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November 16, 2018

Mitchell C. Bernstein, PE
Director
Department of Implementation
City of Alexandria

Re: City of Alexandria Master Stormwater Management Plan
Cover Letter and Concurrence Statement

Dear Mr. Bernstein:

Enclosed please find AKRF's Concurrence Review Memo of the Alexandria Waterfront: Flood Mitigation Implementation Master Stormwater Management Plan prepared for the City of Alexandria (CoA or the "City") by Stantec Consulting Services (Stantec) and dated November 5, 2018. The Concurrence Review Memo is organized into three sections 1) Peer Review Process 2) Summary of Findings, and 3) Review of Revised Materials.

Included as part of and referenced in the review memo are the following appendices:

- Appendix A - Kickoff meeting agenda prepared by OLIN, dated June 21, 2018
- Appendix B - Interim findings meeting minutes prepared by OLIN, issued July 23, 2018
- Appendix C - Engineers resolution meeting minutes prepared by OLIN, issued October 8, 2018
- Appendix D - Technical review prepared by AKRF, dated August 31, 2018

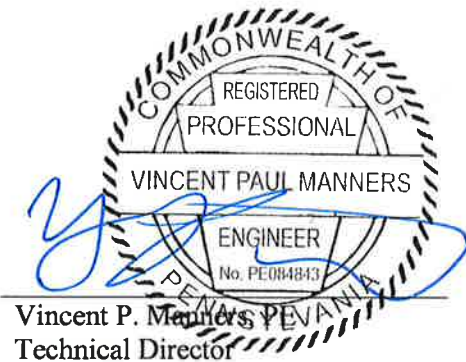
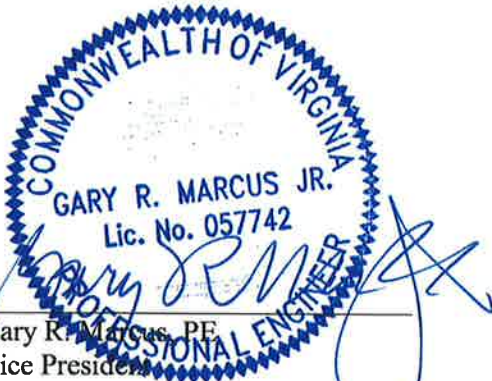
STATEMENT OF CONCURRENCE

AKRF provided a peer technical review of the primary flood mitigation measures (approach and strategy) proposed by Stantec, the City's engineer, as part of the Master Stormwater Management Plan. The review was organized into three core topics 1) outfalls, bypass storm sewers, and local storm sewers review, 2) structural bulkhead review, and 3) pump station review. Given the objective of eliminating nuisance flooding, AKRF agrees with the basic approach (i.e. building a structural bulkhead and using pumps to discharge stormwater runoff across the bulkhead to the river) to flood mitigation proposed in the Master Stormwater Management Plan. AKRF agrees with Stantec that Alternative 3 presented in the Master Stormwater Management Plan, which eliminates stormwater bypass in favor of larger pump stations, provides the most feasible approach as compared to the other alternatives identified. AKRF agrees with Stantec that Alternatives 1 and 2, which would include the use of a stormwater bypass to

reduce the reliance on pump stations, are not feasible due to insufficient hydraulic grade. In addition to the review of feasibility and general approach to flood mitigation, AKRF's review recommends general best engineering practices and the further study of several design elements, which are appropriate to address in later stages of design. These comments have been conveyed to the City of Alexandria and the design teams, and are noted in the Master Stormwater Management Plan as such. AKRF's concurrence with the Master Stormwater Management Plan is predicated on the City and the City's engineer adequately addressing these recommendations in future design phases.

The review focused on a critical assessment of the design approach and strategy, as well as a targeted review of key design calculations. The review consisted of specific documents provided by the City of Alexandria and the design team; it should not be assumed that additional information sources outside of this list were reviewed. The performance of this review does not constitute acceptance of the design concepts or requirements, therefore AKRF does not accept liability for any of the work performed or to be performed. The responsibility for the planning and design remains with the Engineer of Record.

Sincerely,
AKRF, Inc.



Encl.

