional level as part of the PVSC DEAR and Regional DEAR required by the Permit.

However, to address individual compliance with the Permit in the event that implementation of a Regional CSO LTCP is not feasible due to technical or financial constraints, PVSC and the Permittees must select alternatives that can be implemented independently by each Permittee, in addition to the selection of a Regional Alternative. As such, this report and the SIARs, developed by each of the Permittees (included as Appendices to the Regional LTCP), discuss selection of alternatives to be implemented by each Permittee independently from the region. The Regional LTCP discusses selection of a Regional Alternative to be implemented at the regional level.

Based on the above, this Section focuses on the selection of alternatives that can be implemented by PVSC independently.

D.2 LTCP SELECTION PROCESS

The USEPA CSO Guidance Manual for LTCPs, issued in 1995, provides a guidance to municipalities for the development of a "comprehensive LTCP that recognizes the site specific nature of CSOs and their impacts on receiving water bodies." The guidance states that "the final plan should include water quality based control measures that are technically feasible, affordable, and consistent with the CSO Control Policy." PVSC used the CSO Guidance Manual in conjunction with the National CSO Policy and the requirements of Part IV of the PVSC NJPDES Permit to develop the LTCP selection process.

Sections A through C of this report describe the various steps that have been performed in conformance with the NJPDES Permit issued in 2015 to establish the basis for the selection and implementation of the LTCP. The submitted reports required under each step, are included as appendices to the Regional LTCP, as listed in **Table A-1** in Section A of this report. The steps required prior to the selection of alternatives are as follows:

1. A System Characterization Work Plan and a Baseline Compliance Monitoring Program Work Plan was developed by January 1, 2016,
2. A Map of the Combined and Separate Sewer Areas within the PVSC CSO District was developed by July 1, 2016.
3. Characterization of the receiving waters in accordance with the approved System Characterization Work Plan and Baseline Compliance Monitoring Program Work Plan and a System Characterization Report summarizing the results of the characterization work was completed and submitted by July 1, 2018.

4. A Public Participation Process Report, a Compliance Program Monitoring Report, and a Consideration of Sensitive Areas Plan were submitted by July 1, 2018; concurrent with the System Characterization Report.
5. Water Quality Modeling (WQM) and Hydraulic and Hydrogeological Modeling (H&H Model) was performed in accordance with the permit requirements to inform the alternatives development and selection process.
6. A Development and Evaluation of Alternatives Report (DEAR) including screening process of applicable CSO control technologies, establishing the various alternatives considered for future selection and implementation, was submitted in July 1, 2019.

Upon review and approval of the PVSC DEAR, analysis of the WQM and H&H Model, and input from the public participation process, the permit requires that a Selection and Implementation of Alternatives Report (SIAR) be submitted, that includes the selected alternative to formulate the LTCP and implementation schedule. As noted above, each Permittee developed a SIAR for independent implementation (Municipal Alternative), each of which is appended to the Regional LTCP. A Regional Alternative for regional implementation is discussed in the latter.

D.3 SELECTION OF ALTERNATIVES

Upon completion of steps 1 through 6 listed above, and in parallel to the ongoing Public Participation process and H&H Modeling efforts, PVSC proceeded to analyze the alternatives available for selection that could be recommended for implementation as the PVSC LTCP. The criteria established for the PVSC Alternative selection follow the recommendations of the CSO Guidance Manual, the National CSO Policy, and the requirements of Part IV of the PVSC NJPDES Permit, as follows:

- The Alternative(s) uses one or more CSO control technologies deemed applicable during the DEAR screening process for implementation by PVSC,
- The Alternative(s) or CSO control technology can be applied independently by PVSC; that is, the planning, implementation, financing, operation and maintenance of the implemented alternative or technology, will be within the total jurisdiction and ownership of PVSC and does not require land acquisition or control of outfalls/regulators operated by and permitted to others,
- The Alternative(s) accomplishes at least one of the nine minimum control requirements from the National CSO Policy and Part IV.F of the PVSC NJPDES Permit.

Given that PVSC does not own or operate any CSS, or CSO outfalls, and it does not own any land area where Green Infrastructure can be applied to significantly reduce CSOs, the only CSO control technology pre-selected during the DEAR screening process that can be applied by PVSC independently is Wet Weather Blending, designated in the PVSC DEAR and Regional DEAR Alternatives as the “Plant Bypass (720 MGD)”, and referred to in this report from this point forward as the “Secondary Treatment Bypass”.

This CSO control technology can be selected and implemented as an Alternative that meets the criteria listed above, as it is a CSO control technology selected during the PVSC DEAR screening process (See **Table B-3**), it can be applied independently by PVSC, and it maximizes flow to the WRRF for treatment, which is one of the nine minimum control requirements from the NJPDES Permit and the National CSO Policy. No other Alternatives or CSO Control Technologies selected during the PVSC DEAR screening and evaluation process meet the criteria established above, to be considered for implementation. Further, the installation and implementation of a Secondary Treatment Bypass is permitted by the PVSC NJPDES Permit, as last modified on December 10, 2019. The Secondary Treatment Bypass enables increased wastewater treatment capacity during wet weather.

The Parallel Interceptor is one of the Regional Alternative technologies proposed in the Regional LTCP. **Figure D-1** shows the potential location of the Newark Parallel Interceptor. **Table D-1** summarizes the associated CSO capture and overflow event performance for the Secondary Treatment Bypass and the addition of the Parallel Interceptor to maximize the regional benefits of the bypass.

Table D-1: Performance Summary for the Secondary Treatment Bypass and Parallel Interceptor

Performance Indicator	Secondary Bypass Only	Bypass + Parallel Interceptor Parallel Interceptor
Parallel Interceptor Length (ft.)	-	29,296
Annual Overflow Volume Reduction (MG)	752	1,085
Annual Overflow Percent Reduction	16%	24%

The remainder of this Section will focus on the Secondary Treatment Bypass Alternative, as the selected Alternative for application by PVSC independently from other Permittees.

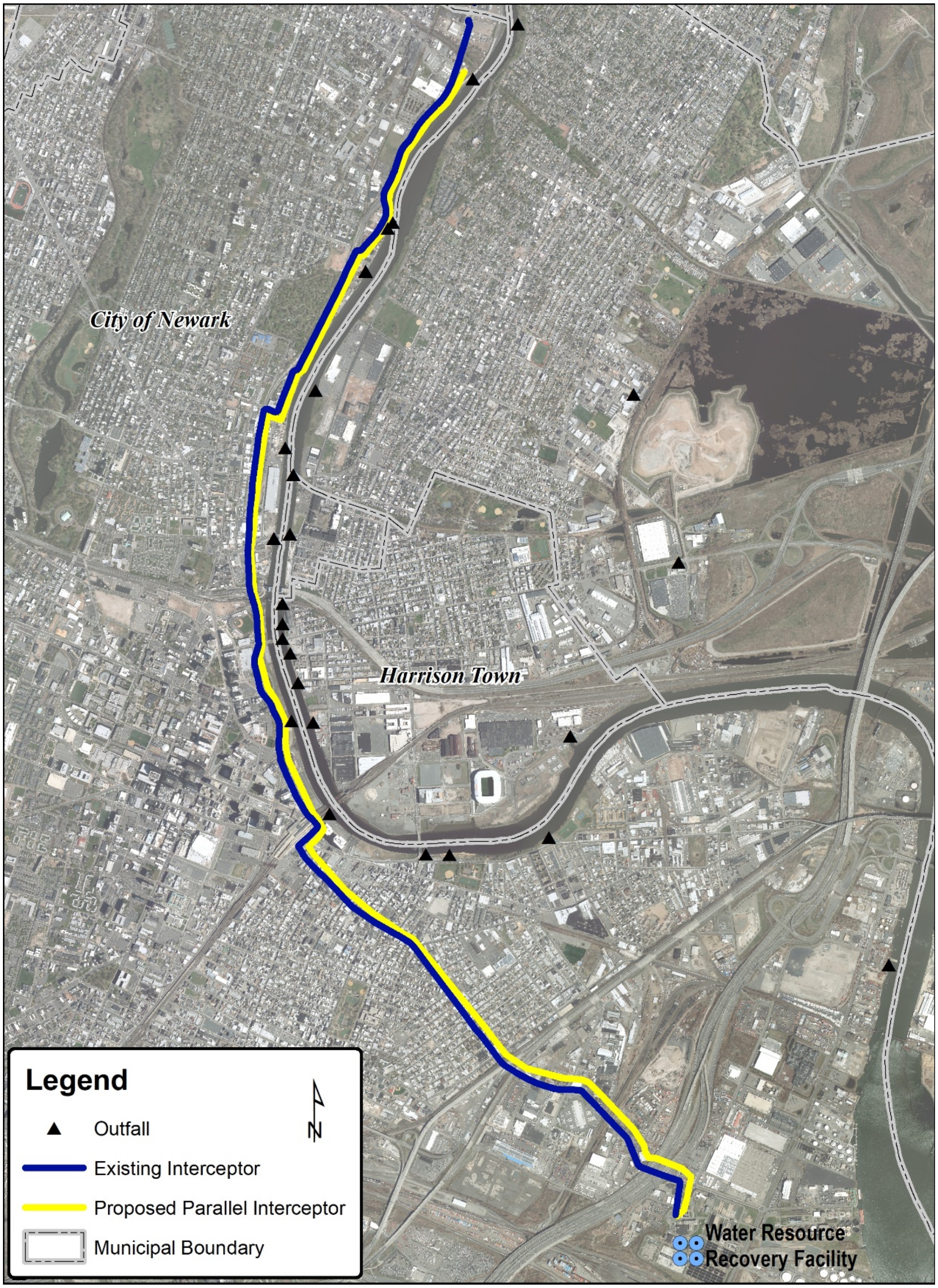


Figure D-1: Location of the Newark Parallel Interceptor

D.3.1 Description

In 2019, PVSC conducted a No Feasible Alternatives (NFA) Analysis to investigate various alternatives to expand the PVSC WRRF Wet Weather Treatment Capacity to 720 MGD, the maximum hydraulic capacity of the WRRF, such that NJPDES permit compliance could be maintained for instantaneous flows greater than 400 MGD. According to the NFA Analysis Report, included as **Appendix A** of this report, the instantaneous flow of 400 MGD corresponds to the maximum capacity of the secondary treatment train based on historical plant observations and numerous studies including sampling, stress-testing, and Computational Fluid Dynamics (CFD) modeling.

The NFA Analysis satisfies the requirements of USEPA's 40 CFR 122.41(m) "bypass" provision, which, as noted in **Table B-3** under the Wet Weather Blending CSO control technology description, requires that the Permittee demonstrates that there are no feasible alternatives to bypassing secondary treatment.

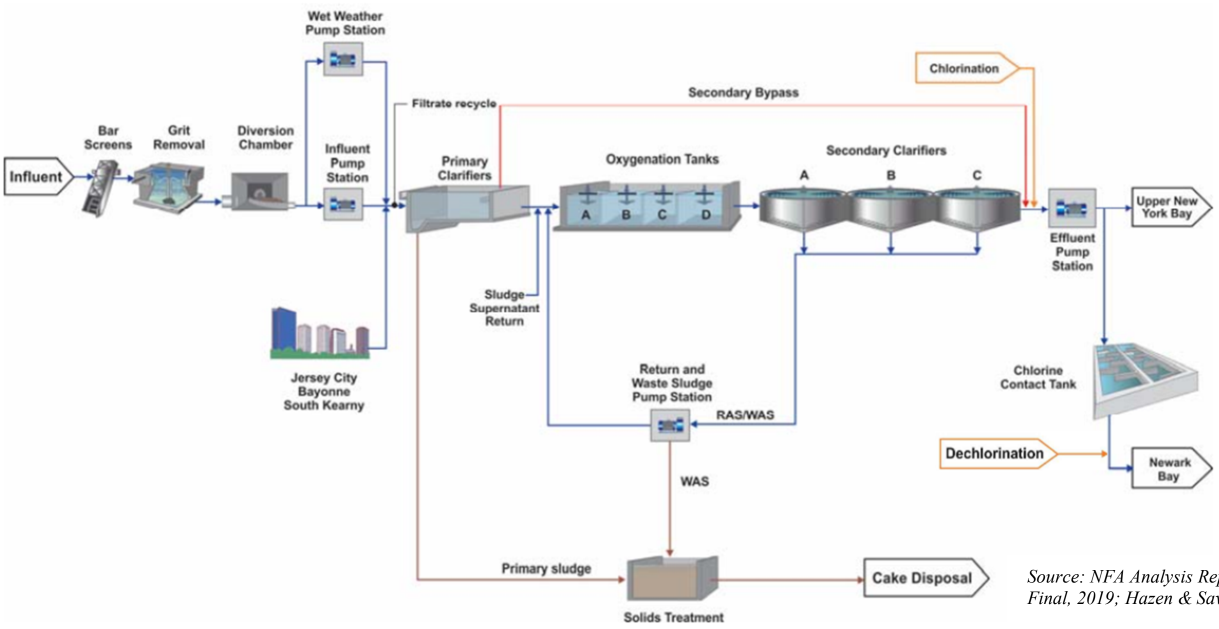
The alternatives evaluated as part of the NFA Analysis are listed below.

- Operational Modifications: Chemically enhanced primary treatment
- Modifications to Infrastructure:
    - Secondary Treatment Bypass
    - Step-Feed
    - BioActiflo
    - Temporary Return of Activated Sludge
    - Re-routing Recycling Streams
    - Structural Modifications to Final Clarifiers
    - Routing Waste Activated Sludge into the Primary Clarifiers
    - Main Stream Ballasted Floc – BioMag®
    - Additional Final Clarifiers Infrastructure

Further detail of the analysis completed in 2019 can be found in the NFA Analysis Report included in **Appendix A**. Updates to modeling and cost of implementation that have occurred since the final report was issued in 2019 are not reflected in the report and are presented in this Section, as applicable.

Upon evaluation of the various alternatives, including criteria such as permit compliance, schedule, and cost, in addition to operational feasibility and efficiency, the NFA Analysis Report concluded that the Secondary Treatment Bypass is the only alternative that can reliably expand the wet weather treatment capacity up to 720 MGD while maintaining permit compliance, providing operational flexibility, relative low cost, and a short implementation schedule.

The selected Secondary Treatment Bypass alternative consists of routing a stream of primary effluent during wet weather flows, around the PVSC WRRF's secondary treatment, to be combined prior to disinfection and plant effluent discharge; thus, expanding the plant's wet weather capacity. **Figure D-2** depicts the WRRF process flow diagram implementing the recommended CSO control alternative of secondary treatment bypass expansion.



Source: NFA Analysis Report, Final, 2019; Hazen & Sawyer

Figure D-2: Secondary Bypass Process Flow Diagram

The NFA recommends for secondary treatment bypass piping to be installed at the primary effluent channel, upstream of sludge recycling, to convey wet weather flow to the secondary clarifiers' (SC) effluent channel, where wet weather blending with secondary effluent can take place, prior to disinfection and discharge. This proposed configuration would avoid overloading the secondary treatment system while still providing the benefits of primary settling and disinfection prior to discharge.

Hydraulic modeling using InfoWorks software utilized as part of the NFA analysis, indicates flow up to 320 MGD could be bypassed. The NFA secondary bypass option was analyzed with a secondary bypass triggered at approximately 400 MGD. Key findings from the modeling analysis are summarized in **Table D-2**.

Table D-2: NFA Secondary Bypass Modeling Key Findings

Key Findings	Value	Details
Flow Through Plant	720 MGD	Peak wet weather capacity upon implementation of the secondary bypass
Maximum Flow Through Secondary Treatment	400 MGD	320 MGD of Primary Effluent flow would be bypassed around secondary treatment during wet weather conditions
Mixed-Liquor Suspended Solids Concentration to the SCs	2,900 – 3,100 mg/L	Solids concentrations dictated by a Solids Retention Time of 1.5 days

Key Findings	Value	Details
Estimated Effluent Quality	< 45 mg/L	An acceptable Surface Overflow Rate of 800 gpd/ft^2 (based on 12 SCs online, 400 MGD flow through secondary treatment, and 15 MGD internal recycle) is achieved with the bypass of 320 MGD. Predicted effluent quality is sufficient for MJPDES Permit compliance.
Key changes to equipment/infrastructure		New infrastructure is required to reroute a portion of primary effluent from the existing twin conduits to the SC effluent channel
Operational requirements		Wet weather monitoring and flow reporting A magnetic flow meter is currently planned for measurement

The implementation of a secondary treatment bypass expansion would allow PVSC an alternative to capture, provide primary treatment, and disinfect wet weather flows above 400 MGD and reliably treat up to 720 MGD of influent flow while meeting the effluent permit requirements summarized in **Section A.2.4**. Upon implementation of the secondary treatment bypass, the existing interceptor will be able to convey a total flow above 400 MGD to the PVSC WRRF. However, in order to convey 720 MGD, a new regional interceptor and increased pumping capacity from the HCFM will be required due to hydraulic limitations of the existing CSS.

D.3.2 Remaining Overflows

As PVSC does not own or operate any CSO outfalls or regulators, it does not have jurisdiction over the overflow discharges at the CSO outfalls owned and operated by other Permittees within the hydraulically connected system. However, implementation of the Secondary Treatment Bypass will enable treatment of higher wet weather flows at the PVSC WRRF, thereby maximizing flow to the Publicly Owned Treatment Works (POTW) for treatment, which is one of the Nine Minimum Controls required by the Permit. The Secondary Treatment Bypass will also increase the CSS's ability to convey wet weather flow. The latest hydraulic modeling analysis updated after the Final NFA Analysis Report was submitted estimates the Secondary Treatment Bypass can contribute to reductions in CSO discharges of about 750 million gallons per year based upon the typical rainfall year. Additional reduction in CSO discharges totaling 1 billion gallons per year (based on the typical year) can be realized with the simultaneous implementation of the Regional Parallel Interceptor described in **Section D.3.**

D.3.3 Ability to Meet Water Quality Standards

Given that PVSC does not own or operate any CSO Outfalls, WQ at CSO Outfalls cannot be measured by PVSC alone for compliance, as stated in the PVSC's NJPDES Permit:

"STPs that do not own/operate any CSO outfalls are not required to comply with NMC #9, *Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls"***.**

However, based on the analysis performed by PVSC in the NFA Analysis Report, it is expected that the plant's permit compliance can be maintained up to 720 MGD if the Secondary Treatment Bypass Alternative is implemented. Details of the Effluent Permit compliance for the Secondary Bypass is found in Section 4.2.2.1.3 of the 2019 NFA Report (**Appendix A**).

D.3.4 Non-Monetary Factors

In addition to technical feasibility and permit compliance, the following non-monetary factors were considered in the selection of the PVSC Alternative:

- Short-term public impact during construction
    - Construction within the plant boundaries reduces neighborhood and traffic impacts
    - The WRRF can be operated at its current permitted capacity during bypass construction without impact to sewer conveyance and treatment performance, despite the expectation of minor, short-term shutdowns for tie-ins
    - Operation of the WRRF can be performed within current permit limits such that the receiving waterbodies do not experience additional CSO discharges or temporary bypasses of partially treated effluent
- Long-term public impact post-construction
    - Improved operation and capacity of the CSS as a result of the increased wet weather treatment capacity at the WRRF
    - Improved water quality and protection of uses by treatment and disinfection of the WRRF wet weather flows previously discharged to receiving waterbodies when exceeding the plant's instantaneous flow treatment capacity
- Incorporation of multiple ancillary community benefits
    - Increased wet weather treatment capacity reduces the frequency of interceptor surcharging and risk of sewer backups
- Effectiveness at reducing CSO-related elements
    - Increased treatment capacity of wet weather flows contributes to increasing CSO volume capture and treatment.

D.3.5 Cost Opinion

In contrast to the non-monetary factors listed above, the following cost considerations were taking into consideration for the selection of the PVSC Alternative:

- Estimated Capital and O&M Costs align with typical engineering practice
    - Industry standards and design guidelines will be followed in implementing the secondary treatment bypass which is a proven technology with a long history of successful performance
    - The local construction market is fully capable of performing the installation
    - Costs of constructing supplemental linear storage and conveyance infrastructure are relatively high as compared to the expansion of existing treatment processes or using available storage within the existing collection system

- Site constraints
    - Construction within the WRRF boundaries eliminates the need for land acquisition, encroachment into private property and easement acquisition, and reduces coordination and relocation of public utilities and costly short-term or permanent impacts to traffic during construction, operation, and maintenance of the Selected Alternative

- "Expandable" Alternatives
    - Fluctuations in population, commercial and industrial users within the PVSC treatment district as well as increased use of water-saving technologies may result in variations of dry and wet weather flow conditions in the future.
    - No further expansion of the plant capacity is anticipated to be necessary; however, plant operations can be modified to address the changing needs of the Treatment District and its member communities
- Ease of permitting/potential permitting issues
    - As permitting for the construction of the Selected Alternatives is consistent with those obtained for current construction projects being performed at the WRRF, no permitting issues are anticipated.
    - Maintenance and Protection of Plant Operations will be incorporated into the construction documents to maintain plant performance and NJPDES Permit throughout construction of the Selected Alternative.

D.3.6 Selection of Recommended Alternative

As noted in **Section D.3** above, only one of the CSO Control Technologies, Secondary Treatment Bypass, was pre-selected as feasible as part of the DEAR Screening of Technologies and meets the selection criteria defined in this Section as follows:

- Can be implemented by PVSC independently from the CSO Permittees in the hydraulically connected system
- Achieves one of the nine minimum controls required by the permit
- Achieves permit compliance both during and post-construction
- Achieves non-monetary factors such as low impact to the public during construction and operation, benefits water quality of the receiving water body, and contributes to CSO discharge volume reduction
- Represents a low-cost solution when compared to treatment process expansion or addition, or to a new tunnel or interceptor located within the public and/or private property

Furthermore, the NFA Analysis identified the Secondary Bypass for wet weather flows over 400 MGD as the only alternative to reliably treat 720 MGD while maintaining permit compliance. It was also identified as the most cost effective, expedient, and technically feasible alternative.

The Secondary Treatment Bypass was presented to the Public by PVSC in the context of the NFA Analysis team in October 16, 2018, and was introduced to the public in the context of the

DEAR and SIAR development at the Public Participation Meetings held in the years 2019 and 2020. Refer to the Public Participation Report in Appendix E of the Regional LTCP for more detail.

Table D-3 summarizes the CSO volume reduction, and cost for the selected alternative.

Table D-3: Selected Alternative

Selected Alternative	Additional CSO Volume treated	Capital Cost
PVSC WRRF Secondary Treatment Bypass	752 million gallons/year	$45M

D.4 DESCRIPTION OF RECOMMENDED LTCP

Section D.3 describes the process to select the alternative for the PVSC LTCP. The screening of CSO control technologies as part of the DEAR, NFA Analysis, and criteria established as part of the SIAR resulted in the selection of the PVSC WRRF Secondary Treatment Bypass Expansion to 720 MGD Alternative. Implementation of this Alternative is recommended for the PVSC LTCP regardless of whether a regional collection system alternative or independent LTCP implementation is selected by PVSC and the CSO Permittees of the hydraulically connected communities.

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SECTION E - FINANCIAL CAPABILITY

E.1 INTRODUCTION

This section of the SIAR quantifies the projected affordability impacts of the proposed long term CSO controls on the eight combined sewered municipalities that are served by PVSC.

The Financial Capability Assessment is a two-step process including ***Affordability*** which evaluates the impact of the CSO control program on the residential ratepayers and ***Financial Capability*** which examines a Permittee's ability to finance the program. Affordability is measured in terms of the Residential Indicator (RI) which is the percentage of median household income (MHI) spent on wastewater services. Total wastewater services exceeding 2.0% of the median household income are considered to impose a high burden by USEPA. The financial capability analysis uses metrics similar to the municipal bond rating agencies.

E.2 BASELINE CONDITIONS (WITHOUT CSO CONTROLS)

This analysis utilizes 2019 as the base year for wastewater system costs and for the annual cost per typical single family residential user of the municipal wastewater systems. For the PVSC analysis, annual costs and median household incomes are averages weighted by the number of households in each municipality using U.S. Census data as shown in **Table E-1**.

Table E-1: Baseline (2019) Annual Wastewater Costs per Typical Single Family Residential User

Municipality		2019 Cost per Typical Residential User		
		$ / Year	Median Household Income	Residential Indicator
1	Bayonne	$421	$58,800	0.72%
2	East Newark	$436	$61,400	0.71%
3	Harrison	$395	$63,600	0.62%
4	Jersey City	$440	$62,700	0.70%
5	Kearny	$499	$64,400	0.77%
6	Newark	$340	$35,600	0.96%
7	Paterson	$463	$36,200	1.28%
8	North Bergen MUA	$557	$59,600	0.93%
Averages Weighted by Households		$421	$49,975	0.88%

The estimated annual cost for wastewater services for a typical single-family residential user for 2019 was $421. This estimate is based on typical residential potable water usage is 4,500 gallons monthly. It includes, where applicable, both direct wastewater service charges and the estimated portions of property taxes for the average residential assessment that may be attributed to the operation and maintenance of the municipal collection sewer systems.