Concurrence Review Memo

cc: AKRF File

Alexandria Waterfront: Flood Mitigation Implementation

Master Storm Water Management Plan



Prepared for:
City of Alexandria



Prepared by:
Stantec
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Fairfax, VA 22030

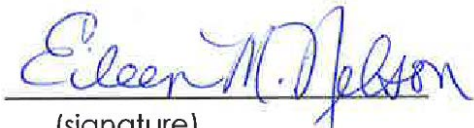
November 5, 2018

Sign-off Sheet

This document entitled Alexandria Waterfront: Flood Mitigation Implementation Master Storm Water Management Plan was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of City of Alexandria (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

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EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

The City of Alexandria's Flood Mitigation Implementation Project is intended to address and mitigate the frequent flooding experienced in the Core Area. Currently, flooding is common in the Core Area, especially at King Street, and the extent of the disruption created by each event ranges from inconvenient road flooding to negatively affecting commerce and damaging homes, businesses, and infrastructure. The City of Alexandria has commissioned Stantec Consulting Services Inc. to oversee this preliminary phase of the Flood Mitigation Implementation Project with the intention of reducing the common nuisance flooding that afflicts the area. This portion of the project will allow the City of Alexandria to invest in an expansive and highly visible revitalization project on the Waterfront.

The proposed Flood Mitigation System has multiple components which work together to reduce flooding in the Core Area. The bulkhead is designed to keep the Potomac River from inundating the Core Area, while a local storm sewer system is employed to avoid nuisance flooding by routing water to pump stations which will pump stormwater into the river. A bypass storm sewer system is proposed to divert upstream drainage areas directly to the Potomac River to alleviate strain on the local storm system and pump stations. These flood mitigation measures are proposed to reduce the risk of flooding of the Core Area up to the 10-year flood elevation of 6.0'. Three alternative scenarios were developed for the storm sewer system and pump stations. Stantec recommends Alternative 3, which does not employ bypass systems due to flooding potential, and routes all upstream and local drainage to the two pump stations.



ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

INTRODUCTION

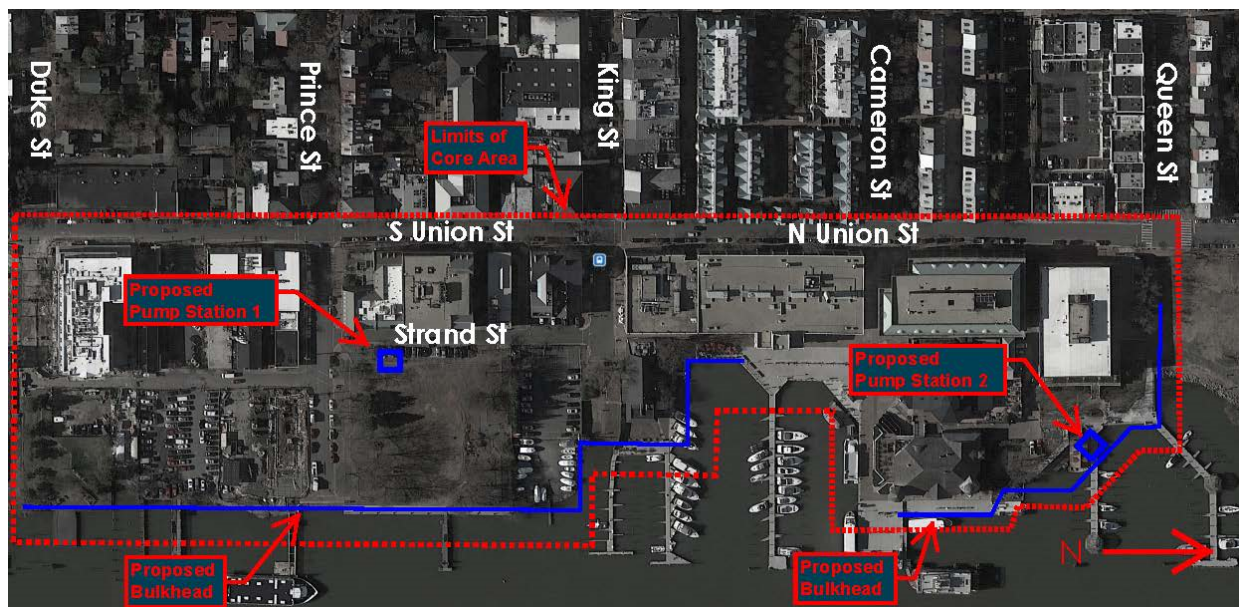
2.0 INTRODUCTION

The City of Alexandria, Virginia, is a municipality located on the west bank of the Potomac River, six miles south of Washington, D.C. The City is 15.75 square miles and includes 946.7 acres of open space and park lands.

Alexandria is prone to flooding from heavy rainfall and from tropical storms creating overbank flooding from the Potomac River and its tributaries (Backlick Run, Cameron Run, Four Mile Run, Holmes Run, Hooft's Run, Taylor Run, Timberbranch Run, Strawberry Run, and Lucky Run). The most common local flooding problem is due to summer thunderstorms with high intensity-short duration rainfall. The tidal influence on the Potomac River, in conjunction with development in low lying areas, and an overtaxed storm water system are also contributing factors to flooding (City of Alexandria T&ES, <https://www.alexandriava.gov/FloodMap>).

The objective of this Master Storm Water Management Plan (MSWMP) is to define the tributary drainage basins necessary to support the design of the flood mitigation and storm sewer infrastructure systems. The MSWMP includes a Water Quality Impact Analysis (WQIA), reviews the applicability of the flood mitigation measures recommended in the 2010 Potomac River Waterfront Flood Mitigation Study, and includes preliminary location and sizing for storm water conveyance and management components within the Alexandria Waterfront's "Core Area".

The Alexandria Waterfront's "Core Area" encompasses approximately one-half mile of Potomac River shoreline. The Potomac River, Queen Street, Duke Street, and Union Street bound the Core Area. These limits are further defined by the Waterfront Small Area Plan Implementation, Design Schematic Pricing Set drawings (dated 9/10/2014) and the Waterfront Flood Mitigation Project, 15% Concept Design submission drawings (dated 7/31/2014), both provided by the City of Alexandria.



ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

BACKGROUND

3.0 BACKGROUND

The City of Alexandria experiences frequent flooding from heavy rainfall which affects businesses, residences, and infrastructure along the waterfront. The King Street intersections with Strand Street and with North Union Street are low points in the waterfront area, which see flooding even during small storm events. This report analyzes the ten-year storm event in accordance with the City of Alexandria Intensity-Duration-Frequency (IDF) curves. The ten-year storm event is expected to yield a Potomac River flood elevation of 6.0 feet (NAVD 88 vertical datum).

The flooding table shows the flooding elevation for each flood event as specified by the Potomac River Waterfront Flood Mitigation Study, and mean high and low water elevations specified by Moffat & Nichol.

Return Period of Studied Flood Events

Flood Event	Elevation (feet, NAVD88)	Return Period (years)
Mean Lower Low Water	-1.30	-
Mean Low Water	-1.16	-
Mean High Water	1.43	-
Mean Higher High Water	1.65	-
Nuisance	4.0	1.5
10-year Flood	6.0	10
Intermediate	8.0	30
Extreme	10.2	100

3.1 RAINFALL BACKGROUND

This report uses the City of Alexandria's Intensity-Duration-Frequency (IDF) curve to perform storm pipe computations and hydraulic grade line (HGL) computations in accordance with City of Alexandria standards. The City of Alexandria uses their IDF curve for storm sewer conveyance computations and does not extend beyond the 100-year storm. To analyze larger storms, NOAA Atlas 14 data is utilized, though these intensities are typically considered for storm water management purposes only. In comparison, the City's IDF curve is more conservative than the NOAA Atlas 14. A comparison table of intensities is below.

	City of Alexandria (1989)	NOAA Atlas 14
Recurrence Interval (yr.)	Intensity (in/hr.)	Intensity (in/hr.)
1	4.60	4.28
2	6.20	5.15
5	8.10	6.11
10	9.00	6.83



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BACKGROUND

	City of Alexandria (1989)	NOAA Atlas 14
Recurrence Interval (yr.)	Intensity (in/hr.)	Intensity (in/hr.)
25	10.80	7.74
50	12.50	8.41
100	13.80	9.07
500	-	10.50
1000	-	11.20

3.2 CLIMATE CHANGE

To prepare for the possible effects of climate change, the City of Alexandria commissioned the Technical Memorandum "Rainfall Frequency and Global Change Model Options for the City of Alexandria, Virginia" (dated August 30, 2011). The memorandum provided an analysis of predicted changes in daily and annual precipitation for the years 2050 and 2100.