Based on the estimated household weighted MHI of $49,975 the Residential Indicator was 0.88% in 2019, or at the border between what the EPA guidance defines as a low burden and a medium burden. By definition the current residential indicator for one half of the households is greater than the 0.88%.

E.3 SUMMARY & CONCLUSION

E.3.1 Affordability Impacts of the Proposed CSO Controls

PVSC has committed to expanding the wet weather treatment capacity at its wastewater treatment plant to 720 MGD which will provide substantial CSO control benefits to the eight combined sewered municipalities. Planning and design work for this capacity expansion is underway and the project is projected to be completed in 2024. The estimated capital costs for this project total approximately $45 million and the projected incremental annual operation and maintenance costs resulting from the plant expansion are $640,000.

Since the capacity expansion will provide benefits to the overall PVSC service area, it anticipates that these costs will be allocated across the entire service area utilizing its existing cost allocation methodology. For purposes of this analysis only, it is assumed that the entire $45 million in capital costs will be financed through new borrowing using the New Jersey Infrastructure Bank with 20 year loans. The resulting annual debt service payments and incremental O&M costs are estimated to be $3.9 million. Of this, the eight combined sewered municipalities would be responsible for around $2.5 million. Based on the 2019 PVSC intermunicipal cost allocations, the projected incremental costs by municipality are as shown on **Table E-2**.

Table E-2: Impacts of PVSC Plant Capacity Expansion on Municipal and Residential Costs

	Municipality	Incremental PVSC Annual Costs	Annual Impacts on Typical Single Family Residential Wastewater User		
			Incremental	Total Annual	Residential Indicator
1	Bayonne	$135,200	$2.20	$423	0.72%
2	East Newark	$8,500	$9.48	$445	0.73%
3	Harrison	$22,300	$4.48	$399	0.63%
4	Jersey City	$597,200	$4.06	$444	0.71%
5	Kearny	$126,400	$11.40	$510	0.79%
6	Newark	$1,161,500	$6.58	$347	0.97%
7	Paterson	$343,800	$8.20	$471	1.30%
8	North Bergen MUA	$103,300	$3.43	$560	0.94%
	Total	$2,498,200			
	Weighted by # Households		$5.60	$426	0.90%

As shown on **Table E-2**, the impact on typical single family residential user costs per year are around $5.60 weighted by the number of households. The total cost per household would increase to around $426 from $421 and the residential indicator would increase slightly from 0.88% to 0.90%. It should be noted that the projected costs per typical residential user do not include the municipalities' costs of implementing their respective CSO Long Term Control Plans. The above analysis is limited to the impacts of the PVSC plant expansion costs.

E.3.2 Financial Capability Assessment

The second part of the financial capability assessment - calculation of the financial capability indicator for the Permittee - includes six items that fall into three general categories of debt, socioeconomic, and financial management indicators. The six items are:

1. Bond rating
2. Total net debt as a percentage of full market real estate value
3. Unemployment rate
4. Median household income
5. Property tax revenues as a percentage of full market property value
6. Property tax revenue collection rate

Each item is given a score of three, two, or one, corresponding to ratings of strong, mid-range, or weak, according to EPA-suggested standards. The overall financial capability indicator is then derived by taking a simple average of the ratings. This value is then entered into the financial capability matrix to be compared with the residential indicator for an overall capability assessment). Numbers 2, 5 and 6 these metrics are applicable only to municipalities utilizing tax funded general obligation debt. Therefore, this analysis is limited to those metrics that are applicable to the use of revenue funded debt. As shown on **Table E-3**, the overall score for the financial indicators is 2.0 yielding an EPA Qualitative Score of "midrange". As each of the financial indicators are generally based upon publicly available data from 2019 or earlier, this analysis does not reflect the current and lingering impacts of the COVID -19 Pandemic and should be revisited upon memorializing the LTCP implementation schedule in the City's next NJPDES Permit.

Table E-3: Permittee Financial Capability Indicator Benchmarks

Indicator	Rating	Numeric Score
Bond Rating	Strong	3.0
Unemployment Rate (municipal data weighted by # households)	Weak to Midrange	1.5
Median Household Income (municipal data weighted by # households)	Weak to Midrange	1.5
	Total	6.0
	Overall Indicator Score: (numeric score / number of applicable indicators)	2.0
	EPA Qualitative Score	Midrange

E.3.3 Implementation Feasibility Implications

The 1997 EPA guidance indicates that ratepayers and Permittees who are highly burdened future expenditures added to their current wastewater treatment, conveyance, and collection costs can be allowed 15 years to complete capital projects to handle CSOs. In extreme cases, the guidance suggested a 20-year compliance schedule might be negotiated.[1]

The affordability analysis detailed above has documented that the selected $45 million (current dollars) capital expenditures improvement program along with related operation and maintenance costs would result in a Residential Indicator of 0.90%, slightly below the EPA "median burden" trigger upon completion of the PVSC plant expansion. Again, this result does not include the impacts of the costs of the municipalities' long term control programs. These impacts are evaluated in Section E of their respective SIARs. Additional details for each municipality are provided in individual FCA Memoranda presented in Appendix P of the Regional LTCP enforcing the limits to the affordability of CSO controls and the City's financial capability.

E.3.4 Potential Impacts of the COVID-19 Pandemic in Affordability

The projections and conclusions concerning the affordability of the CSO control program proposed in this SIAR by PVSC are premised on the baseline financial conditions of PVSC and the municipalities as well as the economic conditions in New Jersey and the United States generally at the time that work on this SIAR commenced. While the impacts of the pandemic on the long-term affordability of the CSO LTCP are currently still unknown, it is reasonable to expect that there will be potentially significant impacts. There are several dimensions to these potential impacts, including reduced utility revenues and household incomes
.

Given the current and likely continuing uncertainties as to the New Jersey and national economic conditions, PVSC and the municipalities will be reticent to commit to long term capital expenditures for CSO controls without the incorporation of adaptive management provisions, including provisions to revise and reschedule the long term CSO controls proposed in this SIAR based on emergent economic conditions beyond the permittees' control. These provisions could include scheduling the implementation of specific CSO control measures to occur during the five year NJPDES permit cycles. Although an implementation schedule is being proposed as part of this SIAR based upon the findings of the FCA, a revised affordability assessment should be performed during review of the next NJPDES permit to re-evaluate and validate financial capability and to identify any revisions to the proposed controls that may or may not be financially feasible during that next permit period.

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[1] Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development, EPA 832-B-97-004, Page 46.

SECTION F - RECOMMENDED LONG-TERM CONTROL PLAN

F.1 INTRODUCTION

With an annual average design treatment capacity of 330 MGD, PVSC has evaluated alternatives to expand the WRRF wet weather treatment capacity to 720 MGD while maintaining compliance with all NJPDES permit conditions and requirements, and avoiding costly, complex, and unproven upgrades. **Section D.3** describes the process to select the recommend Secondary Treatment Bypass Alternative for the PVSC LTCP.

F.2 RECOMMENDED LTCP

Given that, as discussed in **Section D.3,** only one Alternative was considered feasible for independent implementation by PVSC. The recommended PVSC LTCP comprises the Selected Alternative, as the single element of the LTCP. This is a favorable outcome to the municipalities served by PVSC and the waterbodies to which the PVSC WRRF discharges, as it allows for faster implementation and benefits to the community and the CSO Permittees during the first NJPDES permit cycle of the LTCP implementation schedule.

The Recommended LTCP will be implemented by PVSC independently from other Permittees within the CSS PVSC Treatment District. It consists of implementing the PVSC WRRF Secondary Treatment Bypass, which can bypass up to 320 MGD from the primary clarifiers' effluent channel to the effluent channel of the secondary clarifiers, where the flows would be combined and disinfected prior to discharge. This bypass will maximize the plant's wet weather treatment capacity up to 720 MGD, allow for the entirety of the primary effluent flows to be disinfected prior to discharge, and will reduce the CSO volume discharged upstream of the WRRF. The Secondary Treatment Bypass Alternative details are discussed in **Section D.3** of this report, and in **Appendix A**.

F.3 IMPLEMENTATION COST OPINION

PVSC plans to fund the Secondary Treatment Bypass through the New Jersey Infrastructure Bank. The updated estimated capital cost as of June 2020 is $45 million. The current estimated yearly operation and maintenance cost is $0.64 million. The estimated life cycle cost opinion is approximately $55 million based on a 20-year useful life.

Given the Secondary Treatment Bypass is currently at the preliminary design stage, the capital cost opinion is $45 million. This has been updated from the cost stated in the NFA Analysis Report which included a high-level/planning level construction cost opinion. At the current design stage, a budgetary construction cost opinion has been developed by the Design Engineer based on the Association for the Advancement of Cost Engineering (AACE) guidelines for an International Class 5 estimate. Class 5 estimates have a typical accuracy of -50% to -20% on the low side and +30% to +100% on the high side. This latest conceptual design capital cost opinion includes design engineering fees, engineering design services and supervision during construction, and the following construction cost assumptions:

1. General Conditions and Indirect Costs - 15%
2. Subcontractor Overhead and Profit - 21%
3. Contractor Overhead - 10%

4. Contractor Profit - 10%
5. Contractor Profit on Subcontracted Work - 5%
6. Escalation to Midpoint of Construction - 9.8%, based on historical average of 3%/year
7. Bond and Insurance - 3%
8. Design Contingency - 40%

F.4 IMPLEMENTATION SCHEDULE

The PVSC NJPDES Permit requires that *"the Permittee [shall] submit a construction and financing schedule in accordance with D.3.a and G.10, for implementation of Department approved LTCP CSO controls. Such schedules may be phased based on the relative importance of the adverse impacts upon water quality standards and designated uses, the Permittee's financial capability, and other water quality related infrastructure improvements, including those related to stormwater improvements that would be connected to CSO control measures."*

At the time of the development of this report, the COVID-19 Pandemic has greatly impacted the State of New Jersey such that the design schedule of the Secondary Treatment Bypass has been delayed. The Secondary Bypass is now expected to be in operation at the end of 2026. **Table F-1** presents the estimated schedule for implementation of the Recommended PVSC LTCP.

Table F-1: Implementation Schedule for the PVSC LTCP

Project	Description	Year
Secondary Treatment Bypass	Final Design	2022
	Submit to NJIB for Authorization to Advertise	2023
	Construction Start[1]	2023
	Construction Completion[2]	2025
	Placed in Operation[3]	2026

1. Assuming an Authorization to Advertise is issued in a reasonable amount of time by the NJIB, a successful bid process and an Authorization to Award is issued by the NJIB.
2. Assumes construction start in the third quarter of 2023 and no issues encountered during construction including impacts due to coordination with other ongoing construction projects.
3. Assumes no issues during construction including impacts due to coordination with other ongoing construction projects.

F.5 BASIS FOR LTCP DEVELOPMENT AND IMPLEMENTATION SCHEDULE

The LTCP development and implementation schedule is based on the construction schedule for each project, and the financing schedule for the overall LTCP. As the single element of the Recommended PVSC LTCP, design of the Secondary Treatment Bypass project is currently underway. The facility is expected to be completed and placed in operation in the year 2024. **Table F-1** above presents the design and construction schedule for this project.

F.6 CSO REDUCTION VERSUS TIME

According to the NFA Analysis Report and further updated through modeling, once the Secondary Treatment Bypass is implemented, the reduction in CSO discharges are projected to be 750 million gallons per year based on the typical hydraulic year. Additional reduction in CSO discharges totaling 1 billion gallons per year (based on the typical year) can be realized with the simultaneous implementation of the Regional Parallel Interceptor described in **Section D.3.**

Appendix A

Passaic Valley Sewerage Commission, New Jersey - WWTP No Feasible Alternatives (NFA) Analysis Report, Final Report, January 2019

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Passaic Valley Sewerage Commission, New Jersey – WWTP No Feasible Alternatives (NFA) Analysis

Final Report

Hazen Project No. 90319-000

January 2019

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Attachment 2: Sensitivity Assessment of the Final Settling Tanks at the Passaic Valley Sewerage Commission (PVSC) with the aid of a 3D CFD Model, March 2017

Attachment 3: Sodium Hypochlorite Storage Facilities Upgrade Project Investigation Phase - Findings Summary, May 21, 2014

1. Introduction

1.1 Objective

The Passaic Valley Sewerage Commissioners (PVSC) owns and operates one of the nation's largest wastewater treatment facilities. With an annual average design treatment capacity flow of 330 million gallons per day (mgd), PVSC is currently evaluating alternatives to expand its wet weather treatment capacity to 720 mgd while maintaining compliance with all conditions and requirements of its New Jersey Pollutant Discharge Elimination System (NJPDES) permit, and avoiding costly, complex, and unproven upgrades. Currently, PVSC's secondary treatment train is limited to an instantaneous flow of 400 mgd based on historical plant observations, numerous studies involving site specific sampling, stress-testing, and Computational Fluid Dynamics (CFD) modeling of the secondary clarification process. Permit compliance cannot be guaranteed with instantaneous flows higher than 400 mgd under all process conditions. The capacity limitation which is primarily associated with the Final Clarifiers (FCs) is addressed in this report by examining several alternatives with the intention of increasing the plant's overall treatment capacity.

1.2 Procedures of Analysis

An analysis of historical plant influent, performance, and operating data and previously conducted feasibility studies provided the starting point and foundation for the results presented herein. This foundation was combined with the use of sophisticated, plant-specific modeling tools calibrated to historical PVSC operations and processes (Infoworks for hydraulic modeling, BioWin process modeling, and CFD modeling of secondary clarification) and construction cost estimates to determine the effectiveness and feasibility of implementing operational and/or infrastructure changes to meet the objective of increasing wet weather treatment capacity at the PVSC wastewater treatment facility.

Historical data and limited field sampling provided influent loading conditions, operational conditions, and effluent quality with which to calibrate and validate the modeling tools. BioWin and CFD models were combined dynamically to predict secondary plant performance. These tools were applied to various potential wet weather treatment alternatives to predict treatment capacities and effluent quality.

Effectiveness, schedule of implementation, and costs of each alternative were estimated to determine the feasibility of actual implementation of the various alternatives. The need for additional testing and current status in the industry at plants of a similar size and treatment process was also taken into account to determine the feasibility of the various alternatives.

2. Description of Existing System

2.1 Plant History

Construction of the original plant facilities, which provided only primary treatment for an average wastewater flow of about 150 mgd, was completed in 1924. Since then, numerous plant expansions have been constructed to increase capacity. In the 1930s and 1940s, additional sedimentation basins were constructed. In the 1950s and 1960s, the sedimentation basins were mechanized, and their capacity was increased. Sludge handling facilities were added, and modifications were made to the grit chambers and screenings facility.

Additional construction of a grit and screenings chamber, grit and screenings incinerator facilities, and chlorination facilities were initiated in the early 1970s to improve treatment, increase capacity, and implement Environmental Protection Agency (EPA) disinfection requirements.

To bring the plant into full compliance with more stringent EPA requirements on water quality, construction of an upgrade to secondary treatment levels with a full replacement of the existing primary clarifiers began in 1977. Secondary plant start-up occurred in October of 1981, and full plant start-up with the new primary clarifiers occurred in December of 1985.

To meet the March 17, 1991 New Jersey Department of Environmental Protection (NJDEP) deadline to end Sludge Ocean Dumping, a new Interim Sludge Dewatering Facility was constructed, with start-up on March 11, 1991. Dewatered Sludge Cake was shipped by rail to various landfills until September 1996 when landfilling was stopped and beneficial reuse of sludge cake through daily landfill cover began.

2.2 Current Plant Treatment Operations

The PVSC facility is one of the largest wastewater facilities in the United States. It is located in Newark, NJ on a 162-acre plant site, and has the capacity to discharge 330 mgd (annual average) of treated wastewater. **Figure 2-1** provides a site aerial. PVSC provides secondary treatment using a high purity oxygen activate sludge (HPOAS) process.

A description of the various treatment processes and major equipment are provided below and called out in **Figure 2-2,** with a focused view of the liquid treatment train shown in **Figure 2-3**. The units currently in operation include:

- Preliminary Treatment facilities containing six 12 ft. wide climber bar screens with six gravity grit channels
- An Influent Pumping Station containing six 90 mgd screw pumps
- Four wet weather pumps, pumps No. 1 through 3 with a 100-125 mgd capacity (note pump No. 1 is currently out of service), pump No. 4 with a 225 mgd capacity
- Twelve Traveling Bridge Primary Clarifiers (PCs), each 90 ft. by 280 ft. by 12 ft. deep
- Twelve four-compartment Biological Oxygenation Tanks, each 58 ft. by 235 ft. by 30 ft. deep, with mixer-type rotating surface aerators utilizing pure oxygen
- Return and Waste Activated Sludge (RAS and WAS) Pumps; three 75 mgd RAS screw pumps and four 5 mgd WAS pumps

- Two Oxygen Production Plants designed to produce 500 tons of pure oxygen per day with a storage tank which can hold 2,000 tons of liquid oxygen at minus 280°F
- Twelve three-compartment Slip Tube Final Clarifiers (FCs), each 120 ft. by 362 ft. by 14 ft. deep
- An Effluent Pumping Station with four 250 to 310 mgd pumps
- A Sodium Hypochlorite Chlorination facility consisting of five 30,000-gallon storage tanks and three metering pumps; three 14 gpm pumps, with a total capacity of 42 gpm and firm capacity of 28 gpm
- A Gravity Thickener complex with twelve 100-foot-diameter, 24 feet deep (from weir to bottom of cone) units with 24 (320 gpm) thickened sludge pumps (note, not all tanks are used as thickeners)
- Four 1,200 gpm thickening centrifuges to increase the sludge solids content from the Gravity Thickeners
- A twelve-train Sludge Heat Treatment Facility (ZIMPRO) capable of stabilizing and sterilizing sludge by means of heating to 390°F at a pressure of 650 psi. Each train can treat 260 gpm of sludge, and not all trains are available for use.
- Six covered Decant Tanks 85 ft. diameter by 30 ft. deep, used to concentrate the stabilized sludge, with 12 decant (440 gpm) sludge pumps
- A Supernatant Treatment Plant (STP) utilizing 4 extended aeration activated sludge trains to decrease the high pollutant load in the liquid fraction of the treated sludge before it is returned to the main treatment plant (available if needed, but currently not in use and would need significant rehabilitation);
- Five, two-meter by two-meter, recessed chamber filter presses to dewater the heat-treated sludge

The infrastructure described above for the liquid and solids treatment trains at PVSC can provide reliable conveyance and treatment for all dry weather flows and loads, allowing for the annual average design treatment flow of 330 mgd plus an appropriate quantity of wet weather flow. The plant infrastructure also has hydraulic capacity for instantaneous wet weather flows up to 720 mgd through preliminary, primary and secondary unit processes.

PVSC’s secondary treatment plant is properly operated and maintained and has been designed to meet secondary limits (actual limits provided in **Table 2-1**) for flows greater than peak dry weather flows and consistently maintains permit compliance through its secondary treatment processes up to an instantaneous wet weather flow of 400 mgd. The long-standing challenge at PVSC is the impact of wet weather flows on New Jersey Pollutant Discharge Elimination System (NJPDES) effluent pollutant concentrations limits and percent removals for Carbonaceous Biochemical Oxygen Demand (CBOD) and Total Suspended Solids (TSS) associated with FC performance. The unique FCs have three sequential circular sludge collector mechanisms in large rectangular tanks and have caused a bottleneck in the wet weather capacity of the PVSC plant. Despite the challenges with the FCs, PVSC has not been issued a significant Notice of Violation of non-compliance due to failures of the operation or maintenance of its secondary treatment processes in over 15 years. See **Section 2.7** for further details on the assessment of the existing FCs.

2.3 Process Flow Diagram

The PVSC process flow diagrams shown in **Figure 2-4** and **Figure 2-5** depict the plant's operation in dry and wet weather, respectively. Due to the capacity of the secondary treatment system (further discussed in **Section 2.7)**, flow to the plant is limited during wet weather events by closing upstream interceptor regulator gates. Up to six of the plant's twelve PCs are used to store and equalize influent wet weather flow, which is then bled back into the treatment process as the storm subsides (further discussed in **Section 2.4)**. At high flow operation and depending upon the tidal condition, flows in excess of the capacity of the main outfall (Outfall 001A) to the Upper New York Bay are directed to a separate chlorine contact tank for disinfection and discharge through a second outfall to the Newark Bay (Outfall 002A).