The study used the SimCLIM modeling application to create an IDF curve for Alexandria based on historical rainfall data collected at five (5) local rainfall recording stations. To account for the effects of climate change, the application applied 12 daily global circulation models with low, medium, and high greenhouse gas emissions to predict future rainfall intensity and frequency.

The IDF curve developed by SimCLIM for both 2050 and 2100 predicts that storms under twelve (12) hours at the ten (10)-year return period will have a lesser precipitation intensity than the IDF curve provided by the City of Alexandria. The precipitation intensity used as the baseline storm in this report uses a conservative storm duration of five (5) minutes, and is consequently a greater intensity than predicted by the SimCLIM models.

The following table shows the 10-year, 5-minute storm precipitation intensities for the Alexandria IDF curve, NOAA Atlas 14 IDF curve, and SimCLIM Rainfall Intensity for the present, 2050, and 2100. This further supports using the current City IDF curves as the most conservative rainfall estimates for storm water management and flood mitigation analysis.

IDF Curve	Precipitation Intensity (in/hr.)
Alexandria IDF	9.00
NOAA Atlas 14	6.83
SimCLIM (1945-2010)	7.08
SimCLIM 2050	7.38
SimCLIM 2100	7.67

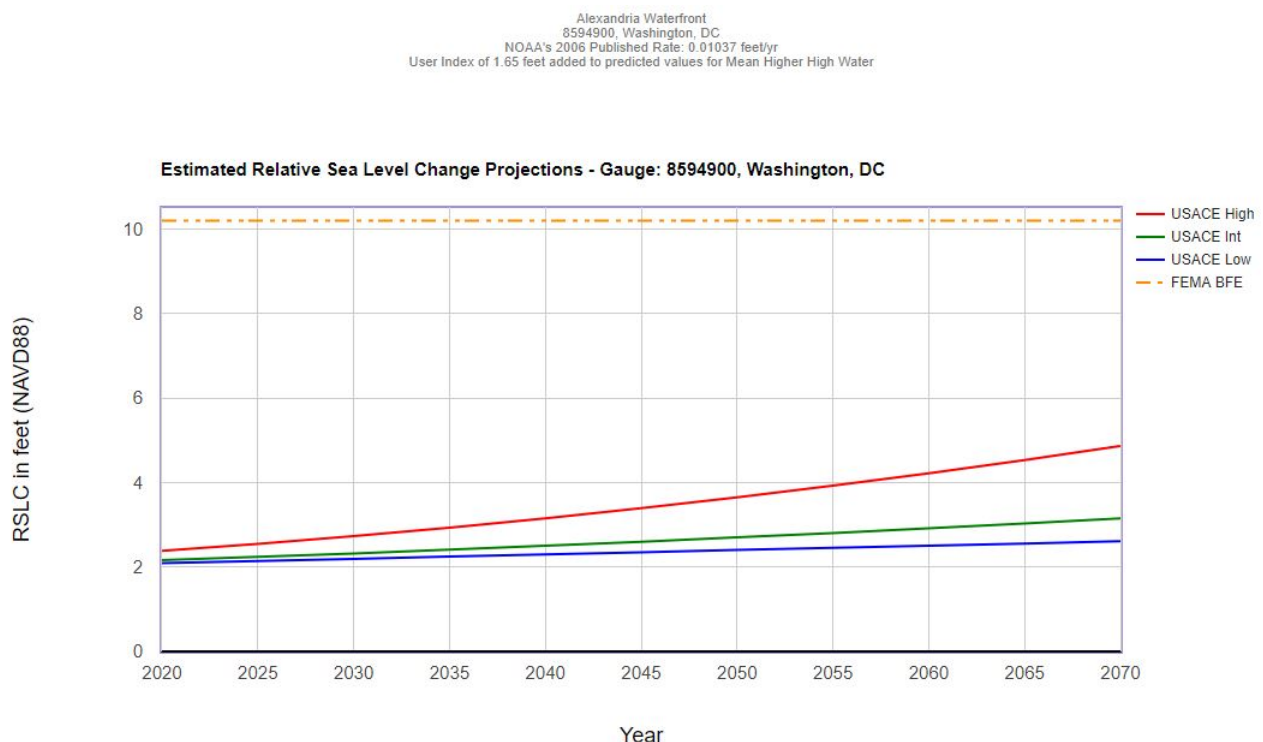
ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