Figure 2-1: PVSC Aerial

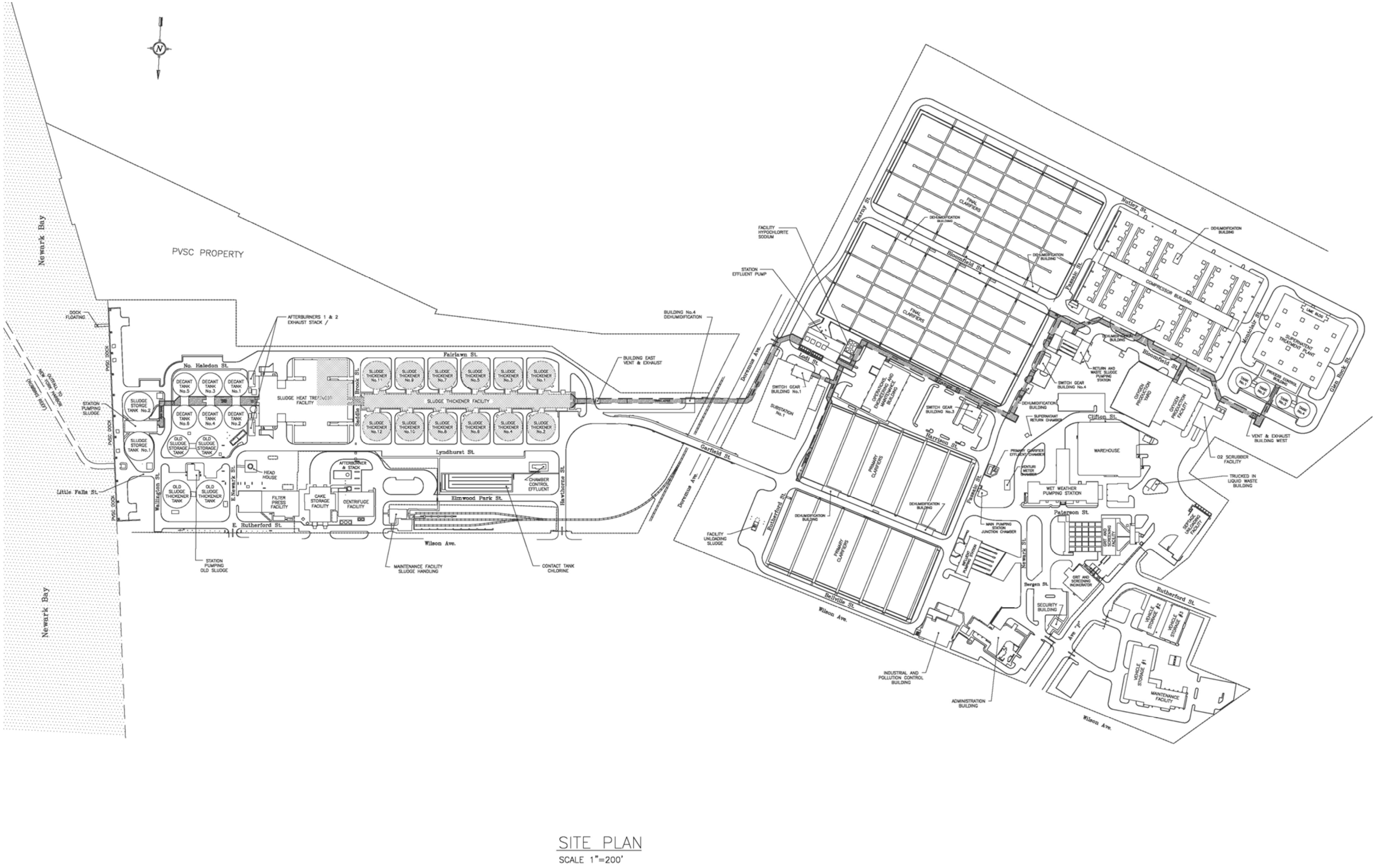

Figure 2-2: PVSC Site Plan and Treatment Facilities

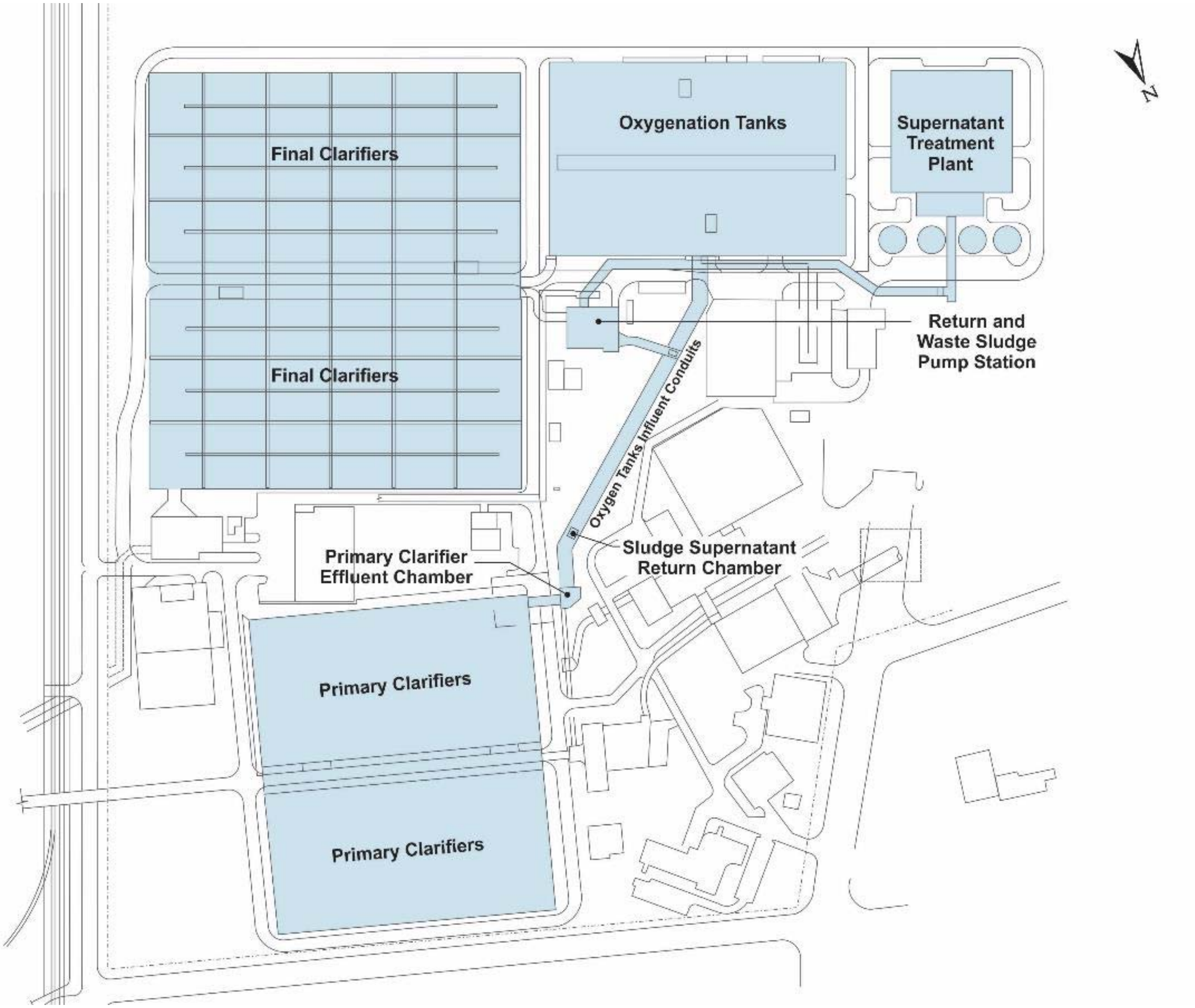

Figure 2-3: PVSC Site Plan and Treatment Facilities – Liquid Treatment

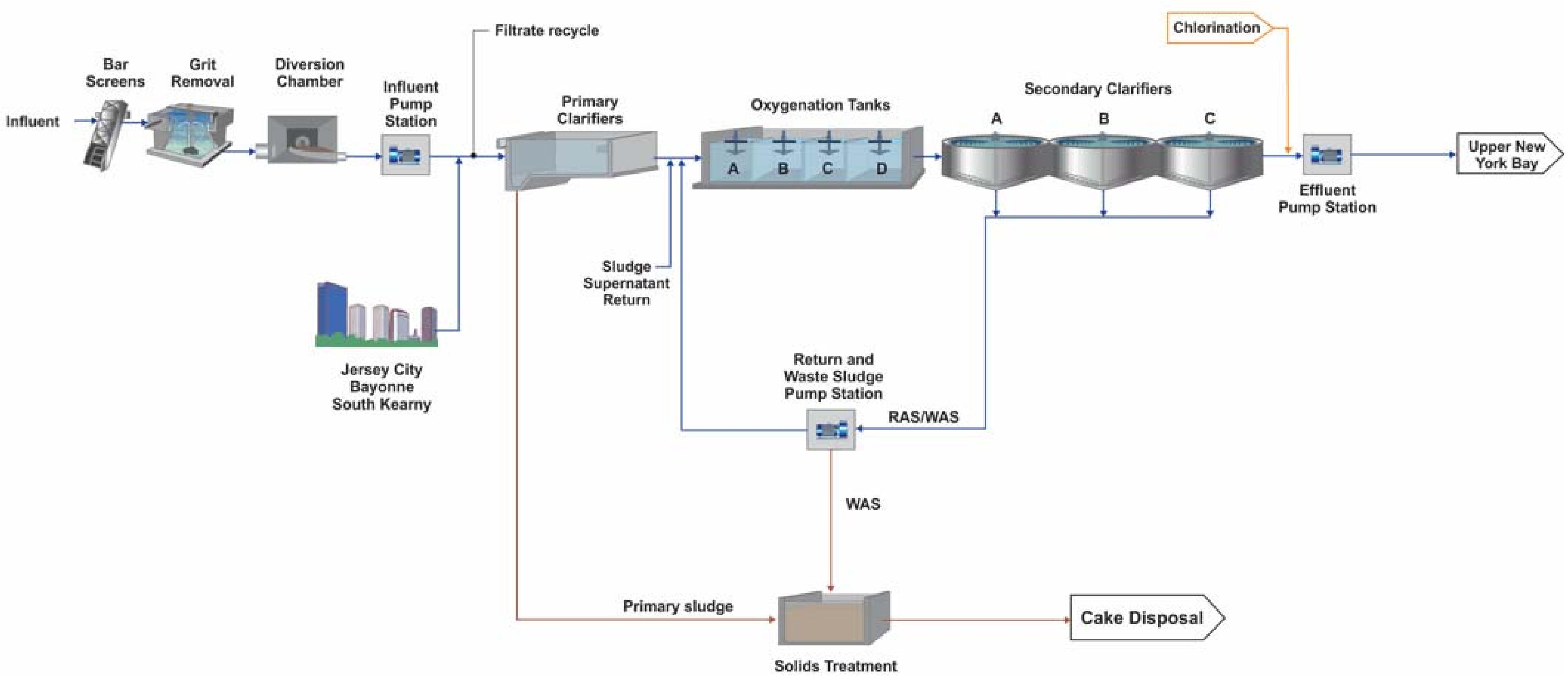

Figure 2-4: PVSC Dry Weather Process Flow Diagram

Note, both dry and wet weather pumps are utilized during dry weather conditions to ensure all equipment is available and functional during wet weather events.

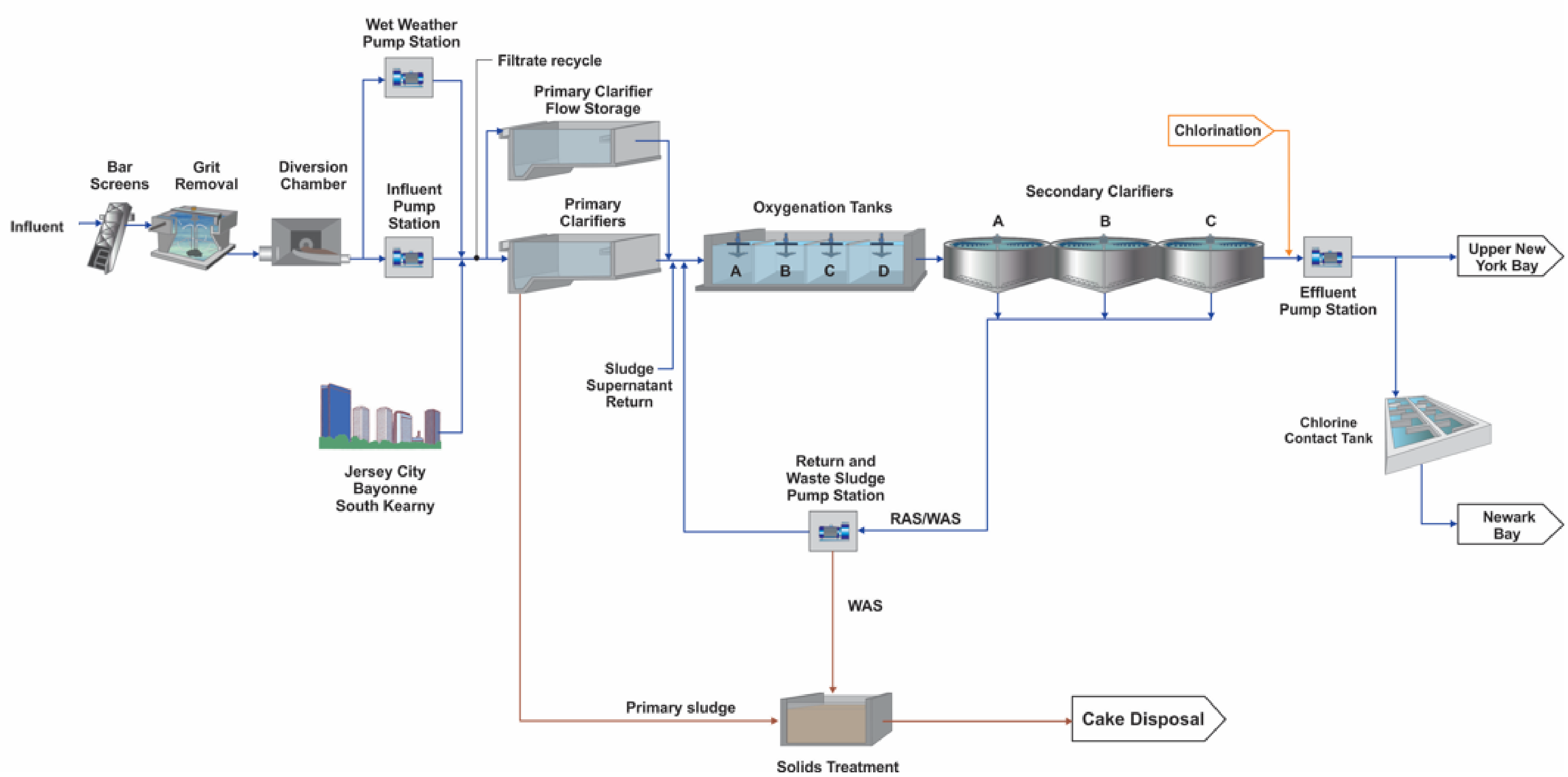

Figure 2-5: PVSC Wet Weather Process Flow Diagram

2.4 Current Wet Weather Flow Process

During wet weather events, CSO regulator gates are utilized to maintain flows in the treatment plant to prevent non-compliance with PVSC's NJPDES permit treatment requirements and prevent washout of biomass from the FCs. Note, CSO regulators are not activated in dry weather. When the influent flow reaches an instantaneous maximum of 350 mgd during a wet weather event, all regulator gates are closed with the exception of the Clay Street regulator.

In order to reduce the amount of CSO, PVSC has implemented an operating procedure to convert available offline PCs to wet weather flow storage. When the influent flow reaches an instantaneous maximum of 400 mgd during a wet weather event, up to six PCs are filled with influent flow for storage. When the available PCs are full, and flow to the plant is still above 400 mgd, the Clay Street regulator is closed if required. Notification emails are sent to the Newark Regulator Use Notification Group when regulator gates are closed and reopened, with emails sent out both with the initial closing of regulator gates and when the Clay Street Regulator is closed.

When the plant influent flow falls below 350 mgd, even if the wet weather event is continuing, regulator gates are reopened. If, during a wet weather event, flow increases above 350 mgd after reopening the Regulator Gates, professional judgment is used, based upon current plant conditions, to determine if the Regulator Gates need to be re-closed to maintain effluent permit requirements. Filled PCs are dewatered to the primary facility main conduit after the wet weather event has concluded.

Use of PCs for flow storage is limited to the number of PCs offline/available for wet weather storage and the duration of the storm; storage PCs take approximately 20 minutes to fill. By implementing wet weather flow storage in the PCs, PVSC has **prevented approximately 150 million gallons of CSO in 2017.**

2.5 NPDES Effluent Requirements

PVSC is authorized by the NJDEP to discharge to the Upper New York Bay through Outfall 001A under the NJPDES permit number NJ0021016. Discharges to the Upper Newark Bay through Outfall 002A are allowed when the hydraulic capacity of outfall 001A to Upper New York Bay is exceeded during periods of heavy precipitation. All effluent discharged to the Upper Newark Bay must receive the same treatment as effluent discharged to the Upper New York Bay. There is no bypassing of any treatment steps in the current operation. The current effluent permit requirements are provided in

Table 2-1. Note, the weekly average is monitored using a rolling 7-day average that re-starts at the beginning of each month.

Table 2-1: PVSC Permit

Parameter	Unit	Limit	Details
Flow	mgd	330	Annual Average
Effluent TSS	mg/L	30	Monthly Average
	kg/d	41,900	Monthly Average
	mg/L	45	Weekly Average
	kg/d	62,850	Weekly Average
	%	85	Monthly average (minimum)
Effluent Ammonia	kg/d	53,700	Monthly Average
	kg/d	78,400	Daily Maximum
Effluent Fecal Coliform	#/100mL	200	Monthly Geometric Average
	#/100mL	400	Weekly Geometric Average
Effluent CBOD	mg/L	25	Monthly Average
	kg/d	34,916	Monthly Average
	mg/L	40	Weekly Average
	kg/d	55,867	Weekly Average
	%	85	Monthly average (minimum)
Total Cyanide	kg/d	120	Monthly Average
	kg/d	255	Daily Maximum
Nickel	kg/d	150	Monthly Average
	kg/d	262	Daily Maximum
Zinc	kg/d	562	Monthly Average
	kg/d	1,037	Daily Maximum
Lead	kg/d	162	Monthly Average
	kg/d	300	Daily Maximum
Copper	kg/d	187	Monthly Average
	kg/d	350	Daily Maximum
Mercury	kg/d	2.5	Monthly Average

2.6 Design Capacities of Treatment Units

Table 2-2 summarizes the unit processes and design capacities for PVSC's secondary treatment system. As shown, the secondary treatment processes are sized for a peak hourly flow of 720 mgd.

Table 2-2: PVSC Unit Processes and Design Capacities

	Units	Annual Average	Maximum Month	Peak Hourly
Design Influent Conditions				
Flow	mgd	330	434	720
Biochemical Oxygen Demand (BOD)	mg/l	240	-	-
	lbs/day	661,000	-	-
Total Suspended Solids (TSS)	mg/l	344	-	-
	lbs/day	947,000	-	-
Existing Influent Conditions (2012 to 2017)				
flow	mgd	228	300	698
Carbonaceous Biochemical Oxygen Demand (CBOD)	mg/l	179	-	-
	lbs/day	340,000	448,000	-
	Peaking Factor (PF)	1.0	1.3	-

	Units	Annual Average	Maximum Month	Peak Hourly
Total Suspended Solids (TSS)	mg/l	157	-	-
	lbs/day	299,000	393,000	-
	PF	1.0	1.3	-
Influent Pumping (dry weather)				
No. of pumps installed	-	6	6	6
No. of pumps operating	-	3	4	5
Approximate pump capacity	mgd	90	90	90
Influent pumping rate	mgd	270	360	450
Wet Weather Pumping				
No. of pumps installed	-	4	4	4
No. of pumps operating	-	0	0	2
Approximate pump capacity	mgd	100-125 or 225	100-125 or 225	100-125 or 225
Influent pumping rate	mgd	0	0	~325
Rated TOTAL influent pumping capacity (Dry plus Wet Weather Pumping)	**mgd**	**270**	**360**	**775**
Grit Removal				
No. of grit removal units installed	-	6	6	**6**
No. of grit removal units operating	-	3	4	6
Grit Removal unit Capacity	mgd	120	120	120
Rated influent Grit Removal capacity	mgd	360	480	720
Mechanical Screening				
No. of screens installed	-	6	6	6
No. of screens operating	-	3	4	6
Screen Capacity	mgd	120	120	120
Rated influent Screening capacity	mgd	360	480	720
Primary Clarifiers				
No. of tanks	-	12	12	12
No. of tanks operating	-	6	9	12
Length	ft	280	280	280
Width	ft	90	90	90
Side water depth (swd)	ft	12.33	12.33	12.33
Surface area per tank	sf	25,200	25,200	25,200
Total surface area	sf	151,200	226,800	302,400
Approximate SOR	gpd/sf	504	756	1,008
Weir length per tank	ft	1,028	1,028	1,028
Weir length	ft	6,168	9,252	12,336
Approximate weir overflow rate	g/lf/day	53,500	46,900	58,400
Rated primary clarifier capacity	**mgd**	**330**	**400**	**720**
Oxygenations Tanks				
No. of tanks	-	12	12	12
No. of tanks operating	-	12	12	12
No. of stages	-	4	4	4
Stage width	ft	58	58	58
Stage length	ft	58	58	58
Side water depth (swd)	ft	29.9	29.9	29.9
Volume per tank	MG	3.0	3.0	3.0
Total volume	MG	36.0	36.0	36.0
Hydraulic detention time	hours	2.6	2.0	1.2
Target MLSS	mg/l	2,200	2,200	2,200

	Units	**Annual Average**	**Maximum Month**	**Peak Hourly**
Biomass under aeration	lbs	660,500	660,500	660,500
Solids Retention Time	d	1.5-2.0	-	-
Food to Mass ratio	lbCBOD/lbVSS	0.69	-	-
Rated oxygenation tank capacity	mgd	**330**	**400**	**720**
Final Clarifiers				
No. of tanks	-	12	12	12
No. of tanks operating	-	10	11	12
Length	ft	362	362	362
Width	ft	120	120	120
Side water depth (swd)	ft	13.60	13.60	13.60
Surface area per tank	sf	43,440	43,440	43,440
Total surface area	sf	434,400	477,840	521,280
Approximate SOR	gpd/sf	760	837	1,381
Approximate SLR	lb/ft2/d	20	21	31
Weir length per tank	ft	1,391	1,391	1,391
Weir length	ft	13,910	15,301	16,692
Approximate weir overflow rate	g/lf/day	23,700	26,100	43,100
Original Design Capacity	mgd	330	400	720
Rated final clarifier capacity	mgd	400	400	400
RAS and WAS Pumping				
No. of RAS pumps installed	-	3	3	3
No. of RAS pumps operating	-	2	2	2
Approximate pump capacity	mgd	75	75	75
Influent pumping rate	mgd	150	150	150
Percent of influent flow	%	45%	35%	21%
No. of WAS pumps installed	-	4	4	-
No. of WAS pumps operating	-	3	3	-
Approximate pump capacity	mgd	5	5	-
WAS pumping rate	mgd	15	15	-
Rated RAS and WAS pumping capacity*	mgd	**330**	**434**	**720**
Disinfection				
Hypo storage				
No. of tanks	-	5	5	5
No. of tanks operating	-	5	5	5
Volume, each	MG	30,000	30,000	30,000
Volume, total	MG	120,000	120,000	120,000
Hypo Pumping				
No. of hypo pumps installed	-	3	3	3
No. of hypo pumps operating	-	2	2	2
Approximate pump capacity	gph	840	840	840
Hypo pumping rate	gpm	28	28	28
Rated Disinfection treatment capacity (for secondary effluent)	mgd	720	720	720
Chlorine Contact Tanks (for Outfall 002)				
No. of tanks	-	1	1	1
No. of tanks operating	-	1	1	1
Volume per tank	MG	2.7	2.7	2.7
HRT	min	30		20
Rated Disinfection treatment capacity	mgd	130		200
Effluent Pumping				
No. of pumps installed	-	4	4	4

	Units	Annual Average	Maximum Month	Peak Hourly
No. of pumps operating	-	1	2	3
Approximate pump capacity	mgd	240	240	240
Rated effluent pumping capacity	**mgd**	**240**	**480**	**720**
Gravity Sludge Thickening				
No. of tanks	-	12	12	12
No. of tanks operating	-	10	10	10
Diameter	ft	100	100	100
Surface Area	sf	7854	7854	7854
Centrifuge Thickening				
No. of units	-	4	4	4
No. of units operating	-	4	4	4
Unit Capacity	gpm	1200	1200	1200
Thickened sludge treatment capacity	mgd	6.9	6.9	6.9
Heat Treatment (Zimpro)				
No. of units	-	12	12	12
No. of units operating	-	8	8	8
Unit Capacity	gpm	260	260	260
Thickened sludge treatment capacity	mgd	3.0	3.0	3.0
Decant Tanks				
No. of tanks	-	6	6	6
No. of tanks operating	-	3	3	4
Diameter	ft	85	85	85
Surface Area	sf	5675	5675	5675
Recessed Chamber Filter Presses				
No. of units	-	5	5	5
No. of units operating	-	2	4	4
Unit Capacity	gpm	95	95	95
Treated sludge treatment capacity	mgd	0.27	0.55	0.55

*as a function of influent flow

2.7 Actual Capacities of Treatment Units

As mentioned previously, permit compliance cannot be guaranteed with instantaneous influent flows higher than 400 mgd under all process conditions. PVSC has a long history of attempting to improve the FC operations and increase their reliable treatment capacity. This included rebuilding of the FCs with inlet dissipation, surface floatables collection, baffle walls, draft tube sludge removal improvements and effluent launder improvements under a 1997 program. Extensive full-scale stress testing and modeling of the FC structures was completed by Hazen at the time. Despite these enhancements, effluent TSS concentrations are elevated at high flow conditions, as shown in **Figure 2-6**.

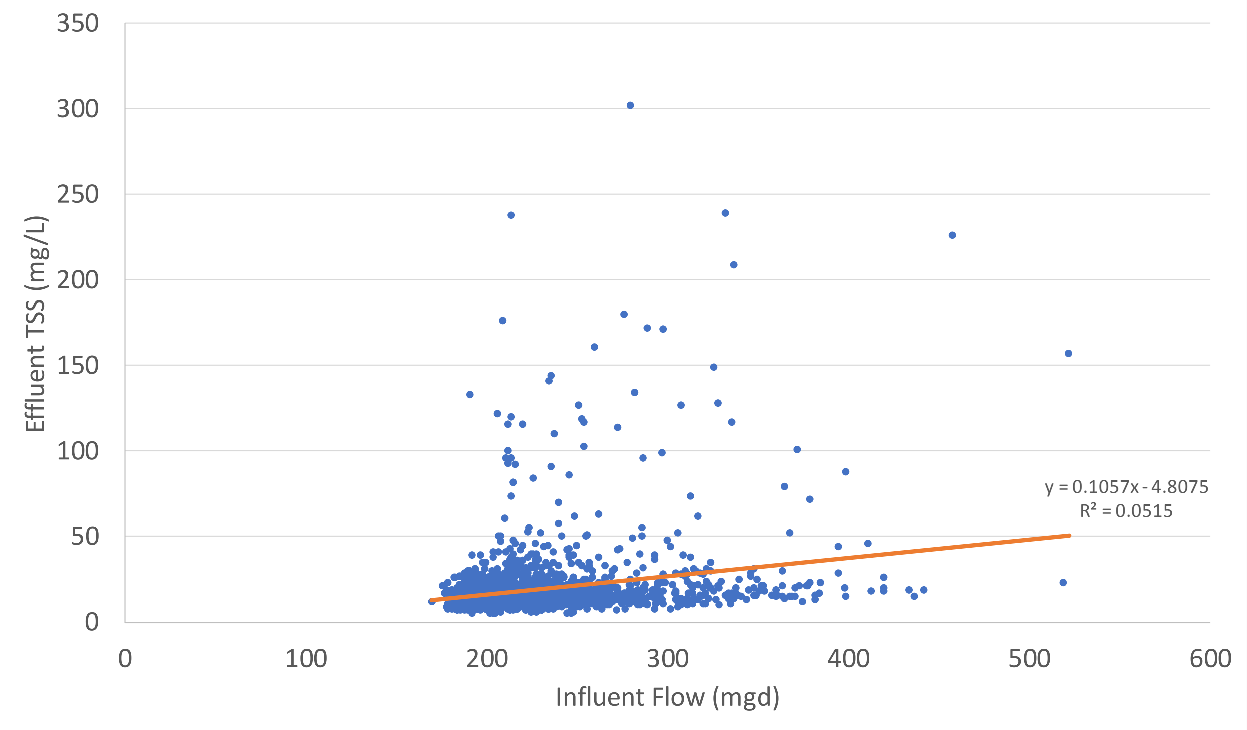

Figure 2-6: PVSC Influent Daily Flow vs. Effluent TSS

Additional and extended testing was completed by City College of New York over a 10-year period to fully document and understand limitations with the FCs.