BACKGROUND

3.2.1 SEA LEVEL RISE

Sea level rise is a major effect of climate change over the life of the proposed bulkhead. Sea level rose by an average of 1.2 inches per decade during the 20th century (NOAA). The climate change will increase the sea level rise in the Potomac River and increase flood and overtopping risks for the core area. Additionally, the 100-year flood is projected to occur more frequently. As it relates to the City of Alexandria, high tides and storm surges are a concern with increasing sea level. According to U.S. Army Corps of Engineers, scientists have very high confidence (greater than 90% chance) that the global mean sea level will rise at least 8 inches (0.2 meter) and no more than 6.6 feet (2.0 meters) by 2100.

The U.S. Army Corps of Engineers has developed a Sea-Level Change Calculator to assist in a climate change adaption policy. The Sea-Level Change Calculator uses National Oceanic and Atmospheric Administration (NOAA) and New York City Panel on Climate Change (NPCC 2013) scenarios to help assess what the sea level rise in an area could look like. The nearest gauge to the Alexandria Waterfront Core Area is the Washington DC gauge located near the DC Southwest Waterfront. The graphic and table below show the estimated relative sea level change projections for a 50-year period, with relative elevation at the Mean Higher High Water elevation of 1.65 feet (NAVD88). As shown in the graph, the NOAA 2006 published rate of increase is approximately 0.01037 feet/year.



(source: http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html)



ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

BACKGROUND

Alexandria Waterfront
8594900, Washington, DC
NOAA's 2006 Published Rate: 0.01037 feet/yr
User Index of 1.65 feet added to predicted values for Mean Higher High Water
All values are expressed in feet relative to NAVD88

Year	USACE Low	USACE Int	USACE High
2020	2.09	2.16	2.38
2025	2.14	2.24	2.55
2030	2.19	2.32	2.73
2035	2.25	2.41	2.93
2040	2.30	2.50	3.15
2045	2.35	2.60	3.39
2050	2.40	2.70	3.65
2055	2.45	2.81	3.93
2060	2.51	2.92	4.22
2065	2.56	3.03	4.53
2070	2.61	3.15	4.86

USACE recommends using the intermediate projection for civil works projects. For a 50-year design life of the improvements included in this report, the mean sea level at year 2070 would be 3.15 feet, an increase of 1.5 feet from today's Mean Higher High Water elevation of 1.65 feet.

A proposed bulkhead elevation of 6.0 feet, corresponding to the 10-year flood elevation, was chosen as the most practical height by the City per the 2010 Potomac River Waterfront Flood Mitigation Study: Evaluation and Recommendation of Mitigation Measures (see Section 4.1 for additional information on the proposed bulkhead). The height of the bulkhead is based on existing topography, the need to preserve the look and feel of the waterfront, and for protection of the maximum amount of impacted structures. At the discretion of the City, final design of the bulkhead can consider the capability to raise the top elevation for temporary purposes or for future permanent flood risk reduction, where feasible.

The pump station building design places electrical equipment and generators above the current 100-year flood elevation (10.2 feet). Additionally, in final design, it can be considered to raise the finished floor elevation by a determined amount to account for future sea level rise. The height would be at the discretion of the City. Factors to consider for any additional increase in height include the increased cost of additional building height along with the impacted views and building massing.

ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

BACKGROUND

3.3 BASIS OF DESIGN

The following table is a summary of the elements of this project and associated criteria for design:

	City of Alexandria Design Storm	VDOT Drainage Manual Ch 9 Design Storm	Other Design Storm (NOAA Atlas 14)	Basis of Design Recommendation
Storm System (Pipe)	10-year (9.0 in/hr)	10-year	10-year (6.83 in/hr)	City of Alexandria
Storm System (Pipe at Sag Point)	N/A	100-year (per VDOT Drainage Manual 9.4.8.3)	N/A	VDOT
Storm System (HGL)	10-year (9.0 in/hr) 100-year (13.80 in/hr) 2' freeboard required (for 10-year storm)	10-year	10-year (6.83 in/hr) 100-year (9.07 in/hr)	City of Alexandria 10 & 100 Request that 10-year 2' freeboard requirement to be waived, HGL not exceed throat elevation of inlets
Inlet (Longitudinal & Flanking)	10-year (9.0 in/hr)	4.0 in/hr (assume 50% clogging)	10-year (6.83 in/hr)	City of Alexandria (assume 50% clogging)
Inlet (Sag/Sump)	100-year (13.80 in/hr)	4.0 in/hr (assume 50% clogging)	100-year (9.07 in/hr)	City of Alexandria (assume 50% clogging)
Pump Station (Pumps)	No guidelines, governed by upstream system	No guidelines, governed by upstream system	N/A	City of Alexandria 10-year
Pump Station (Wet Wells)	No guidelines, governed by upstream system	No guidelines, governed by upstream system	If over 40,000 gpm then Hydraulic Institute Standards & Guidelines	City of Alexandria 10-year
Overland Relief	100-year (13.80 in/hr)	100-year	N/A	City of Alexandria



ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

BACKGROUND

All storm sewers shall be constructed to the City of Alexandria Design Standards and Specifications. If the City of Alexandria Design Standards and Specifications and subsequent Memorandums to Industry do not cover any design aspects of the project, then the improvements will be designed per the latest standards and specifications of the Virginia Department of Transportation (VDOT), Virginia Erosion and Sediment Control Handbook (VESCH), American Association of State Highway and Transportation Officials (AASHTO), Manual of Traffic Control Devices (MUTCD), Virginia Work Area Protection Manual (VWAPM), Virginia Uniform Statewide Building Code (VUSBC), Statewide Fire Prevention Code (SFPC), associated International Building Codes (IBC), and any other standards approved by the Directors of Project Implementation, Transportation and Environmental Services, Planning and Zoning, Fire and Code Administration, and Recreation, Parks & Cultural Activities.

Per the City of Alexandria Memorandum to Industry No. 02-09 (dated December 3, 2009), all storm sewers shall be constructed to the City of Alexandria standards and specifications. Minimum diameter storm sewers shall be 18" and acceptable pipe materials are Reinforced Concrete Pipe (RCP) Class IV (ASTM C-76 CL IV) or AWAA C-151 (ANSI A21.51) Class 52. Acceptable minimum and maximum velocities will be 2.0 feet per second and 15 feet per second, respectively. Curb inlets will conform to the City of Alexandria standard (CSDI-1 or CSDI-1A) with a curb opening of 5 inches (0.42 ft) and lengths of either 5', 10', 15', or 20'. Where appropriate and applicable, VDOT standard combination curb and grate inlet structures may be utilized. In accordance with VDOT standards, if a combination inlet is used, it will be designed as an on-grade curb inlet without consideration of the grate due to its propensity to clog. The Fairfax County Public Facilities Manual (PFM) standard 24" cover over pipe will be used due to slope and vertical crossings constraints. Additional approved structural measures, such as concrete cradles, will be provided when cover or clearance requirements cannot be met.

In addition, non-compliant ramps adjacent to replaced inlets will be reconstructed to meet current ADA standards.

The Rational Method was chosen as the appropriate basis of analysis for storm sewer pipe design for this report as the project study area is under 200 acres. The time of concentration is conservatively assumed at five (5) minutes. A Rational c-factor of 0.80, representing 80% impervious cover, was chosen based on the commercial nature of the drainage areas. This model provides a conservative peak runoff rate to size the conveyance pipes for preliminary design. Analysis has not yet been conducted using a method such as NRCS TR-55, modeling the entire storm event and the volume of water generated during these storms. This is intended to be done during the final design. Using the NRCS 24-hour Type II storm distribution, most of the storm occurs between hours 11.5 to 12.5. A mass balance model would be created to include the incoming storm volume runoff, the storage volume availability in the pump stations and storm sewer pipes, and the output of the pump stations. This model will allow the pump station design to be optimized during final design.