A 3D CFD model was built of PVSC's FCs using historical data and extensive field data collected during stress testing of the FCs. The detailed sampling and modeling results conducted by the City College of New York were summarized in the document *Report on additional data collection and Performance Assessment using Computational Fluid dynamics (CFD) 3-dimensional modeling of the Final Settling Tanks at the Passaic Valley Sewerage Commissioners (PVSC) Waste Water Treatment Plant, April 2015* (Attachment 1), which concluded that at an influent flow rate of 400 mgd, the plant will violate its discharge permit limits during poor settling conditions. At instantaneous flowrates higher than 400 mgd, the FCs fill with Mixed Liquor Suspended Solids (MLSS) from the oxygenation tanks and effluent TSS and CBOD concentrations rapidly deteriorate resulting in a loss of biomass needed for treatment and possible permit violations on TSS and CBOD.

It was noted in the April 2015 report that an increased RAS flow should be considered to increase the treatment capacity at poor settling conditions, and this more detailed analysis was conducted and documented in the report *Sensitivity Assessment of the Final Settling Tanks at the Passaic Valley Sewerage Commission (PVSC) with the aid of a 3D CFD Model, March 2017* (Attachment 2). Results from the additional modeling showed that increased RAS flow could improve the capacity of the FCs to 435 mgd, however implementation of this recommendation in April 2016, as shown in **Figure 2-7**, has not resulted in an avoidance of process upsets, with elevated effluent TSS concentrations related to wet weather events.

Figure 2-7: PVSC Operation at Elevated RAS Flows

Easily implementable modifications were considered as a part of this analysis and will be discussed in **Section 4.2.2.6**.

3. Flow Characterization

3.1 Treatment Plant flows

This section will characterize the influent flow to PVSC and show the impact of wet weather on historical treatment plant influent and performance. A four-year database (2014 through 2017) was selected for all parameters presented and reviewed in this study. The timeframe selected is of a significant duration, provides several wet weather events, and did not have any major infrastructure/equipment changes or atypical catastrophic weather events.

3.1.1 Plant Influent Flow

PVSC's historical daily average influent flow from 2014 through 2017 is provided in **Figure 3-1**. As shown, seasonal wet weather flow increases with each spring are apparent, but the average plant flow of 228 mgd has been consistent over the past four years, with no overall increase in plant flow. 400 mgd is highlighted, as performance cannot be guaranteed at flows in excess of an instantaneous 400 mgd.

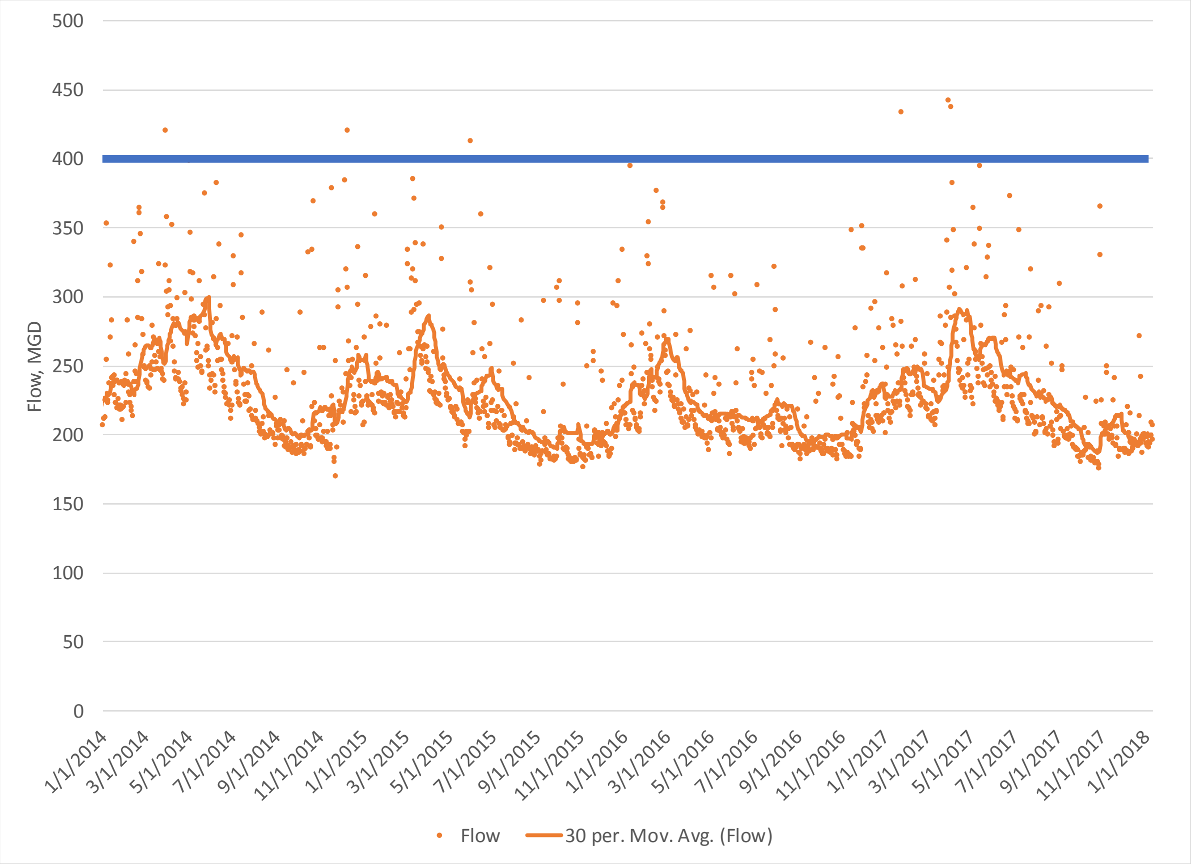

Figure 3-1: PVSC Historical Daily Average Influent Flow

Historical data for flow is broken out by year from 2014 through 2017 in **Table 3-1**, and a percentile plot of daily flow data is shown in **Figure 3-2**, with detailed information broken out in

Table 3-2. Over the past four years, daily average flows to PVSC are typically below 400 mgd; however there have been several wet weather events where the daily average flow to the plant has exceeded 400 mgd. Maximum peak hourly flows to PVSC have approximated 600 to 700 mgd historically. These historical flows in excess of 400 mgd are due to the procedure used to determine when regulator closings can be initiated, which is based on influent flow; though regulators are closed when influent flow is measured at 350 mgd, flows entering the plant can exceed 350 mgd due to the flow that is already in the pipe at the time of the regulator closing. Additionally, regulators are only closed during wet weather. There are some conditions, such as snow melt, that are not considered wet weather but still result in elevated flows. These high flow conditions have resulted in daily average effluent TSS concentrations as high as 157 mgd. Average effluent TSS concentrations for influent flows in excess of 400 mgd, weighted by the number of hours of sustained high flows, is 24 mg/L, 50 percent higher than the average effluent TSS concentration of 16 mg/L for influent flows below 400 mgd.

Table 3-1: Annual Flow Data 2014-2017

	2014	2015	2016	2017
Target flow (mgd)	720	720	720	720
Average daily flow (mgd)	243	223	219	231
Maximum average daily flow (mgd)	522	413	395	442
Maximum peak hourly flow (mgd)	699	607	565	597

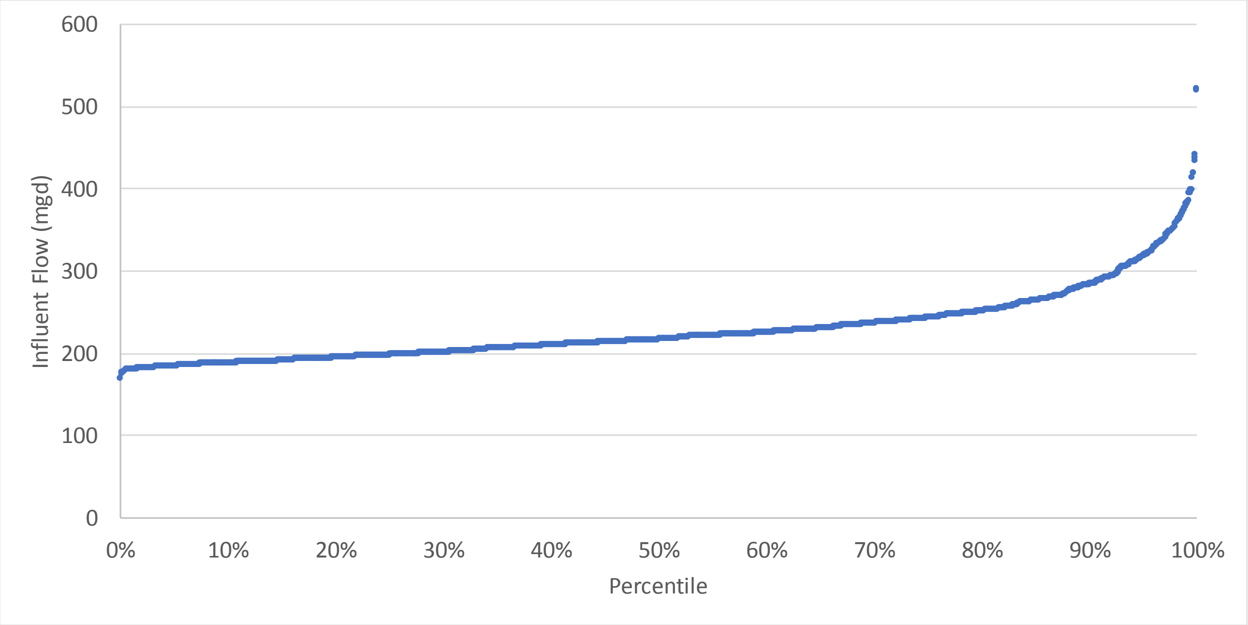

Figure 3-2: PVSC Historical Daily Average Influent Flow Percentile Plot

Table 3-2: PVSC Historical Daily Average Influent Flow Percentiles

	Daily Average Flow (mgd)
50th percentile	218
75th percentile	244
90th percentile	285
95th percentile	318
99th percentile	382

A summary of historical dry and wet weather plant effluent is provided in **Table 4-1**. Based on **Figure 3-2** and 2014-2017 historical rainfall data for Newark Airport that recorded 116 rain events per year with an average duration of approximately 6 hours, wet weather is defined as flows above the 90th percentile, established as 285 mgd in

Table 3-2. As shown in

Table 3-3, plant effluent quality shows a deterioration during wet weather events while attempting to limit instantaneous plant influent flows to 400 mgd. Wet weather loading conditions and operational observations are discussed in **Section 4.1.1**.

Table 3-3: PVSC Historical Dry and Wet Weather Performance

		Dry Weather Q_{inf} < 285 mgd	**Wet Weather Q_{inf} > 285 mgd**
Effluent TSS	mg/L	17	29

4. Potential Measures to Increase Wet Weather Capacity

4.1 Historical WWTP Flows and Loads Analysis

PVSC's historical database was used to determine typical influent flow and load conditions and PC performance under dry and wet weather, operational conditions needed to ensure sufficient biological treatment, and a typical wet weather hydrograph. These parameters were needed to develop loading scenarios and operational settings for analysis of the alternatives presented in **Section 4.2**.

4.1.1 Influent Flow and Load Conditions

A summary of historical dry and wet weather influent is provided in **Table 4-1**. As shown, plant influent loads show an increase during wet weather conditions as compared to dry weather conditions. This increase is similar in magnitude to the increased loads experienced during maximum 30-day loading conditions, detailed in **Table 4-2**.

Table 4-1: PVSC Historical Dry and Wet Weather Influent

		Dry Weather $Q_{inf} < 285$ mgd	Wet Weather $Q_{inf} > 285$ mgd
Influent cBOD	mg/L	185	143
Influent cBOD Load	lb/d	330,000	380,000
Influent COD	mg/L	440	361
Influent COD Load	lb/d	790,000	960,000
Influent TSS	mg/L	158	149
Influent TSS Load	lb/d	290,000	400,000

Table 4-2: PVSC Historical Wet Weather, Annual Avg, Max Mo, and Max 30-d Influent Loads

		Wet Weather $Q_{inf} >$ 285 mgd	Annual Average Load	Max Month Load	Max 30d Load
Influent cBOD Load	lb/d	380,000	330,000	370,000	380,000
Influent COD Load	lb/d	960,000	810,000	900,000	940,000
Influent TSS Load	lb/d	400,000	300,000	340,000	350,000

For the alternatives analysis, the maximum 30-day loading conditions were used during the simulated wet weather event, annual average loading conditions used in the dry weather conditions preceding and following the wet weather.

4.1.2 Primary Clarifier Removals

A summary of historical dry and wet weather primary effluent and PC removals is provided in

Table 4-3. As shown, primary removals do not show a significant change during wet weather. To take into account the typical increase in PCs in service during wet weather events, a PC TSS removal of 40% was used for the alternatives analysis. Alternatives using Chemically Enhanced Primary Treatment (CEPT) assumed a conservative PC TSS removal of 70%.

Table 4-3: PVSC Historical Dry and Wet Weather Primary Tank Performance

		Dry Weather Q_{inf} < 285 mgd	Wet Weather Q_{inf} > 285 mgd
PE COD	mg/L	347	295
PE COD Load	lb/d	638,500	786,800
COD % removal	%	26%	27%
PE TSS	mg/L	87	85
PE TSS Load	lb/d	154,600	227,700
TSS % removal	%	48%	45%

4.1.3 Biological Treatment Requirements

Solids retention time (SRT), defined as the average time the activated sludge solids are in the system, is an important operating parameter of an activated sludge wastewater treatment plant and is calculated by dividing the mass of solids in the oxygenation tanks by the mass of solids leaving the treatment process via the effluent or WAS. A minimum SRT is important to ensure that CBOD removal targets are achieved and that sufficient bioflocculation occurs to promote settling in the FCs.

Figure 4-1 shows the average SRT at PVSC, based on historical data from 2014 through 2017, has been 1.5 days, and **Figure 4-2** demonstrates that the lowest effluent TSS effluent has been observed at SRTs ranging from 1.3 to 2.1 days. To ensure sufficient biological treatment, an SRT of 1.5 days was targeted to determine the solids inventories needed for the analysis of each alternative.

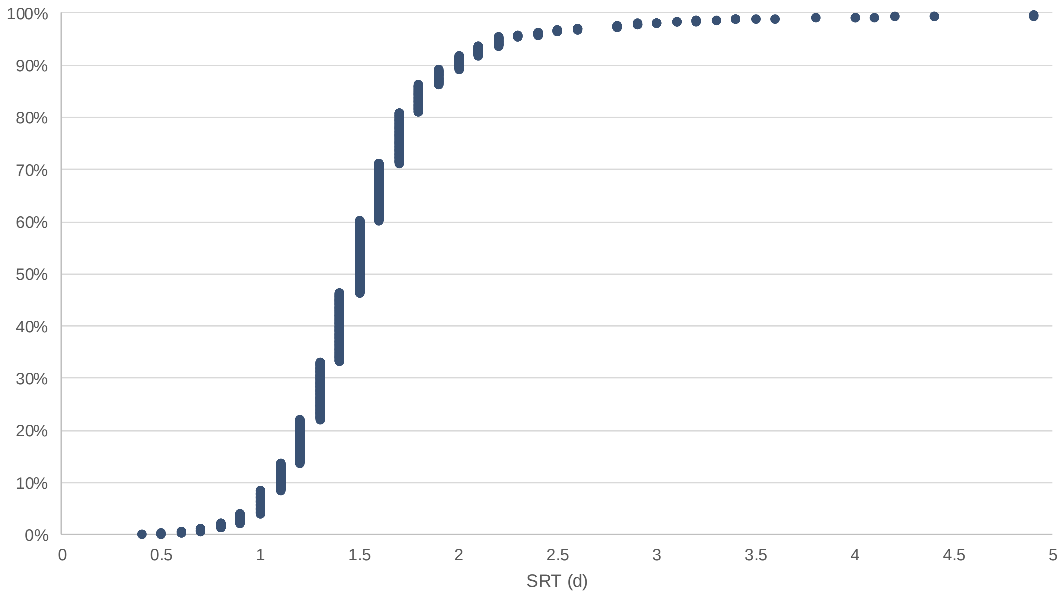

Figure 4-1: PVSC Historical SRT

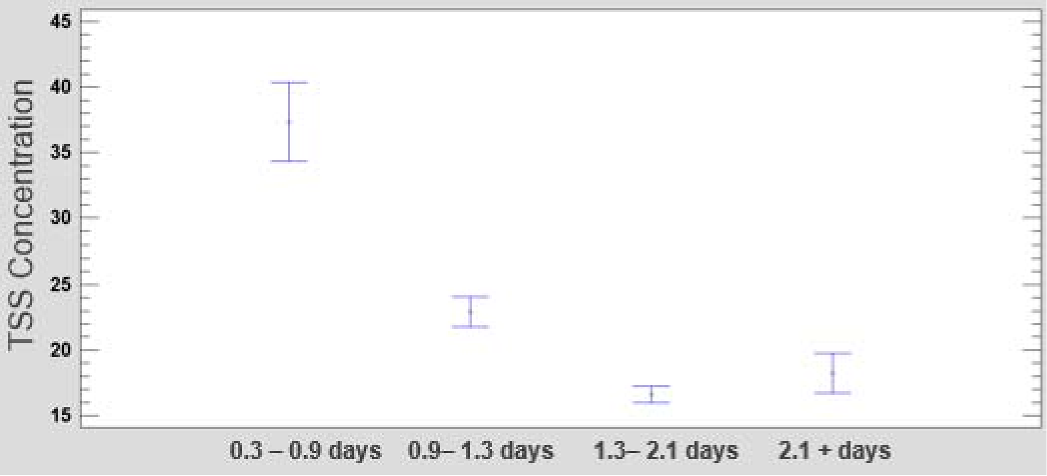

Figure 4-2: Effluent TSS Observations at varying SRT Ranges

4.1.4 Hydrograph

The hydrograph used in this analysis was taken from PVSC's updated Infoworks model of its collection system. The storm event from the Infoworks model was ratioed up to have a maximum peak wet weather influent of 720 mgd and extended to last 48 hours, to provide for a more conservative, realistic storm event. The resulting hydrograph used in the alternatives evaluation is shown in **Figure 4-3**.

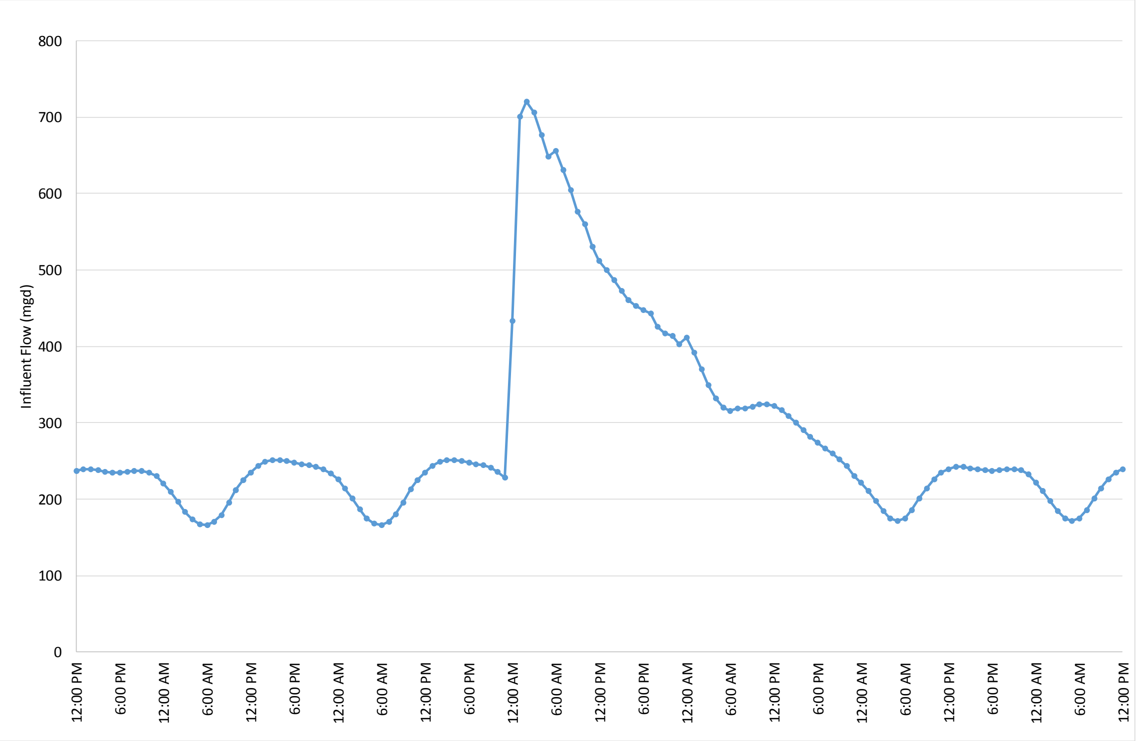

Figure 4-3: Wet Weather Hydrograph modeled

4.2 Analysis of Alternatives

Based upon CFD modeling built from historical plant data, performance, and stress testing, the wet weather capacity of PVSC under current operations is limited to an instantaneous flow of 400 mgd. Several alternatives were examined to increase the wet weather capacity of PVSC, including both operational modifications and changes to infrastructure. The following sub-sections will describe the alternatives, provide a high-level screening for feasibility, and discuss the results of the analysis of each alternative.

For each alternative carried through to analysis, results are summarized and discussed in detail in the following subsections. Relevant insights from hydraulic modeling, BioWin process modeling to predict solids loading to the FCs, and CFD modeling of solids settling and effluent quality are discussed. For most alternatives, the capacity of the FCs limits PVSC's overall treatment capacity, with flow restrictions based on Surface Overflow Rate (SOR) and load restrictions based on Solids Loading Rate (SLR). Modeling demonstrated that the following limitations, identified throughout each alternative analysis, impact effluent quality:

- Aeration (oxygenation) Tank Effluent MLSS (AEMLSS) – Effluent deterioration is expected (due to insufficient bioflocculation) at low SRTs, corresponding to an AEMLSS equal to or below approximately 1,200 mg/L
- Final Clarifier SOR – Effluent deterioration is expected with an SOR equal to or above approximately 800 gpd/ft^2 at poor settling conditions (corresponding to 400 mgd influent flow). Note, SORs as high as 1,100 gpd/ft^2 are acceptable at lower SLRs, which can be achieved with some of the discussed alternatives.
- Final Clarifier SLR – Effluent deterioration is expected with an SLR equal to or above approximately 30.0 lbd/ft^2

Based on the 720 mgd capacity of the entire treatment train, with the exception of the FCs, PVSC evaluated wet weather flow treatment alternatives for their feasibility to treat plant influent flows between 400 and 720 mgd. **Table 4-4** gives the list of alternatives considered and the maximum flow through the plant, with the reasons for limitations preventing the goal of 720 mgd influent flow discussed in the following sections.

Table 4-4: Summary of Maximum Plant Flow Results

	Alternative	Maximum flow for reliable treatment (mgd)
Operational Modifications	CEPT	400
Modifications to Infrastructure	Secondary Bypass	720
	Step-Feed	400 (up to 550*)
	BioActiflo	720
	RAS Storage	400 (up to 550*)
	Rerouting Recycle Streams	400
	Structural Modifications to the FSTs	600

*Several alternatives would require testing/demonstration to confirm capacity and process reliability.