The design of the storm system will be conservative using the City's IDF curve when compared to the NOAA Atlas curve. Additional system components will also be designed with a 10-year City of Alexandria design storm, with 50% clogging expected at the inlets. As such, the City understands the preliminary design of the system is conservative, which is the intent to meet the goals of flood mitigation in the Waterfront Core Area.



ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

PROJECT COMPONENTS

4.0 PROJECT COMPONENTS

Several flood mitigation elements were proposed in the 2010 Potomac River Waterfront Flood Mitigation Study, including a structural bulkhead, pump stations, bypass storm sewer systems, and local storm sewer systems. The proposed flood mitigation system has multiple components which work together to reduce and prevent flooding in the Core Area. The bulkhead is designed to keep the Potomac River from inundating the Core Area and prevent nuisance flooding, while a storm sewer system is employed to route rainwater to pump stations which will pump stormwater into the river. Three alternative scenarios were developed for the storm sewer system and pump stations. These flood mitigation measures are proposed to reduce the risk of flooding of the Core Area up to the 10-year flood elevation of 6.0'. These components shall be reviewed by different specialists, including geotechnical engineers and corrosion control specialists, when the project moves into final design.

4.1 STRUCTURAL BULKHEAD

A vertical, structural bulkhead at an elevation of 6.0' is proposed with this Master Storm Water Management Plan. The bulkhead is proposed to run north-south along the Potomac River from Duke Street through the Marina and ending at Queen Street. The proposed bulkhead will create a continuous protective barrier in the Core Area of the City. The bulkhead will run from Duke Street to Queen Street along approximately 2,360 feet of shoreline. Bulkhead types under consideration are steel sheet piles anchored with batter piles, pile supported deadman, tandem wall deadman arrangements, and soil anchors. There will be a pedestrian promenade along the bulkhead to provide access along the shoreline. Preliminary bulkhead design will be provided separately in the Bulkhead Design Manual, issued by the City. The bulkhead and an overall drainage area map are shown in Appendix A.

The bulkhead will reduce the risk of flooding up to and including the 10-year storm event, to minimize the damage from the frequent smaller flood events. Final design of the bulkhead will allow for the capability to raise the top elevation of the bulkhead by a pre-determined amount for future permanent flood risk reduction, where feasible. Final design of the bulkhead will also take into consideration corrosion, debris removal, and other components to deal with the unique conditions of the Alexandria Waterfront and the Potomac River. These elements will be detailed further in the Bulkhead Design Manual, issued by the City.

At the final design stage, additional considerations will be made for erosion control in the event the bulkhead overtops, including rip-rap behind the base of the wall. Concerns due to erosion at the outfall points in the Potomac River will be addressed at final design with consideration of the ultimate design dredge elevation and implementation of rip-rap or other erosion control measures at each point. The preliminary programmed dredged depth is -6 feet NAVD from Fitzgerald Square Park to Point Lumley. Additional maintenance dredging of the commercial docks and City Marina from the Torpedo Factory to Founder's Park to a depth of -10 feet NAVD is programmed with the project. The dredging extents and approximate volumes are shown in Appendix J.

ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

PROJECT COMPONENTS

4.2 OUTFALLS INTO THE POTOMAC RIVER

An isolation valve must be installed at each outfall into the Potomac River to prevent backflow into the storm system. A standard flap valve, duckbill valve, and in-line valve have been considered.

Traditional flap valves have a long useful life, but create maintenance issues, and metal flapgates are susceptible to corrosion and freezing. Traditional flap valves are prone to clogging and are easily propped open by debris.

The duckbill valve allows flow out into the river but will not allow backflow into the system. Duckbills open with as little as 1-inch of water pressure, and reseals to prevent backflow and debris from entering the system. It is noted that the City of Alexandria has used duckbill structures in the past which have not functioned well, possibly due to improper sizing of the duckbill structure. Duckbill valves should be specifically sized for the outfall pipes' outside diameter to reduce head loss and to reduce deflection inside the valve due to the weight of water. Due to the anticipated size of the duckbill valves and their physical extension beyond the face of the outfall pipes, there is a concern that the duckbill will impair the view of the Waterfront, and interfere with boats in the marina. In addition, duckbill valves require more maintenance after large storms, as they still have a risk to become clogged with debris, which impairs the function of the valve.