4.2.1 Operational Modifications

4.2.1.1 Chemically Enhanced Primary Treatment

4.2.1.1.1 Process Description and High-Level Screening

Chemically Enhanced Primary Treatment (CEPT) includes the addition of chemicals to enhance primary settling to increase removal efficiency and overall secondary primary treatment capacity and. This process consists of coagulation, flocculation and sedimentation. Coagulation is the process whereby charged particles within the waste stream are neutralized or colloids destabilized by the addition of chemicals such as metal salts and some polymers, so that they can adhere to each other. Flocculation is defined as the aggregation of coagulated particles to form large groups of particles, or floc. This process of forming floc can be enhanced with the use of polymers. The larger particle aggregates, or flocs, settle faster thereby enhancing treatment efficiency. Specifically, the addition of chemical coagulants and polymer allows for the increased removal of suspended solids and its associated biochemical oxygen demand, as shown in **Table 4-5**.

Table 4-5: Typical PC Removals with and without CEPT

	Conventional	CEPT
TSS	40 – 60%	70 – 85%
BOD	20 – 50 %	50 – 70%

Coagulants, such as Ferric Chloride, Aluminum Sulfate, or Polyaluminum Chloride, are used to neutralize charged particles or de-stabilize colloids. Flocculation with polymer encourages fine particles to clump together into larger particles that can more easily settle. Using CEPT, higher primary surface overflow rates of 3,000 to 10,000 gpd/sf can be achieved as compared to conventional primary clarification, which are typically limited to 2,000 to 3,000 gpd/sf.

A diagram of the CEPT process along with general chemical dosing information is shown in **Figure 4-4**.

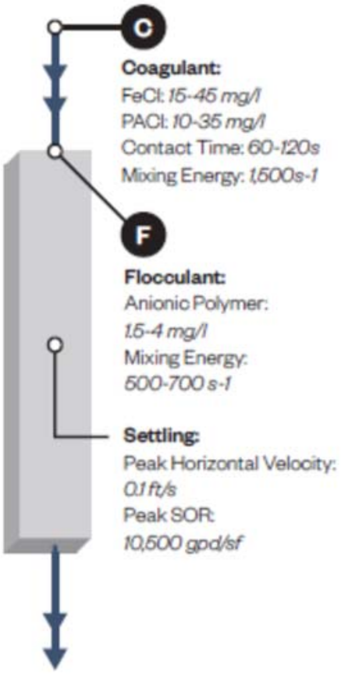

Figure 4-4: CEPT Process

4.2.1.1.2 Alternatives Analysis

Figure 4-5 shows how CEPT could be incorporated into PVSC's existing treatment process. Ferric Chloride addition to the PCs would be initiated during wet weather, with a dosage of 15-40 mg/L, and anionic polymer with a dosage of 1.5-4.0 mg/L.

During wet weather, there would be an increase in primary sludge, on the order of 100,000 lb/d, due to the addition of chemicals (ferric and polymer), however this additional load would be temporary.

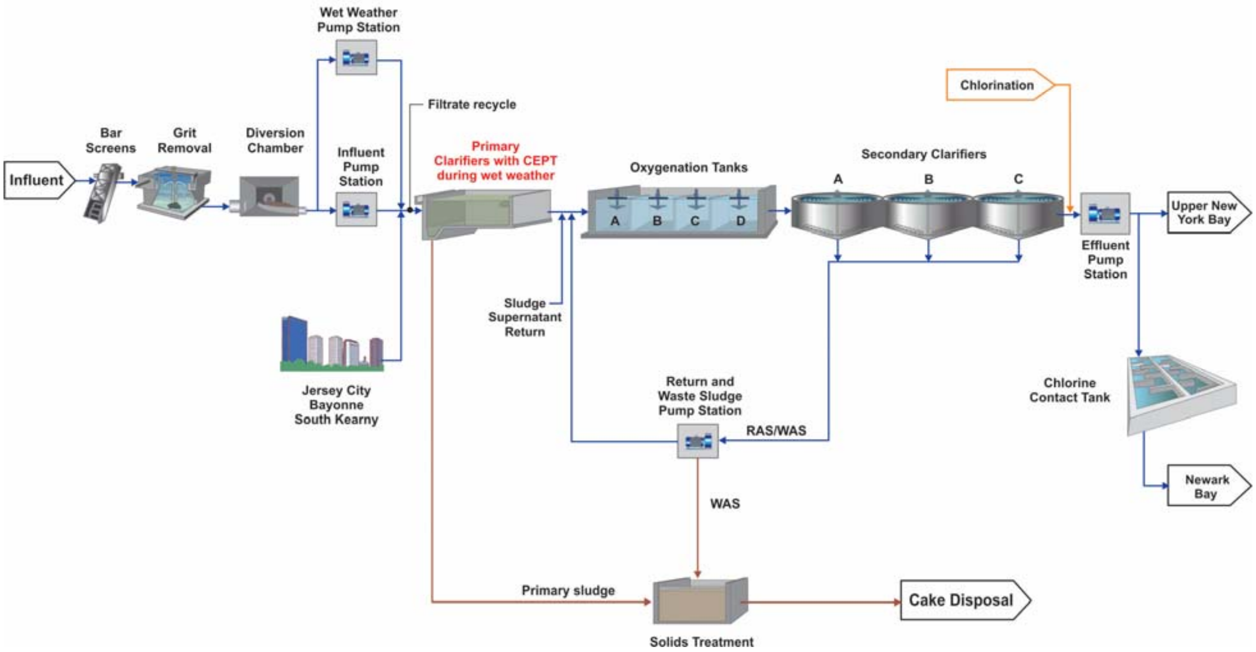

Figure 4-5: CEPT Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with operational CEPT implementation are summarized in **Table 4-6.**

Table 4-6: CEPT Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	720 mgd	No bypass used in this option
MLSS Concentration to the FCs	~2,200-4,100 mg/L	Solids concentrations dictated by an SRT of 1.5 days, with improved PC removals during wet weather (70% removal) due to CEPT
Estimated Effluent Quality	>45 mg/L	SOR of 1,400 gpd/ft^2 (based on 12 FCs online, 720 mgd influent flow, and 15 mgd internal recycle) limits the treatment capacity and prevents compliance with effluent limits. Additionally, the SLR observed increases to as high as 33 lbd/ft^2, which would prevent compliance with effluent limits.
Key changes to equipment/infrastructure	Chemical dosing, storage, and delivery unit needed	Assumed dosage of 20 mg/L ferric and 2 mg/L polymer, to be confirmed with jar testing
Operational Requirements	Wet weather operational practices will be needed to initiate and end chemical addition based on wet weather duration	Bench scale testing of the impact of CEPT on raw influent flow to PVSC is recommended to determine efficacy and refine dosing strategies

A wet-weather CEPT strategy cannot achieve effluent permit compliance at 720 mgd, and does not appreciably increase secondary treatment capacity above 400 mgd, due to high PC removals already observed and the substantial solids loading from internal recycles, currently directed to the head of the oxygenation tanks.

4.2.2 Modifications to Infrastructure

4.2.2.1 Secondary Bypass

4.2.2.1.1 Process Description and High-Level Screening

Routing a stream of primary effluent around secondary treatment, to be combined prior to disinfection and effluent discharge, is a common method to increase a plant's wet weather capacity. Bypass piping would be installed from the primary effluent channel, upstream of the location where sludge recycles are returned, to carry flow to the FC effluent channel, where it would mix with secondary effluent and flow to disinfection and discharge. This process would avoid overloading the secondary treatment system while still providing the benefits of primary settling and disinfection prior to discharge.

4.2.2.1.2 Alternatives Analysis

Figure 4-6 and **Figure 4-7** show how a secondary bypass could be incorporated into PVSC's existing site plan and treatment process. Bypass piping would be installed from the primary effluent conduit, downstream of the location where sludge recycles are returned, to carry flow to the northwest corner of the FC effluent channel (near FC 1, Bay C), where it would mix with secondary effluent and flow to disinfection and discharge.

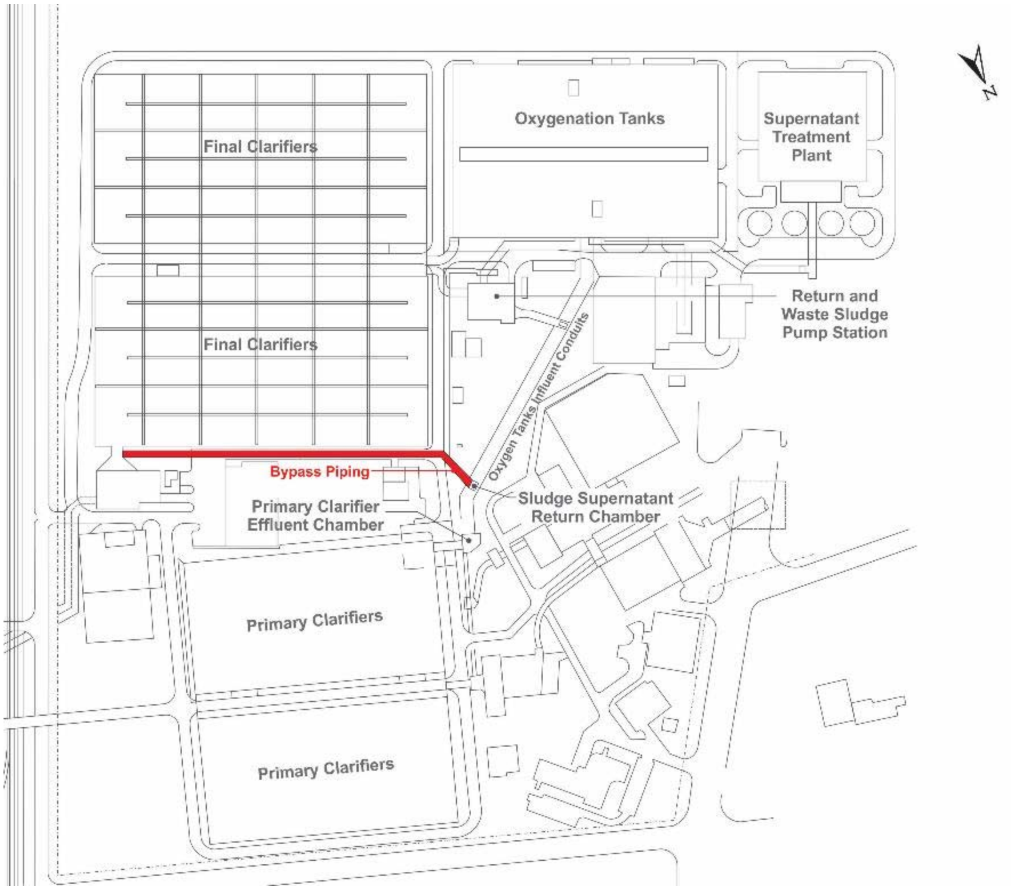

Figure 4-6: Secondary Bypass Site Layout

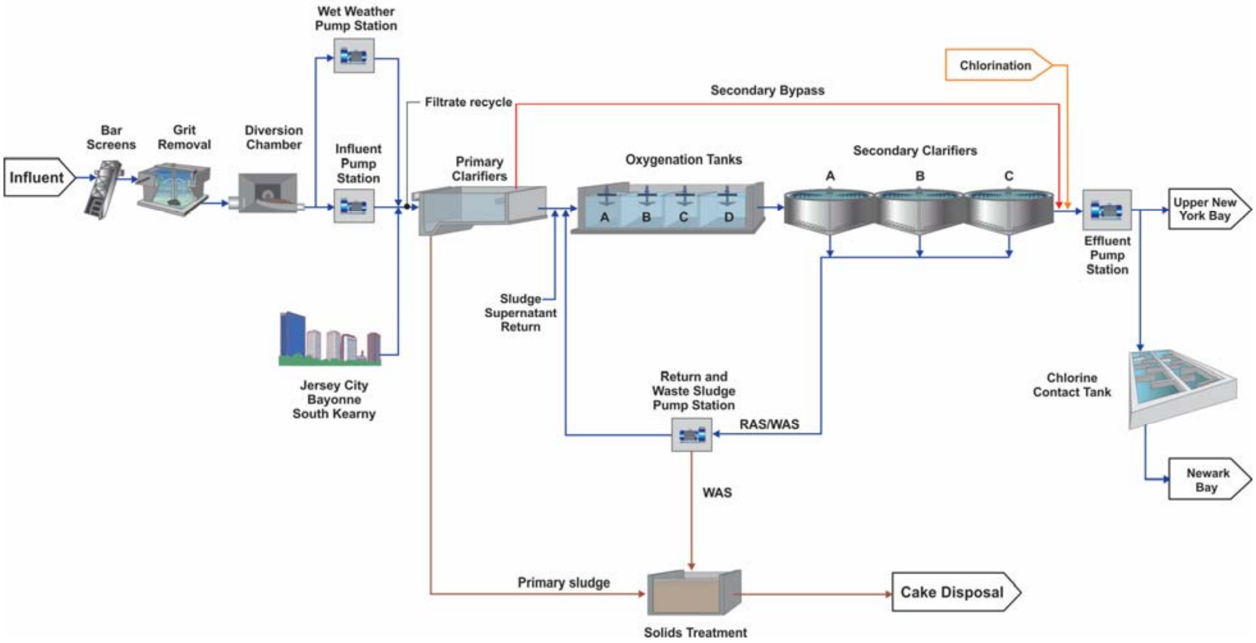

Figure 4-7: Secondary Bypass Process Flow Diagram

Hydraulic modeling using Infoworks software indicates a bypass flow limitation of 220 mgd due to limitations within the FC effluent channel at the northwest discharge location, by FC 1, Bay C. However, flow up to 320 mgd could be bypassed if the discharge location is moved farther east along the effluent channel receiving flow from the odd-numbered FCs. The secondary bypass option was analyzed, with a secondary bypass initiated at 400 mgd, and the results from the modeling analysis are summarized in **Table 4-7.**

Table 4-7: Secondary Bypass Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	400 mgd	320 mgd of PE flow would be bypassed around secondary treatment
MLSS Concentration to the FCs	2,900-3,100 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	<45 mg/L mg/L	An acceptable SOR of 800 gpd/ft^2 (based on 12 FCs online, 400 mgd flow through secondary treatment, and 15 mgd internal recycle) is achieved with the bypass of 320 mgd. Predicted effluent quality is sufficient to prevent permit violations.
Key changes to equipment/infrastructure	New infrastructure is required to reroute a portion of PE from the existing twin conduits to the FC effluent channel	A passive weir structure with Parshall flume flow measurement is recommended
Operational Requirements	Wet weather monitoring and flow reporting	

The implementation of a secondary bypass would allow PVSC to treat up to 720 mgd of influent flow while meeting effluent permit requirements, as described in the following section.

4.2.2.1.3 Effluent Permit Compliance

Effluent permit compliance for the following parameters was determined using historical data for influent flows up to 720 mgd, with a secondary bypass of up to 320 mgd:

- TSS
- CBOD
- NH_3
- Fecal Coliforms
- Total Cyanide
- Nickel
- Zinc
- Lead
- Copper
- Mercury

TSS, CBOD, and NH_3 Compliance

PVSC's historical database of hourly flows and primary effluent and plant effluent concentrations for TSS, CBOD, and NH_3 were used to project blended effluent quality under conditions when flows over 400 mgd were bypassed around secondary treatment. In order to remove the influence of historical process upsets to secondary treatment experienced in both dry and wet weather from high flow events, a maximum effluent TSS of 45 mg/L was assumed, which corresponds to the expected maximum modeled effluent quality with 400 mgd passing through secondary treatment. Due to current plant operations that attempt to limit influent flows to an instantaneous maximum of 400 mgd, the historical database did not provide anticipated wet weather events that peak at 720 mgd. As such, the anticipated storm hydrograph, shown in **Figure 4-3,** was used along with Newark Airport rainfall records, to identify potential storm events that would increase influent flows to the plant above 400 mgd. Different storm "categories" were assigned to rainfall measurements, as shown in **Table 4-8**. These categories were assigned hourly storm hydrographs based on the maximum storm hydrograph, as shown in **Figure 4-8**, and the calculated hourly flows replaced the recorded hourly flows in the plant database. Using the revised hourly flows, primary effluent measurements, and plant effluent measurements, permit compliance was predicted as shown in **Table 4-9**.

Table 4-8: Newark Airport Rainfall from 2014-2017

Rainfall	# occurrences from 2014-2017	Assigned Storm "Category"
Above 5 in	1	5
4-5 in	0	5
3-4 in	4	5
2-3 in	5	4
1.5-2 in	11	3
1-1.5 in	35	2
0.4-1 in	119	1

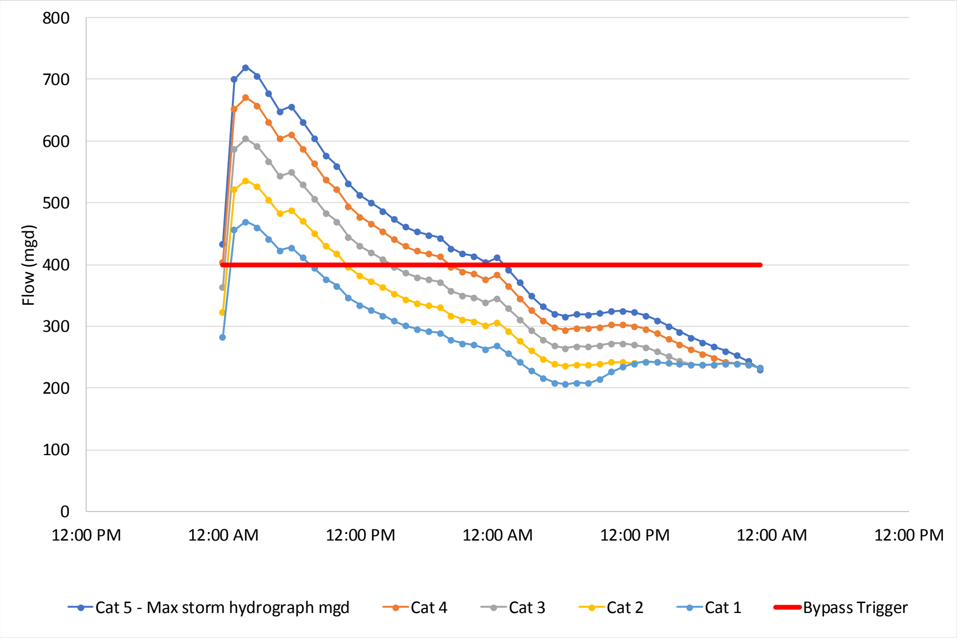

Figure 4-8: Hypothetical Storm Hydrographs

Table 4-9: Forecasted Effluent Quality with Bypassing for Instantaneous Flows above 400 mgd

		TSS						CBOD					Ammonia	
		7-day Average	7-day Average	Monthly Average	Monthly Average	Monthly Average	Monthly Average (wet weather values removed)	7-day Average	7-day Average	Monthly Average	Monthly Average	Monthly Average	Daily Maximum	Monthly Average
	Units	mg/L	kg/d	mg/L	kg/d	% Rem	% Rem	mg/L	kg/d	mg/L	kg/d	% Rem	kg/d	kg/d
Instances of forecasted non-compliance	2014	0	0	0	0	1	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	0	2	0	0	0	0	0	0	0	0
	2017	0	0	0	0	1	0	0	0	0	0	0	0	0
Maximum Forecasted Effluent Quality *(Minimum for Percent Removal)*	***Permit Limit***	***45***	***62,850***	***30***	***41,900***	***85%***	***85%***	***40***	***55,867***	***25***	***34,916***	***85%***	***78,400***	***53,700***
	2014	39	42,429	22	24,422	83%	85%	33	40,541	17	19,605	86%	45,156	29,043
	2015	23	23,445	19	18,968	86%	87%	24	25,375	18	19,626	88%	47,046	35,530
	2016	31	33,233	25	23,720	85%	86%	25	28,868	19	19,088	88%	68,437	50,177
	2017	31	34,818	25	25,871	84%	85%	36	49,853	17	19,993	90%	53,188	39,161

Instances of forecasted permit violations are related to the calculated percent removal for TSS falling below the permitted requirement of 85% removal. A detailed examination of the plant database showed that the low percent removals that contributed to the monthly average percent removal violations were experienced during months with frequent wet weather occurrences, where influent concentrations are dilute and secondary treatment performance is stressed, resulting in higher effluent TSS concentrations. When wet weather days are removed from the calculation of the monthly average percent removal, as shown in the shaded column, compliance is forecasted for all data. Under separate submittal, PVSC will be applying for a permit modification to remove wet weather days, defined as days when bypassing occurs, from the monthly percent removal calculation.

Fecal Coliforms

PVSC's permit requires a monthly geometric average of no more than 200 CFU/100mL and a weekly geometric average of no more than 400 CFU/100mL. A study was conducted and summarized in the document *Sodium Hypochlorite Storage Facilities Upgrade Project Investigation Phase - Findings Summary, May 21, 2014* (**Attachment 3**) that examined the sodium hypochlorite (hypo) dosage requirements under a scenario of wet weather bypassing of 320 mgd of primary effluent and blending with 400 mgd of secondary treatment effluent. A model was constructed to calculate chlorine dosage as a function of the contact time, flow rate, chlorine demand, residual, and decay required to achieve the desired disinfection to comply with PVSC's most strict permit requirement of a monthly geometric average of no more than 200 CFU/100mL (**Figure 4-10)**. Tidal fluctuations that change the flows through Outfall 001A and 002A were also taken into account. Minimum and maximum dosage values were assumed using a range of typical and historical wastewater characteristics; a hypo demand of 12-16 mg/L was assumed for the primary effluent, and plant data was used for secondary effluent.

PVSC furthered the analysis conducted in May 2014 to gain site-specific data on the primary effluent hypo dose needed to achieve a FC count of less than 200 CFU/100mL. The results, shown in **Figure 4-9**, showed that a hypo dose of less than 10 mg/L would achieve a FC count of less than 200 CFU/100mL in less than five minutes of contact for dry weather primary effluent, which would correlate to a primary effluent demand less than 10 mg/L (note, chlorine dosage is the aggregate of the chlorine demand, chlorine decay, and the chlorine residual, therefore dosage is greater than demand). Hypo demand is higher for the more concentrated dry weather primary effluent, as opposed to wet weather primary effluent, and as such, these results confirm that PVSC's primary effluent has a hypo demand lower than the minimum range hypo demand of 12 mg/L assumed in the May 2014 analysis.

PVSC's site-specific investigation on hypo dose needed for dry weather primary effluent confirmed the usage of the projected minimum hypo dosage curve, show in **Figure 4-10**, to determine the needed dosage for up to 720 mgd of treatment at a variety of flow and tide conditions. At the worst-case flow/tidal conditions, a dosage of 23 mg/L would be required for the blended flow.

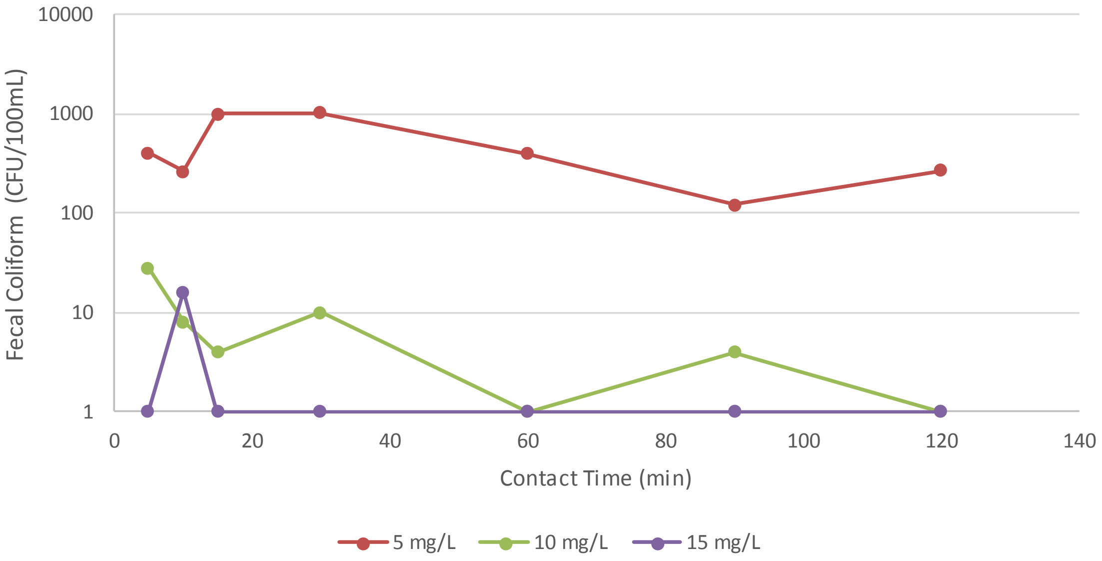

Figure 4-9: Fecal Measurements in Dry Weather Primary Effluent at Varying Hypo Doses

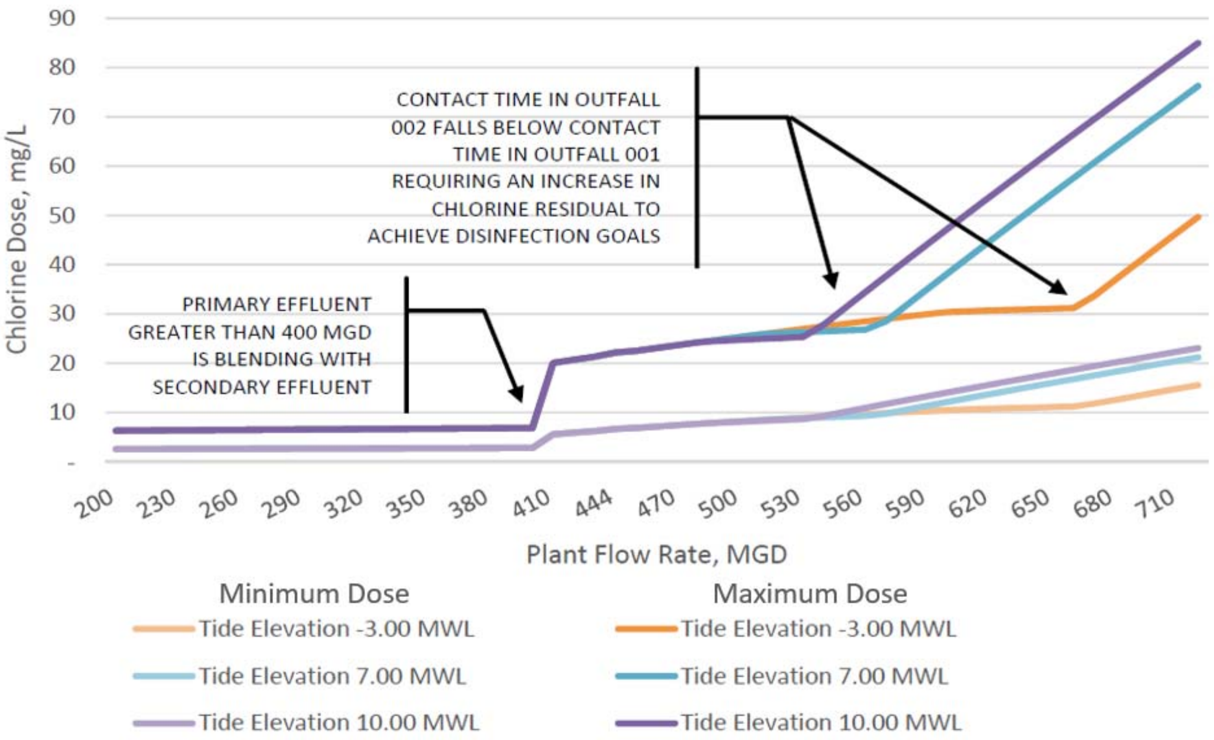

Figure 4-10: Wet Weather Bypassing Chlorine Dosages, Tidal Influences and Varying Flow Rates

Source: Sodium Hypochlorite Storage Facilities Upgrade Project Investigation Phase - Findings Summary, May 21, 2014

An analysis was conducted to ensure sufficient chemical storage and pumping capacity, assuming a hypo dose of 23 mg/L at 720 mgd, a maximum annual average dosage of 6.4 mg/L for flows less than 400 mgd, and the engineered storm patterns previously described in the section calculating TSS, CBOD, and NH_3

compliance.   PVSC will retain over six days of hypo storage capacity with four of their five 30,000 gallon hypo storage tanks online but will need to install three additional 840 gph hypo pumps, and modify associated distribution piping, to meet the instantaneous dosage requirement of 23 mg/L for a blended flow of 720 mgd.

Total Cyanide, Nickel, Zinc, Lead, Copper, and Mercury Compliance

Measurements for influent and effluent Total Cyanide, Nickel, Zinc, Lead, Copper, and Mercury are collected monthly, per PVSC's permit. To ensure the implementation of a bypass would not result in non-compliance with the effluent permit values listed in

Table 2-1, monthly data from the current database of April 2016 through October 2018 was collected for plant influent and effluent (note, primary effluent data is not collected). Due to the limited data available for Total Cyanide, Nickel, Zinc, Lead, Copper, and Mercury, the following conservative assumptions were made to predict effluent quality for treatment of up to 720 mgd:

- The average historical effluent quality would be achieved for flows up to 400 mgd
- A range between the average and maximum historical influent quality would be achieved for bypassed flows over 400 mgd and up to 720 mgd. The average historical influent quality was used for Mercury, as there is no permit daily maximum associated with Mercury.

Table 4-10 demonstrates that even under the conservative assumption that a bypass of 320 mgd would be experienced for a full 24-hour period, there would be no expected violations of the indicated parameters.

Table 4-10: Blended Effluent Quality for Total Cyanide, Nickel, Zinc, Lead, Copper, and Mercury

	Total Cyanide	Nickel	Zinc	Lead	Copper	Mercury
Effluent Load, kg/d Q=400 mgd	30	20	146	20	46	0.4
Effluent Load, kg/d Q=320 mgd (720 mgd minus 400 mgd)	20	19	256	24	76	1.44
Maximum Effluent Load, kg/d Q=320 mgd (720 mgd minus 400 mgd)	28	70	740	74	162	n/a
Total Effluent Load, kg/d Q=720 mgd	**50**	**39**	**402**	**44**	**122**	**2**
Maximum Total Effluent Load, kg/d Q=720 mgd	**58**	**90**	**886**	**94**	**208**	n/a
Permit Monthly Average (kg/d)	**120**	**150**	**562**	**162**	**187**	**2.5**
Permit Daily Maximum (kg/d)	**255**	**262**	**1,037**	**300**	**350**	n/a

4.2.2.2 Step-Feed

4.2.2.2.1 Process Description and High-Level Screening

Step-feed operation effectively reduces the solids loading to the FCs by storing a high concentration of solids (typically RAS) in the upfront stages of the oxygenation tanks, providing a contact stabilization level of treatment in the downstream stages, and sending more dilute mixed liquor flow to the clarifiers. PVSC does not currently have the means to separate RAS from primary effluent prior to the influent to the oxygenation tanks, and thus structural modifications would be needed to achieve a true step-feed configuration. To operate step feed, a new RAS distribution box would be constructed on the surface of the oxygenation tank deck with structural reinforcing below, with piping to distribute RAS to Stage A of each of the 12 oxygenation tanks. A new box would be constructed around the current influent conduit to Stage A of each oxygenation tank with two gates; one gate to allow PE flow to Stage A for normal operation, and one gate to pass PE flow into a new channel that would feed Stage C for use during wet weather operations. Feed to Stage C will allow for the HRT needed to support sufficient bioflocculation, required for acceptable settling.

4.2.2.2.2 Alternatives Analysis

Figure 4-11 and **Figure 4-12** show how step-feed could be incorporated into PVSC’s existing site plan and treatment process. To install step-feed, RAS would flow directly to a new RAS distribution box, without mixing with PE. The distribution box would be constructed on the surface of the oxygenation tank deck, with structural reinforcing below, with piping to distribute RAS to Stage A of each of the 12 oxygenation tanks. A new box would be constructed around the current influent conduit to Stage A of each oxygenation tank with two gates; one gate to allow PE flow to Stage A for normal operation, and one gate to pass PE flow into a new channel that would feed Stage C during wet weather operations.

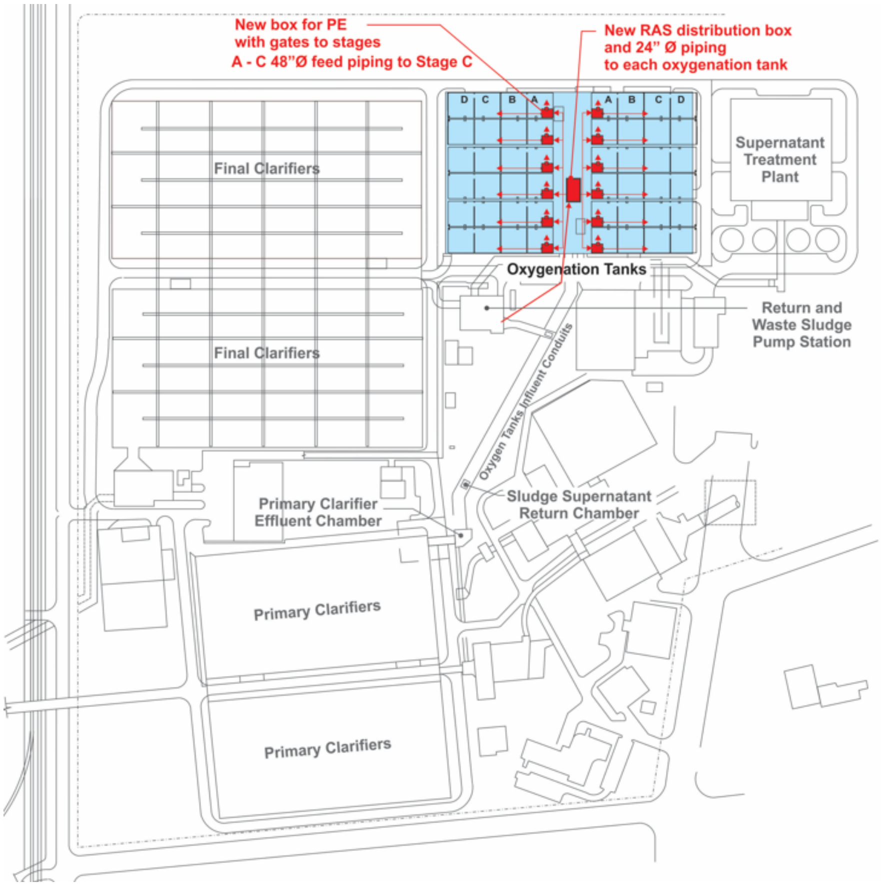

Figure 4-11: Step-Feed Site Layout

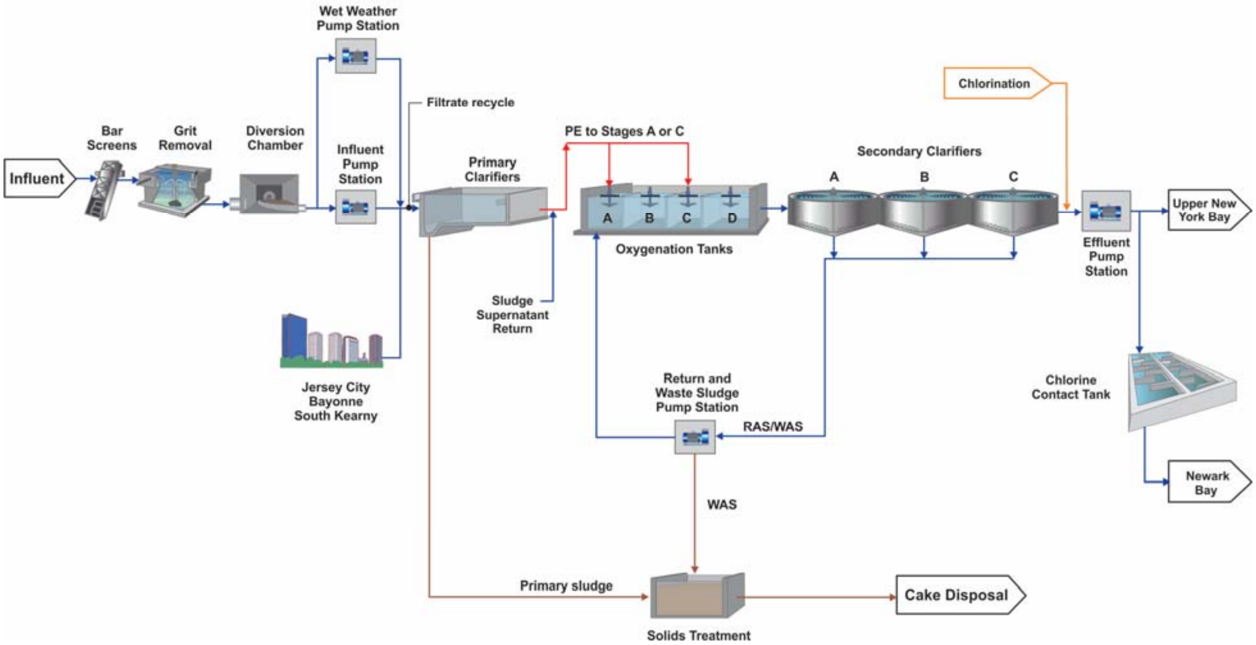

Figure 4-12: Step-Feed Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with step-feed are summarized in **Table 4-11.**

Table 4-11: Step-Feed Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	720 mgd	No bypass used in this option Primary effluent feed to Stage C initiated at 340 mgd
MLSS Concentration to the FCs	1,300-2,500 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	>45 mg/L	SOR of 1,400 gpd/ft^2 (based on 12 FCs online, 720 mgd influent flow, and 15 mgd internal recycle) limits the treatment capacity and prevents compliance with effluent limits
Key changes to equipment/infrastructure	Modifications needed to feed RAS to Stage A, and control PE flow to feed both Stages A and C.	Separation of RAS from the PE, new RAS piping to a new RAS box, RAS distribution piping to Stage A of all oxygenation tanks, new piping for PE distribution to Stage C of all oxygenation tanks, gates to control PE flow to Stages A and C, depending on the mode of operation
Operational Requirements	Wet weather operational practices will be needed to ensure PE gates to Stages A and C are adjusted with increased/decreased flows to PVSC associated with wet weather.	A pilot test of this new structural configuration is recommended prior to implementation at all 12 oxygenation tanks.

Although a step-feed strategy alone cannot achieve effluent permit compliance at 720 mgd, modifications to the oxygenation tanks to allow for step-feed operation could provide increased wet weather secondary treatment up to a maximum influent flow of 550 mgd, while staying below the limiting SOR of 1,100 gpd/ft^2 at the reduced SLR.

There are several important considerations to step-feed implementation:

- There are limited Step Feed Pure Oxygen Activated Sludge installations currently in operation. A survey of eleven Pure Oxygen Activated Sludge facilities indicated that only one has the capability to operate the full facility with step-feed. The lack of experience with step-feed operations at Pure Oxygen Activated Sludge facilities limits the confidence that this process would be effective as a wet weather treatment alternative for 320 mgd of flow. Step-feed should therefore not be considered feasible to increase the wet weather treatment capacity of the facility.
- Pilot testing of this new structural configuration would be required prior to implementation at all 12 oxygenation tanks to verify the secondary treatment system capacity of 550 mgd.
- New flow routing and control will require significant new infrastructure and modifications to existing infrastructure (cost details are provided in **Section 4.3**).
- Redesign and replacement of the existing surface aerators would be required to accommodate the load changes during wet weather operations.
- Significant process issues would be realized related to the Maintenance of Plant Operations (MOPO) during construction, as one or more oxygenation tanks would be out of service for extended periods of time while construction is initiated and completed.
- The schedule for full-plant implementation would be on the order of 20 years or more, taking into account the time needed for conversion of a pilot oxygenation tank, sufficient pilot testing, full-scale design and construction.

4.2.2.3 BioActiflo

4.2.2.3.1 Process Description and High-Level Screening

The installation of a new unit process could achieve secondary treatment of excess wet weather flow beyond the treatment capacity of the current secondary treatment train. High Rate Clarification (HRC) treatment systems use ballasting material to significantly enhance the settling properties of particles serving as a physical-chemical treatment process. A schematic of the Veolia Actiflo HRC process, which uses a microsand ballast, is shown in **Figure 4-13**. In addition to the ballast, these processes also typically use a coagulant for particle charge neutralization, polymer addition for particle agglomeration, lamella plate or tube settlers to further compact the clarifier footprint, and ballast recovery and recirculation systems.

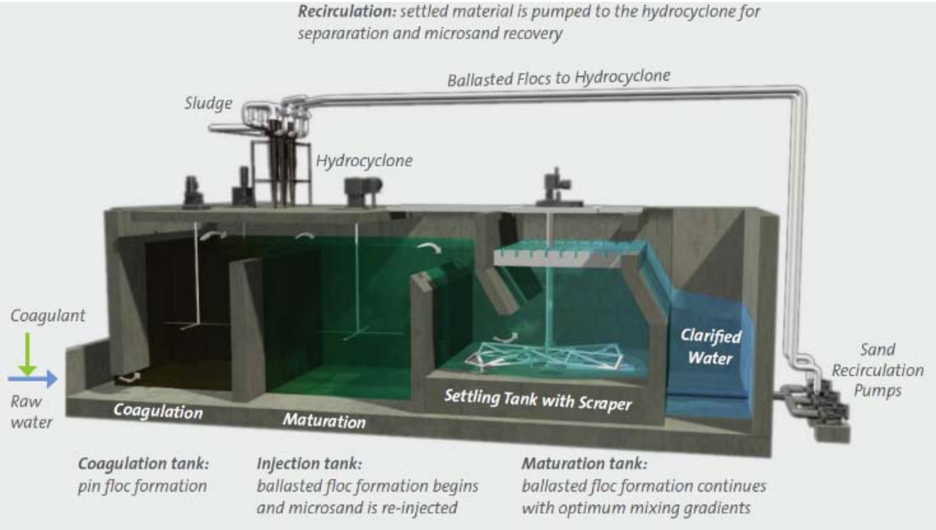

Figure 4-13: Actiflo Ballasted Flocculation System Schematic (Courtesy of Veolia)

The Actiflo process and multiple other manufacturers of similar HRC technologies are currently used without a biological treatment component. However, a biological treatment component can be included by adding a biological contact tank to improve soluble BOD removal. In theory, this treatment process could be offline during dry weather conditions and be activated during wet weather to receive RAS from the dry weather flow treatment process and wet weather influent wastewater. The biomass from the RAS enables reduction of soluble BOD, as with a conventional activated sludge process. The biological contact tank is followed by clarification using the Actiflo process described above. Veolia’s Bio-Actiflo, shown in **Figure 4-14**, is the only HRC technology that currently performs biological treatment.

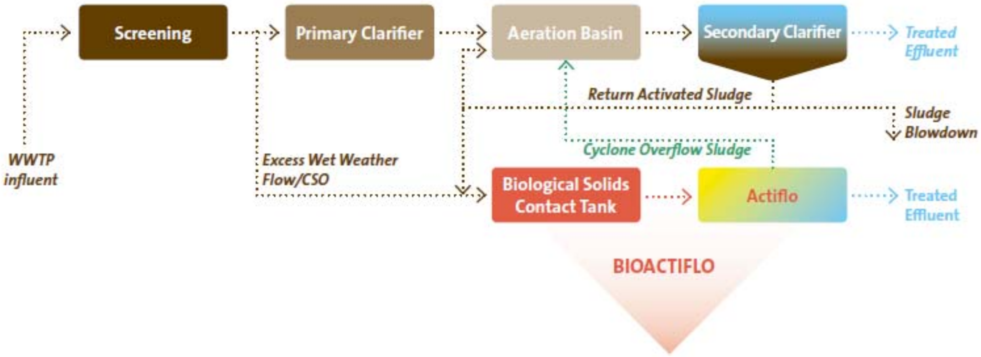

Figure 4-14: BioActiflo System Schematic (Courtesy of Veolia)

The target BOD_5 reduction for the BioActiflo technology is greater than 85% to match or exceed treatment standards. In addition, the Actiflo process has consistently shown efficient removal of TSS, Total P, COD, metals and fecal coliform in the physical-chemical process. There is a significant O&M cost for chemical and ballast addition and process reliability issues have been observed because of the intermittent operation based on wet weather flow conditions. As such, it is recommended that the Bio-Actiflo process be continuously operated even in dry weather, with a small flow stream, in order to provide reliable wet weather treatment.

4.2.2.3.2 Alternatives Analysis

Figure 4-15 and **Figure 4-16** show how the BioActiflo wet weather treatment process could be incorporated into PVSC's existing site plan and treatment process. The existing Supernatant Treatment Plant (STP), which has been out of service since the early 2000s, would be completely rehabilitated to allow for the construction of four BioActiflo reactors.

The BioActiflo process requires approximately 25 minutes of detention time for biological treatment, coagulation, and maturation of the floc, with 40 gpm/ft^2 of clarifier tankage. These design criteria are used to determine the capacity of the existing infrastructure (160 mgd) and what would be needed to treat the target flow of 320 mgd (720 mgd influent goal minus the plant's current limited capacity of an instantaneous 400 mgd) in **Table 4-12**: BioActiflo Design Criteria. To treat 320 mgd of PE flow, 5.6 MG of firm treatment volume is required with one unit out of service (7.4 MG total reactor volume), which is not currently available in the existing PVSC STP tanks (total treatment volume 3.75 MG). To provide for this increased volume, the existing tank walls would be raised 10 ft.

Table 4-12: BioActiflo Design Criteria

	Existing Capacity: 160 mgd	**Expanded Capacity: 320 mgd**
Required Volume at 25 min detention time (MG)	2.8	5.6
Installed Treatment Volume (total) (MG)	3.7	7.4
Firm Treatment Volume (MG)*	2.8	5.6
Required Surface Area (ft^2) at 40 gpm/ft^2	2800	5600
Installed SA (total) (ft^2)	9500	9500
Firm SA (ft^2)*	7125	7125

*Assuming one of four units out of service

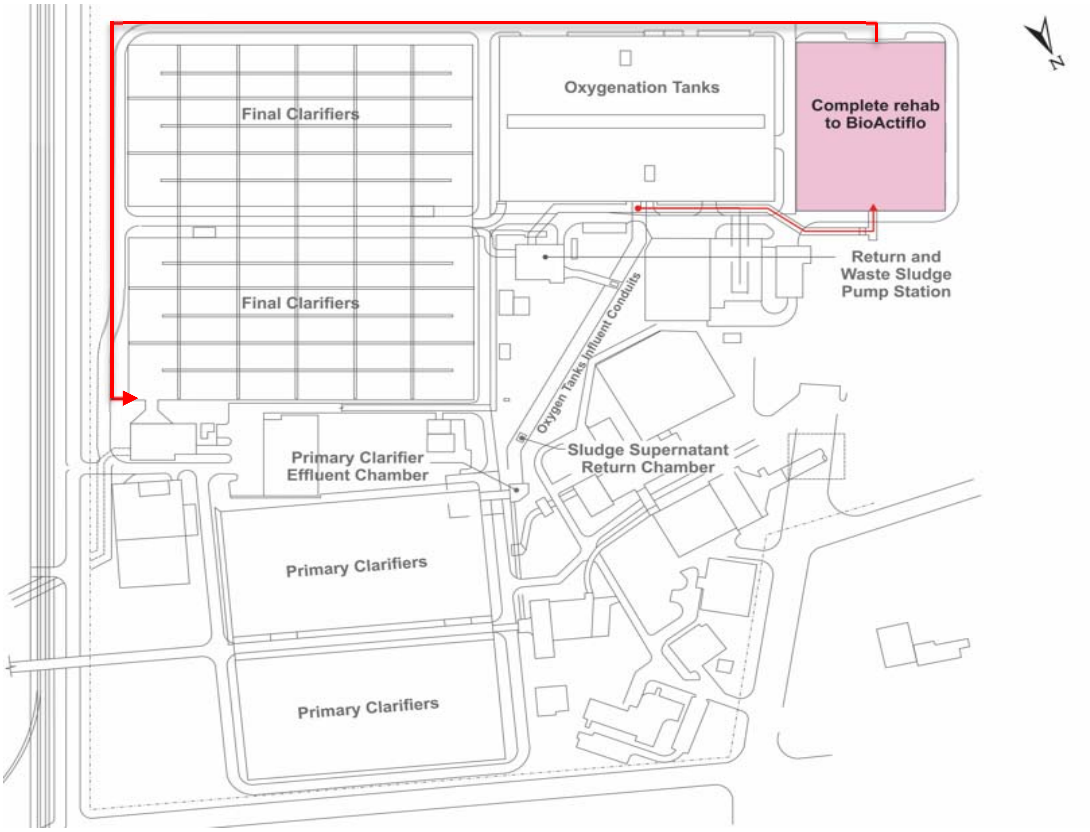

Figure 4-15: BioActiflo Site Layout

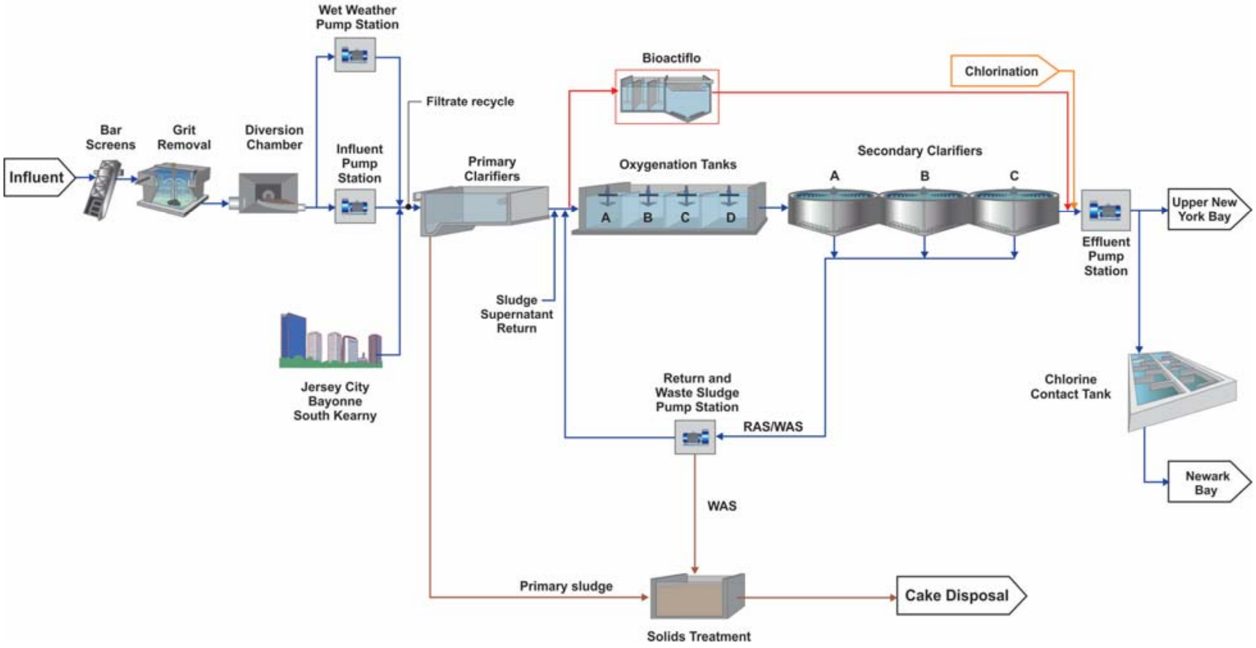

Figure 4-16: BioActiflo Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with BioActiflo are summarized in **Table 4-13.**

Table 4-13: BioActiflo Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	400 mgd	320 mgd sent to BioActiflo process for treatment
MLSS Concentration to the FCs	2,900-4,100 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	<45 mg/L	An acceptable SOR of 800 gpd/ft^2 (based on 12 FCs online, 430 mgd influent flow, and 15 mgd internal recycle) is achieved with application of BioActiflo to 320 mgd. Predicted effluent quality is sufficient to prevent permit violations.
Key changes to equipment/infrastructure	Installation of BioActiflo process	Complete rehabilitation and expansion of the existing STP to install four new 1.85 MG BioActiflo reactors and associated chemical facilities
Operational Requirements	Operation of new unit process, including chemical dosing	The BioActiflo process would have to be continuously operated even in dry weather, with a small flow stream, in order to provide reliable wet weather treatment

While sufficient wet weather treatment can be achieved to allow for an influent plant flow of 720 mgd with the complete rehabilitation and expansion of the existing STP, this alternative has several issues that should be considered:

- Implementation of BioActiflo would require the complete retrofit of the STP for the new unit process, significant piping to overcome hydraulic limitations and discharge effluent at the east end of the effluent channel receiving flow from the odd-numbered FCs, and operation during both dry and wet weather, resulting in a high capital and operational cost (cost details are provided in **Section 4.3**).
- There are limited applications of this technology in the US (see **Table 4-14**), and no existing BioActiflo installations of this size in the US, limiting the confidence that this process would be effective as a wet weather treatment alternative for 320 mgd of flow.
- The STP footprint is currently reserved for the future installation of a new Oxygen Production Plant, as shown in **Figure 4-17**. The current plant, which was constructed and began operation in 1981, is nearing the end of its useful life, and the STP proximity to the oxygenation tanks makes it an ideal location for the new plant. As the plant cannot operate without a functioning Oxygen Production Plant, it is necessary to continue operating the current plant while constructing a new plant.

Table 4-14: Existing BioActiflo Installations

Installation Number	Name	Year Startup	Number of Trains	Total Capacity (mgd)
1	St. Bernard, LA	2014	1	7.5
2	Wilson Creek, TX	2012	1	36
3	4th Creek WWTP, Knoxville, TN	2014	2	22
4	Cox Creek, MD	2017	1	12
5	McHenry, IL	2018	1	10

Given the lack of experience with the BioActiflo technology at this scale and the reservation of the STP space for a new Oxygen Production Plant, the implementation of BioActiflo is not feasible.

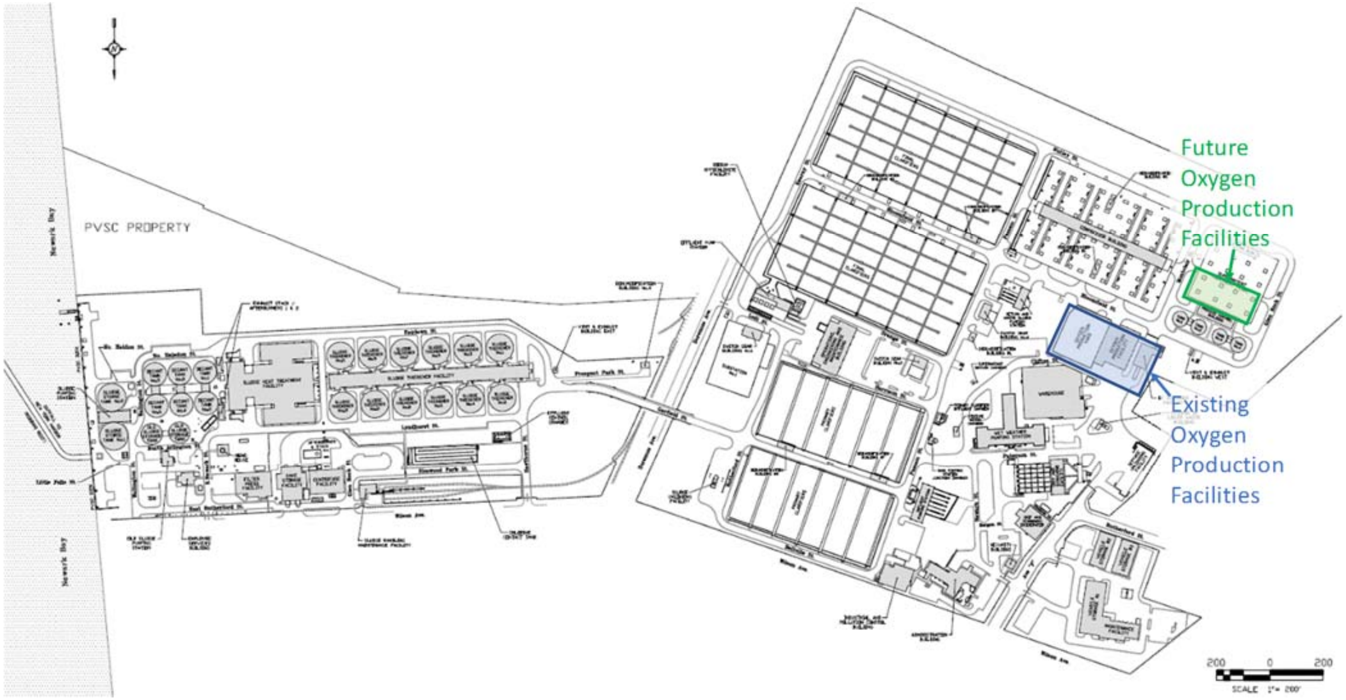

Figure 4-17: Future Oxygen Production Plant

4.2.2.4 Temporary Storage of Return Activated Sludge

4.2.2.4.1 Process Description and High-Level Screening

Temporary RAS storage is a similar concept to Step-Feed, whereby active biomass inventory is protected from washout through storage. The existing STP is currently not in use and could provide storage volume for RAS during wet weather. This alternative would require a new dedicated RAS line from the RAS pumping station that would carry RAS to and from the STP during and after, respectively, wet weather events.

4.2.2.4.2 Alternatives Analysis

Figure 4-18 and **Figure 4-19** show how RAS storage could be incorporated into PVSC's existing site plan and treatment process. Prior to wet weather, RAS would be directed to the STP via gravity using a new pipe through an existing tunnel. At the conclusion of the wet weather event, RAS would be pumped through that same pipe, and discharged to the twin oxygenation tank influent conduits. Tank volume in the existing STP would be expanded from the existing 3.7 MG to provide the needed 5.5 MG of RAS storage.

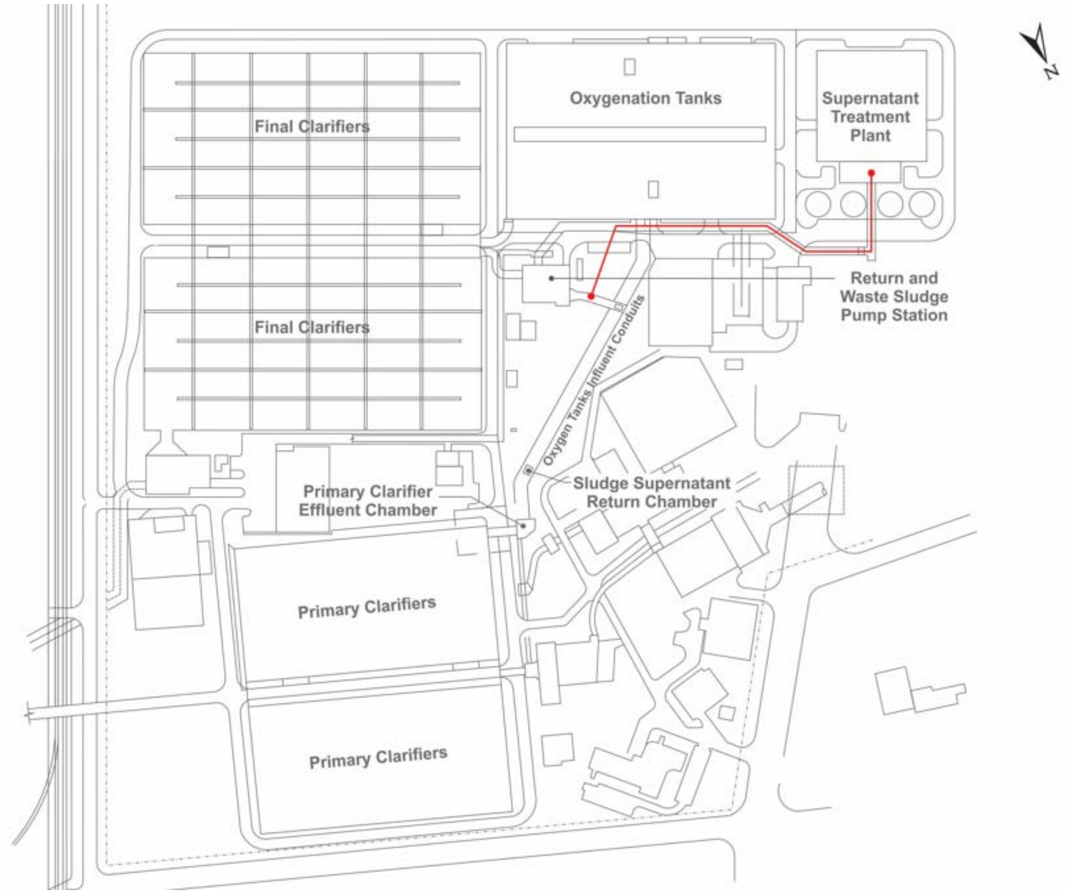

Figure 4-18: RAS Storage Site Layout

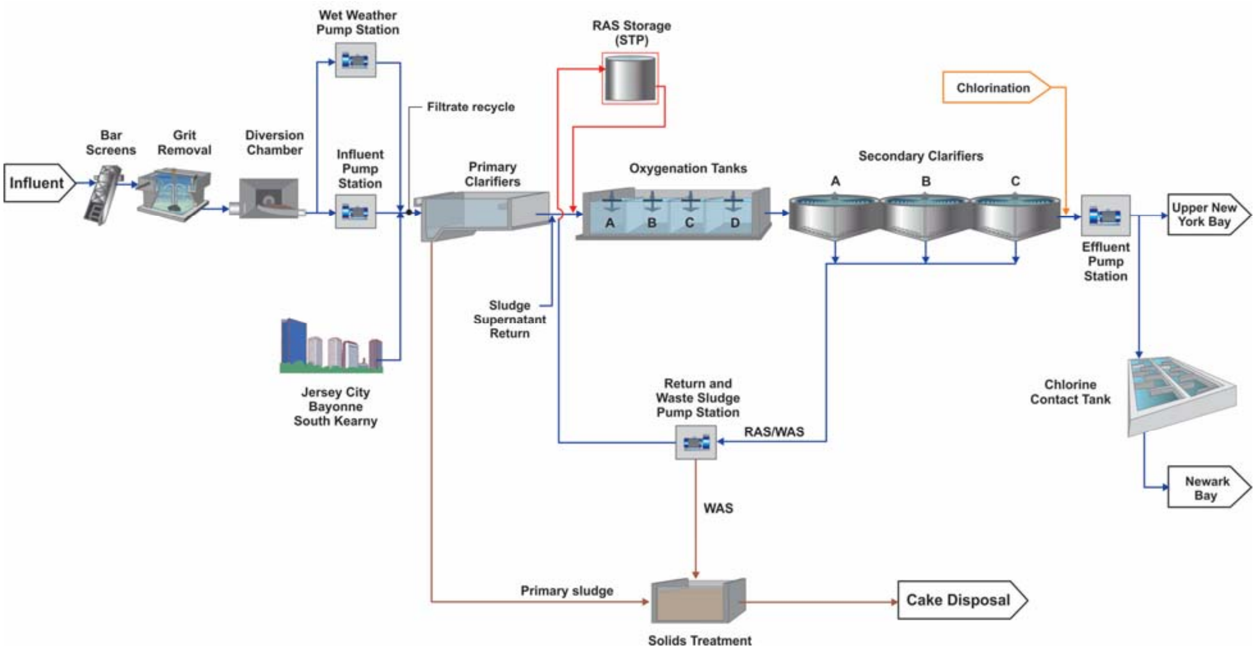

Figure 4-19: RAS Storage Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with RAS storage are summarized in **Table 4-15.**

Table 4-15: RAS Storage Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	720 mgd	No bypass used in this option
MLSS Concentration to the FCs	1,300-2,500 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	>45 mg/L	SOR of 1,400 gpd/ft^2 (based on 12 FCs online, 720 mgd influent flow, and 15 mgd internal recycle) limits the treatment capacity and prevents compliance with effluent limits
Key changes to equipment/infrastructure	New piping from RAS discharge to STP and 50 MGD pump station.	Minor rehabilitation of existing STP tanks
Operational Requirements	Constant weather monitoring for pre-wet weather operation of the diversion of RAS to STP and pump-back at the conclusion of the wet weather event	To ensure solids are not lost to the FCs during a high flow wet weather event, RAS storage would need to be initiated prior to elevated influent flows entering the plant.

The secondary treatment capacity of RAS rerouting cannot meet the goal of 720 mgd and is, in theory, the same as with conversion to step-feed operation which could provide increased wet weather secondary treatment up to a maximum influent flow of 550 mgd, however it requires more infrastructure and equipment, with the inclusion of a pump station, and relies on operational intervention for weather monitoring to prepare for wet weather events by diverting RAS to the STP. A survey of eleven Pure Oxygen Activated Sludge facilities indicated that there are no oxygen activated sludge plants that use RAS storage for wet weather treatment. Also, as mentioned previously in **Section 4.2.2.3.2**, the STP units are currently reserved for the plant’s next Oxygen Production Plant. As such, utilizing this space for the implementation of RAS storage is not feasible.

4.2.2.5 Rerouting Recycle Streams

4.2.2.5.1 Process Description and High-Level Screening

PVSC has a substantial recycle load from the Gravity Thickeners, Decant Tanks, and thickening centrifuges that is combined with PE prior to the oxygenation tanks, as shown in **Table 4-16**. This load reduces the treatment capacity of the secondary system. If the recycle streams could be rerouted to the PCs, additional TSS and particulate CBOD removal would be realized which would reduce the solids and organic loadings to the oxygenation tanks and FCs and increase the secondary treatment capacity.

Table 4-16: Average Internal Recycles at PVSC

2014-2017 Plant Data		
Average Influent TSS	lb/d	300,000
Average PE TSS	lb/d	150,000
Average GTO TSS	lb/d	300,000
Average Centrate TSS (included in GTO)	*lb/d*	*100,000*

Average Decant TSS	lb/d	200,000

4.2.2.5.2 Alternatives Analysis

Figure 4-20 and **Figure 4-21** show how the rerouting of the recycle from Gravity Thickener overflow (GTO), centrate, and decant could possibly be incorporated into PVSC's existing site plan (other piping options exist and could be investigated if this alternative is furthered) and treatment process. In this alternative, the recycle streams would be rerouted to the PCs to realize additional TSS and CBOD removal and increase the secondary treatment capacity. Note, impacts on solids handling equipment would be minimal, as the primary sludge load would increase to the Gravity Thickeners, but the WAS load to those same Gravity Thickeners would decrease by approximately the same amount.

Rerouting recycles to the primary clarifier influent removes some of the recycle load from the secondary treatment process. The reduction will take place during both wet and dry weather periods. During dry weather, the reduced loading will allow a reduction in MLSS while keeping a minimum of SRT of 1.5 days, therefore reducing the MLSS loading on the FCs. The decrease in FC loading will result in lower effluent TSS and CBOD effluent concentrations during dry weather periods.

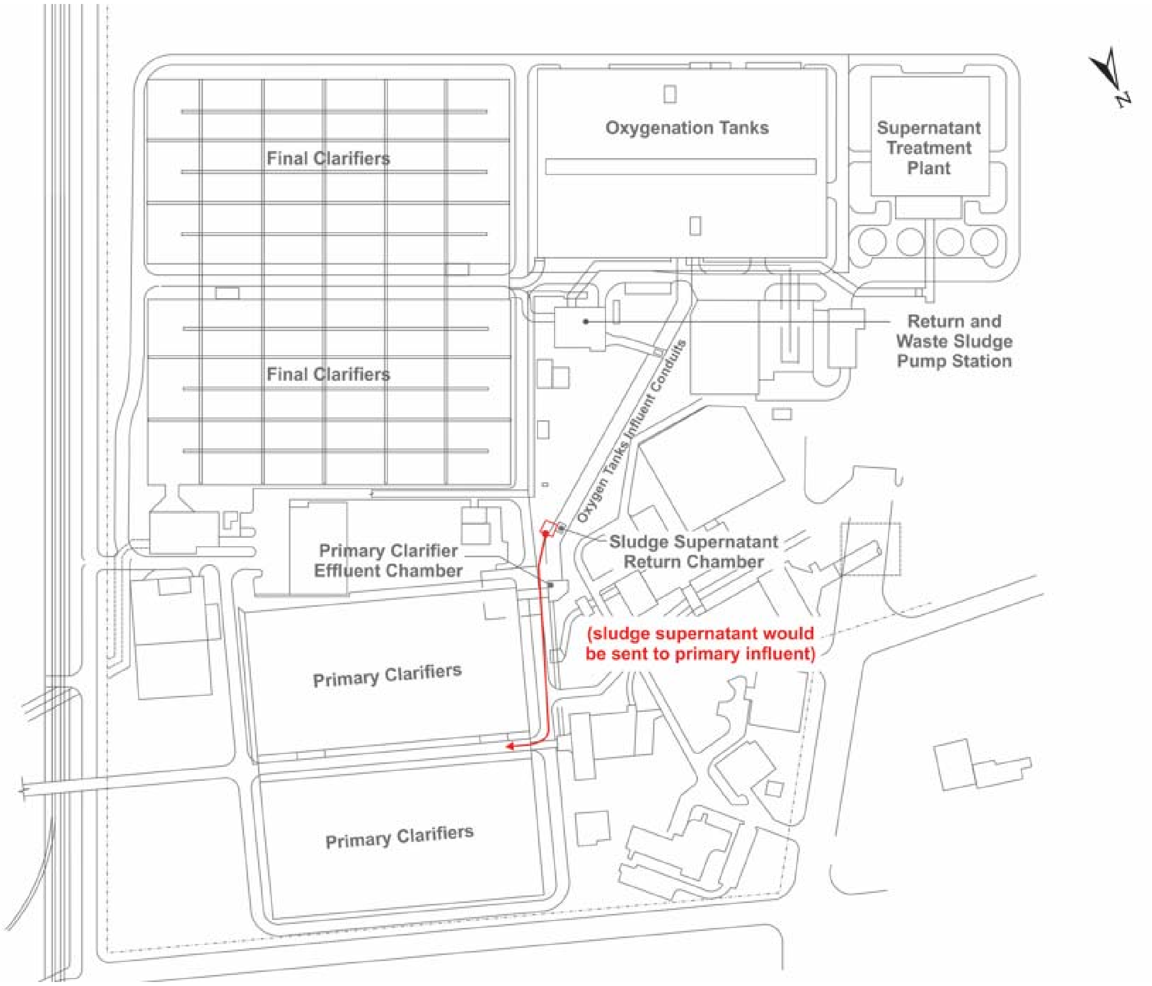

Figure 4-20: Rerouted Recycle Streams Site Layout

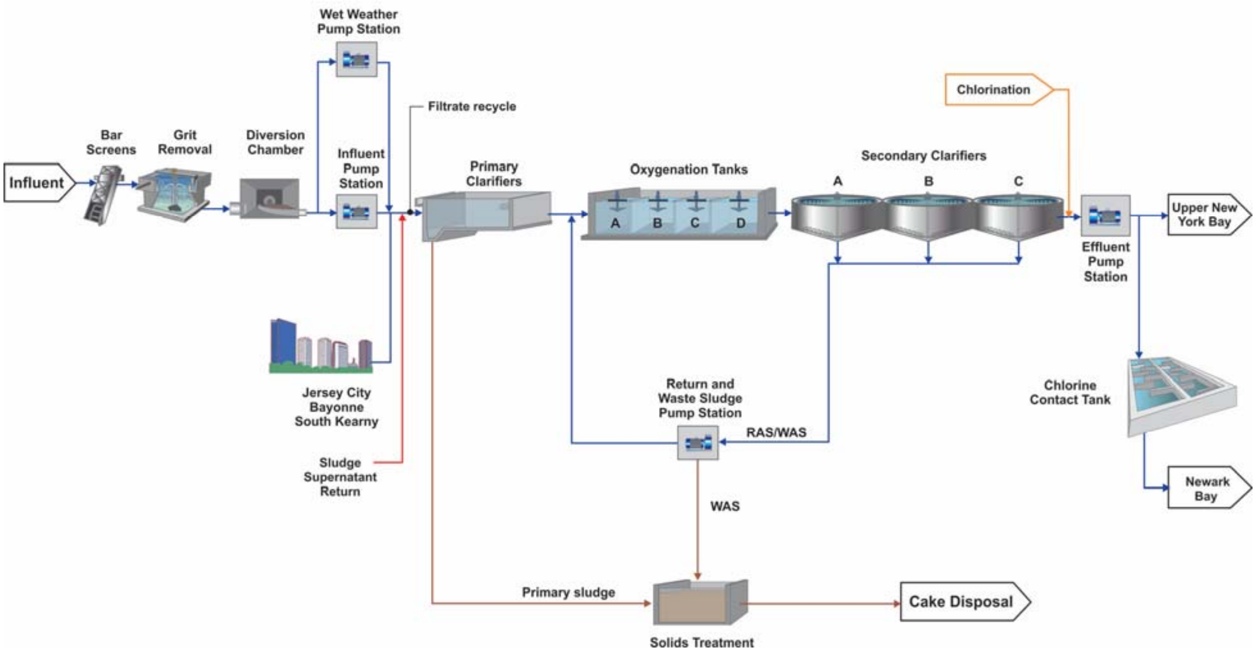

Figure 4-21: Rerouted Recycle Streams Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with rerouted recycle streams are summarized in **Table 4-17.**

Table 4-17: Rerouted Recycle Streams Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	720 mgd	No bypass used in this option
MLSS Concentration to the FCs	~2,000-3,500 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	>45 mg/L	SOR of 1,400 gpd/ft^2 (based on 12 FCs online, 720 mgd influent flow, and 15 mgd internal recycle) limits the treatment capacity and prevents compliance with effluent limits
Key changes to equipment/infrastructure	New piping routed to the head of the PCs	Feasibility analysis needed to ensure sufficient HGL exists
Operational Requirements	None	

The reduction in solids loading to the secondary treatment system would provide process stability benefits to treatment in dry weather as well as wet weather, allowing for operation at higher SRTs resulting in better quality effluent in dry weather. The increase in process stability may reduce the number of monthly percent removal violations, leading to improved permit compliance.

4.2.2.6 Structural modifications to the Final Clarifiers

4.2.2.6.1 Process Description and High-Level Screening

PVSC operates twelve secondary rectangular clarifiers. The clarifiers are split into two trains with six clarifiers each. Each clarifier is further divided into 3 “squircle” bays (A, B, C), with flow entering at the head of A and discharging over weirs in C. **Figure 4-22** depicts the flow path and layout of the FCs.

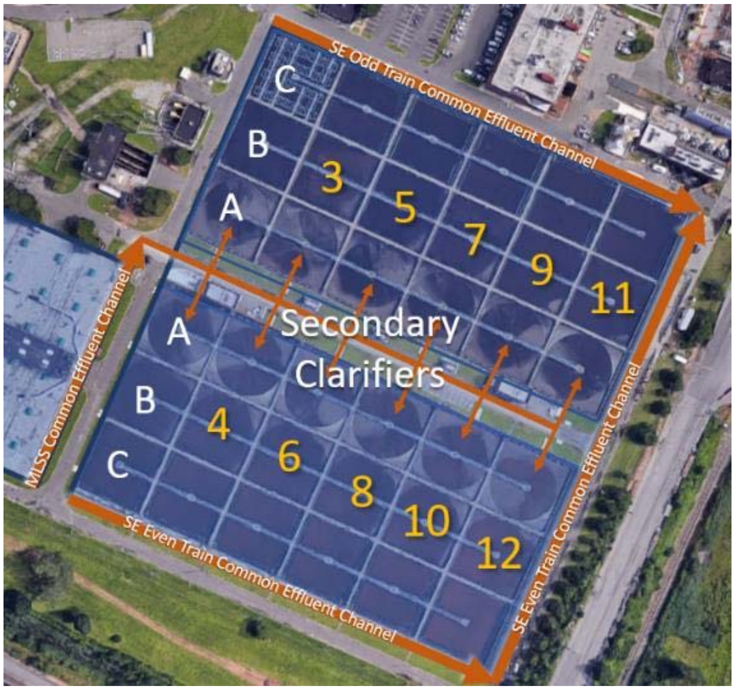

Figure 4-22. PVSC WWTP FC flow path

The size and geometry of the current configuration does not allow for significant improvements to the internal structure of the FCs to improve settling or capacity.

Two options exist to modify the existing FCs:

- Implement the more intricate effluent launder structure that was built for testing in FC #1, as shown in **Figure 4-23**.
- Completely rebuild the FC complex to remove the existing setup of rectangular clarifiers with three squircles in series, and create three independent squircle clarifiers with modern internal equipment out of each existing rectangular clarifier, as depicted in **Figure 4-24**. New influent and effluent channels would be needed for feed and discharge for each FC.

Figure 4-23: Effluent Launder in Bay C, FC 1

Figure 4-24. Alternative FC flow path

CFD simulations and historical operations during wet weather events have shown that FC 1 will fail when exposed to a sustained flow of 40 mgd (480 mgd total plant influent flow) when the oxygenation tank has a concentration of MLSS equal to 2,200 mg/L, despite its enhanced launders. As a result, this option would not provide sufficient wet weather treatment capacity for 720 mgd total plant influent flow and does not provide as much secondary treatment capacity as other evaluated alternatives.

The option to completely rebuild the FC complex to create three independent squircle clarifiers with modern internal equipment out of each existing rectangular clarifier will be evaluated in the following section.

4.2.2.6.2 Alternatives Analysis

Figure 4-25 and **Figure 4-26** show how modifications to the existing FCs to create three independent squircle clarifiers with modern internal equipment out of each existing rectangular clarifier could be incorporated into PVSC's existing site plan and treatment process. Under this alternative, each existing FC bay would become its own distinct clarifier with RAS improvements, Energy Dissipating Inlet (EDI), center well, Stamford baffle, and suction headers or spiral scrapers to provide more modern FC configuration. The influent channels would be built or reconfigured to distribute flow to each new clarifier and new effluent channels would be built to collect treated flow.

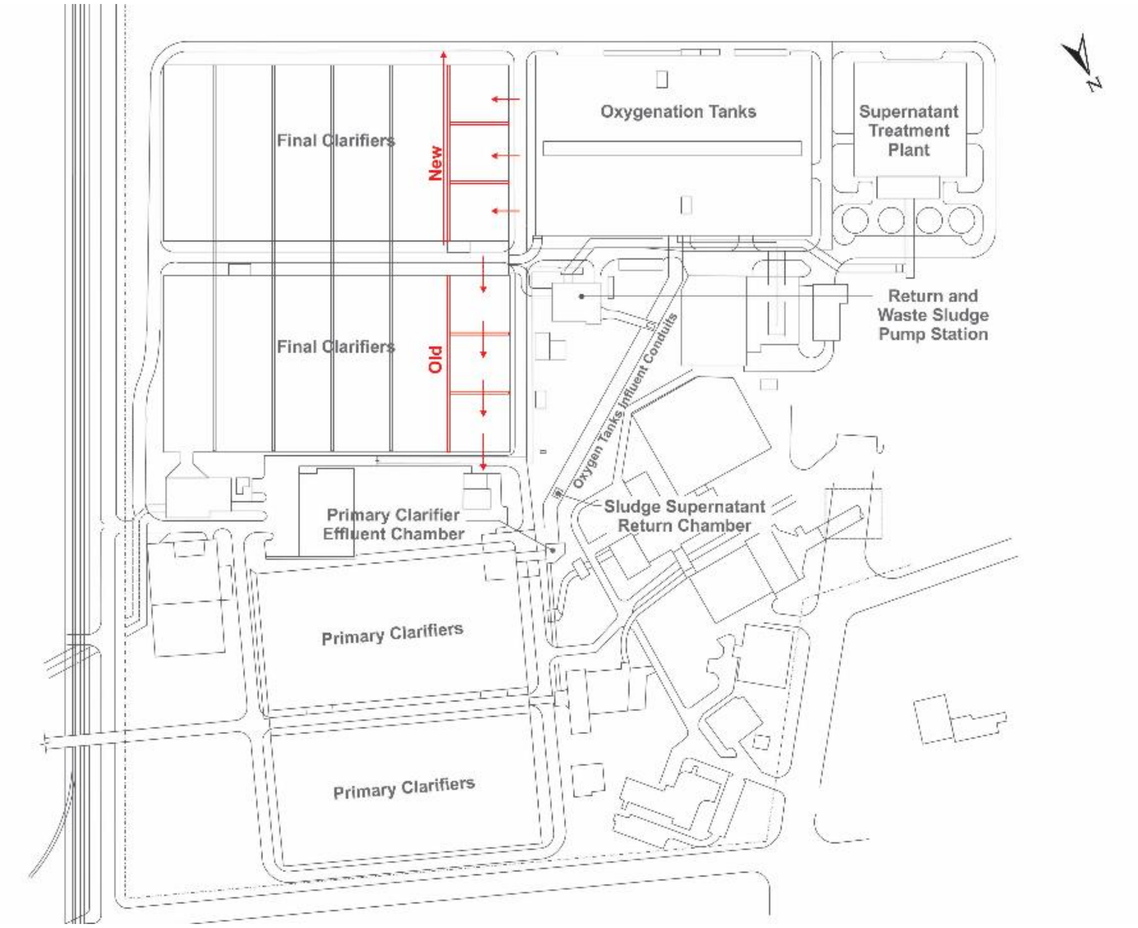

Figure 4-25: Modifications to FCs Site Layout

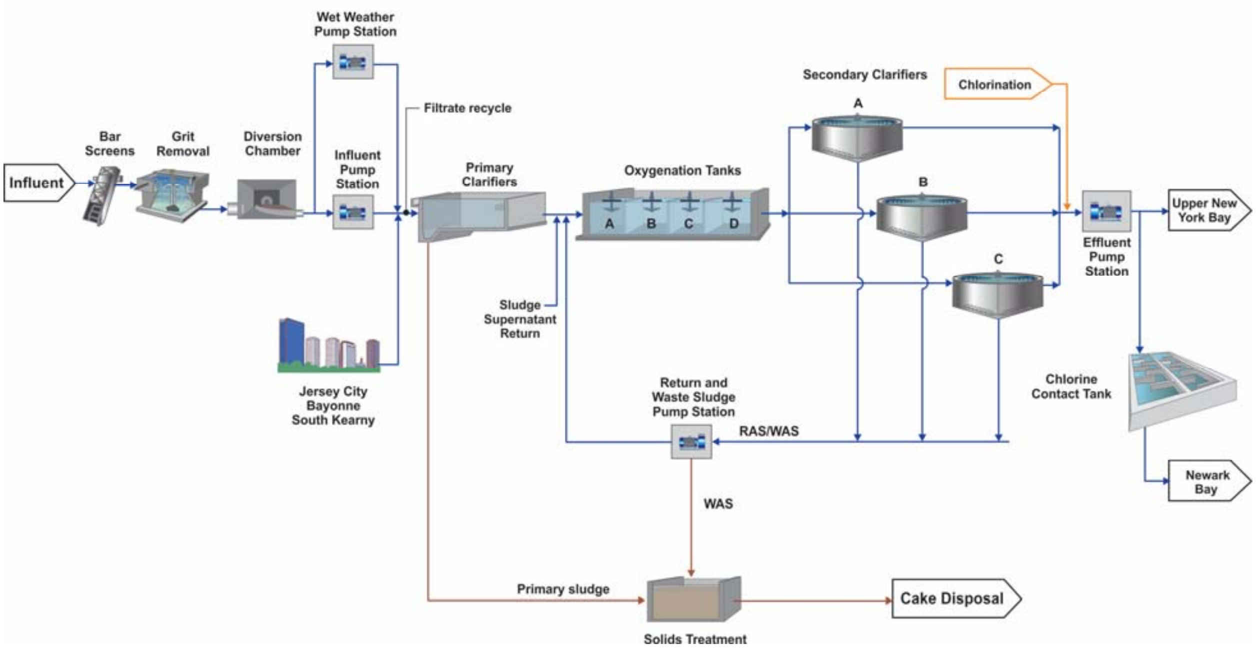

Figure 4-26: Modifications to FCs Process Flow Diagram

Results from the modeling analysis examining the potential for 720 mgd of influent plant flow with modified FCs are summarized in **Table 4-18.**

Table 4-18: Modifications to FCs Results

		Details
Flow through Plant	720 mgd	
Maximum Flow through Secondary Treatment	720 mgd	No bypass used in this option
MLSS Concentration to the FCs	~1,900-4,000 mg/L	Solids concentrations dictated by an SRT of 1.5 days
Estimated Effluent Quality	>45 mg/L	An SOR of 1,400 gpd/ft^2 (based on 12 FCs online, 720 mgd influent flow, and 15 mgd internal recycle) limits the treatment capacity and prevents compliance with effluent limits.
Key changes to equipment/infrastructure	Complete rebuild of the 12 existing FCs	New FCs, with RAS improvements, Energy Dissipating Inlet (EDI), center well, Stamford baffle, and suction headers or spiral scrapers
Operational Requirements	None	

Although rebuilding the FCs alone cannot achieve effluent permit compliance at 720 mgd influent flow, the use of modern FCs could provide increased wet weather secondary treatment up to a maximum influent flow of 600 mgd.

There are several important considerations to rebuilding the FCs:

- Significant process issues would be realized related to the MOPO during construction, as one or more FCs would be out of service for extended periods of time while construction is initiated and completed.

- The schedule for full-plant implementation would be on the order of 20 years or more, taking into account full-scale design and construction.
- There is a significant cost (discussed in **Section 0**) associated with the complete reconstruction of the FCs.

4.2.2.7 Routing Waste Activated Sludge into the Primary Clarifiers

4.2.2.7.1 Process Description and High-Level Screening

Routing WAS to the PCs could potentially offer a level of biological treatment to remove CBOD within the PCs by introducing biologically active biomass to the raw influent. However, given the settling characteristics of WAS are significantly poorer than those of raw sewage, it is expected that poorer primary solids removals would be observed, resulting in an increased load to the secondary system. This option would not provide an increase in wet weather treatment capacity and will not be evaluated further.

4.2.2.8 Main Stream Ballasted Floc - BioMag®

4.2.2.8.1 Process Description and High-Level Screening

Another option to increase the capacity of the secondary treatment system, within the existing footprint, would be to incorporate a ballasted floc technology into the main-stream treatment train, as opposed to a wet weather side stream (as discussed in **Section 4.2.2.3** with BioActiflo).

BioMag® is a ballasted flocculation-aid wastewater treatment process that uses magnetite to increase the specific gravity of biological floc. Magnetite (Fe_3O_4) is an inert iron ore, with a specific gravity of 5.2 and a strong affinity for biological solids. Magnetite substantially increases the settling rate of the biomass, providing the opportunity to increase the capacity of the secondary system.

The BioMag® system is shown in **Figure 4-27**. Virgin and recovered magnetite are blended with mixed liquor or RAS in a magnetite mix tank. The ballasted mixed liquor then flows to the bioreactor, and then on to the secondary clarifier, where the solids settle and thicken. The majority of the resultant “sludge” (with ballast) is returned to the aeration tank via the RAS line. WAS is pumped through a shear mixer and then to the magnetic recovery drum, where the ballast is recovered and sent for blending with the mixed liquor in the magnetite mix tank. The excess biological solids (minus the magnetite) are wasted to sludge processing. Magnetite deposition at the floor of the reactor in cases with poor or limited mixing is a concern of the BioMag® process.

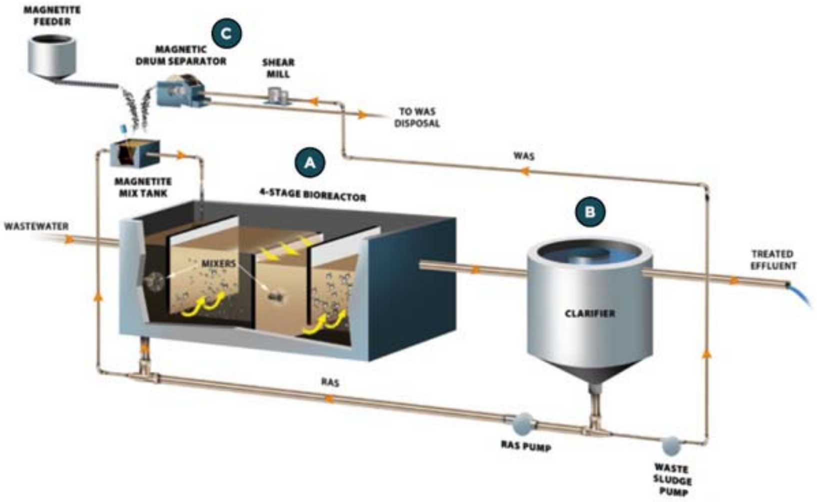

Figure 4-27: BioMag® Process Schematic (courtesy Evoqua)

Incorporating BioMag® into PVSC’s treatment process would require a very high magnetite usage at all times (during both dry and wet weather), with a ratio of magnetite to MLSS of 1:1. Increased aeration and mixing would be needed to keep the magnetite in suspension. No pure oxygen plants or plants of PVSC’s magnitude are currently operating with the BioMag® process, and significant piloting and testing would be required to understand if BioMag® is compatible with the pure oxygen process. The technology associated with this alternative is deemed to be unproven for application at PVSC, is considered not feasible to increase PVSC’s wet weather treatment capacity and will not be evaluated further.

4.2.2.9 Additional FC Infrastructure

4.2.2.9.1 Process Description and High-Level Screening

The existing FCs do not have sufficient capacity to handle flow up to 720 mgd. Historical data, field sampling, and modeling analyses have shown that the FCs are limited in capacity to a firm 400 mgd. To properly treat an additional 320 mgd, additional FCs would be required. There is currently no space on the PVSC site to build new FCs, as the current open or feasible footprints are being used as follows:

- The STP footprint is currently reserved for the future installation of a new Oxygen Production Plant, as discussed earlier in this report, and shown in **Figure 4-17**.
- The site to the east of the primary clarifiers, shown in **Figure 4-28**, is the project site for the standby power generation facility
- The property shown in **Figure 4-29**, is unavailable for any new infrastructure, due to pending litigation with the EPA regarding the Passaic superfund cleanup.

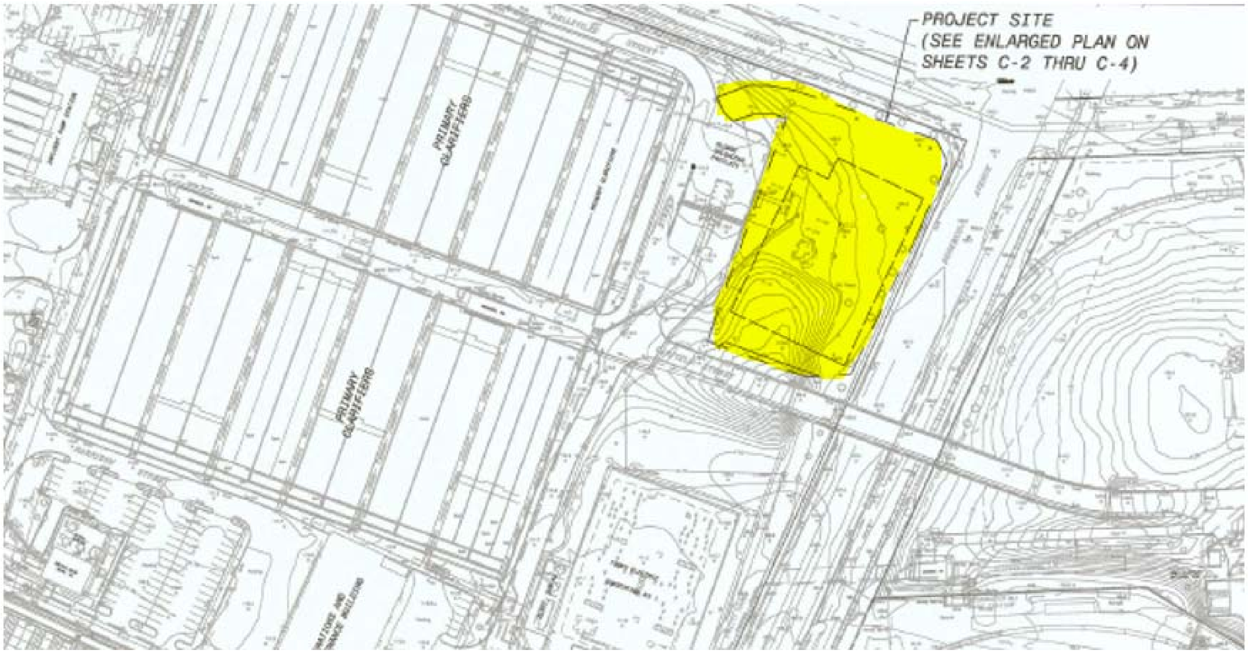

Figure 4-28: Standby Power Generation Facility

Figure 4-29: Site Associated with Passaic Superfund Cleanup

As such this option is considered not feasible to increase PVSC's wet weather treatment capacity and will not be evaluated further.

4.3 Cost Estimating Approach

A preliminary opinion of probable capital cost (OPCC) will be developed for each alternative evaluated. These are preliminary estimates and should be used as a basis for concept screening. As stated in AACE International Recommended Practice No. 18R-97, Class 5 estimates have a typical accuracy of -20% to -50% on the low side, and +30% to +100% on the high side. The OPCC incorporates the opinion of probable construction costs and the following factors:

- Design Contingency: 50%
- Contractor's Overhead: 10%
- Contractor's Profit: 15%
- Escalation: 3% to the assumed midpoint of construction
- Bond and Insurance: 3%

5. Alternatives Evaluation

Table 5-1 provides the preliminary opinion of probable capital costs for operational modifications and infrastructure improvements considered for implementation. Details on the development of capital costs are included in **Appendix A**.

Table 5-1: Preliminary Opinion of Probable Costs

Alternative	Capital Costs	Operational Costs	20-year Net Present Value ($M)
CEPT	$8	$500,000	$15
Secondary Bypass	$23	negligible	$23
Step-Feed	$74	negligible	$74
BioActiflo	$159	$300,000	$162
Temporary RAS Storage	$66	$100,000	$67
Rerouting of Recycle Streams	$4	negligible	$4
Modifications to FCs	$182	negligible	$182

6. Summary of Public Participation

The alternatives presented in this evaluation were presented to the public at the Supplemental CSO Team meeting held October 16, 2018. The presentation, included as **Appendix B**, provided a summary of the plant's existing infrastructure, treatment limitations at high flow conditions, alternatives identified for treatment, analysis methods (hydraulic, process, and CFD modeling), findings, and final recommendations (see **Section 7.0**).

7. Selection of Recommended Measures for Implementation

In order to select the recommended alternative(s) for implementation, the following feasibility criteria were considered against the findings from this study:

- **Priority 1: Permit compliance** – "No" indicates that it is likely that effluent quality would deteriorate with this alternative, leading to permit violations. "Yes" indicates that permit violations are not expected with this alternative and secondary treatment will have process stability. **Only alternatives, or combinations of alternatives, that comply with PVSC's permit will be considered for recommendation.**
- **Priority 2: Time needed for implementation** – "Short" indicates that construction completion is expected within 3-5 years of initiation of design. "Long" indicates that construction completion is expected over 5 years from initiation of design.
- **Priority 3: Cost** – "Low" indicates a 20-year Net Present Value up to $50M. "Medium" indicates a 20-year Net Present Value from $50M to $100M. "High" indicates a 20-year Net Present Value over $100M.

Table 7-1 evaluates each alternative investigated against the criteria listed above with the following opinions:

Table 7-1: Evaluation of Alternatives

Alternative	Reliable treatment of 720 mgd influent flow	Maximum flow for reliable treatment	Time needed for implementation	Cost
CEPT	No	400	Short	Low
Secondary Bypass	**Yes**	**720**	**Short**	**Low**
Step-Feed	No	400 (up to 550*)	Long	Medium
BioActiflo	No	720	Long	High
Temporary RAS Storage	No	400 (up to 550*)	Long	Medium
Rerouting of Recycle Streams	**No**	**400**	**Short**	**Low**
Modifications to FCs	No	600	Long	High

*Several alternatives would require testing/demonstration to confirm capacity and process reliability.

As presented in earlier sections and **Table 4-4,** only a secondary bypass and BioActiflo treatment alternatives can independently support permit compliance at an influent flow of 720 mgd. With the limitations discussed in **Section 4.2.2.3.2** regarding the lack of industry knowledge and application of this technology at the high flows needed, the new Oxygen Production Facility, and the high costs shown in **Table 7-1**, the secondary bypass is considered the only feasible alternative.

While not providing sufficient treatment of 720 mgd of influent flow, the following alternative did have important benefits, as summarized below:

- **Rerouting the recycle streams to the PCs,** while not increasing the firm capacity of the secondary treatment system above 400 mgd, may provide better quality effluent in dry weather and improved permit compliance. A reduction of dry weather effluent concentrations, when averaged with higher effluent TSS and CBOD concentrations realized during wet weather events, will aid in attaining overall compliance with permit limits.

Given the evaluation criteria presented in **Table 7-1** and the benefits of improved process performance related to the aforementioned relocation of sludge recycles, the following overall interim recommendations are provided:

Interim Recommendations: The most cost effective and expedient mean to increase PVSC's overall treatment capacity to 720 mgd while also meeting permitted effluent quality is to implement **two complementary alternatives**:

- **Sludge recycle reroute to the PCs** – This treatment alternative will allow for improved all-weather secondary treatment by reducing the loading on the secondary system.
- **Secondary bypass for flows over 400 mgd –** This treatment alternative will provide a total plant capacity of 720 mgd, with the flexibility to bypass flows of 320 mgd (assuming secondary treatment of 400 mgd), with the understanding that the bypass volume would be minimized, and secondary treatment would be maximized.

When implemented, the reduction in CSO discharges will approximate **1.4 billion gallons per year, a decrease of 37 percent** when compared to no additional treatment volume at the PVSC plant. At this time, it is estimated that the frequency of use for the secondary bypass would be approximately 4 percent of the operational time.

8. Proposed Monitoring Protocol

PVSC will conduct sampling of effluent as required by NJDEP and stated in permit number NJ0021016.

9. Proposed Plan for Public Notice

PVSC will provide public notification as required by NJDEP and stated in permit number NJ0021016.

10. Appendix A: Cost Estimate Details

11. Appendix B: Public Participation Presentation

12. Attachment 1

13. Attachment 2

14. Attachment 3