The in-line valve (CheckMate by Red Valve). This is an in-line valve which is installed within the pipe, produces low head loss, and provide redundancy anywhere in the system. The advantage of this valve is that it is installed inside the pipe and is not visible. It will not cause interference with the view of the Waterfront or impede any boat movement. The in-line valve is designed to be submerged, and will work with 1-inch of differential pressure and function well under low flow conditions. It will seal to prevent backflow and debris from entering the system. In our analysis, municipal users of the CheckMate valve were contacted for their input and experience with their use of the valves. Overwhelmingly, the responses received were positive.

For the above reasons, it is recommended the City use the CheckMate in-line valve for all outfall points. More information on the CheckMate has been provided in Appendix I. Final outfall structure selection will be made by the City at the time of final design, with consideration for functionality, head loss, maintenance, and cost of each valve type.

During final design of the bulkhead, consideration will be made for how the outfall pipes penetrate the bulkhead. Also, at final design, maintenance procedures will be taken into account, with the consideration for redundant structures at the end of the system before the bulkhead to allow access to replace or repair the valves from the land and avoid submerged maintenance on the River side of the bulkhead. Due to the size of the outfall pipes and valves (48"-60"), those redundant structures will have to be large and possibly require confined space entry. If the valves are placed directly at the bulkhead without any energy dissipation devices, then they can be accessed for maintenance during low water elevations and while using temporary cofferdams (such as inflatable bladder dams or water-filled cofferdams).

Concerns due to erosion at the outfall points will be addressed at final design with consideration of the ultimate design dredge elevation. Rip-rap or other erosion control measures will be

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implemented at each point. To minimize adverse occurrences in the river at the discharge points of the pump stations, an energy dissipater device will be necessary. The main purpose of the device will be to reduce the velocity and absorb the velocity head during operation of the high flow pumps. This could be accomplished by increasing the flow area by either multiple discharge pipe through the bulkhead or by a structure. The simplest structure type is a concrete chamber that will contain the turbulence and discharge over a weir to reduce the velocity in the river. Under high flow conditions, the water from the force main will fill the chamber and flow over the weir into the river. The weir location would be located above the mean higher high water elevation, but below the top of the bulkhead. Additional orifices (such as smaller 6" diameter circular holes) can be added to the base of the chamber, such that the chamber will drain down at the same level as the river. The chamber would be sized to provide maintenance to the in-line valves, and with enough space to replace the valves if necessary. Access to maintain the valves would be through lock-down hatches at the elevation of the promenade. The weir and orifices will exit directly at the bulkhead such that there is nothing protruding into the Potomac River.

The final selection of the method may require computational fluid dynamic modeling during the final engineering phase. The existing outfalls are described below in Sections 4.2.1 through 4.2.6, and future conveyance of each outfall is described in Section 4.3.

4.2.1 DUKE STREET

The existing Duke Street storm system outfalls into the Potomac River with an 18-inch RCP pipe at elevation -0.90. Adjacent to Duke Street and South Union Street is the Robinson Terminal South development (plans prepared by others), which proposes four buildings for residential and commercial uses and six townhouse buildings currently under construction. There are proposed storm sewer improvements within this development, which connect to the existing outfall pipe. This outfall pipe is proposed to be removed and replaced.

4.2.2 POINT LUMLEY

There is an existing grate inlet that outfalls in a 15-inch pipe on the east side of the old Alexandria Marine Service and Sales building. This grate and pipe is proposed to be demolished or abandoned in place.

4.2.3 PRINCE STREET

The existing Prince Street storm system outfalls into the existing bulkhead with a 21-inch RCP pipe (not field verified; pipe size/material per available records). The exact location of this outfall cannot be determined at this time, but it is referenced to outfall at elevation -2.00 per the Old Dominion Boat Club final site plan (dated January 2016, plans prepared by others). This outfall is proposed to be demolished or abandoned in place.

An existing curb inlet and 10-inch pipe outfall directly adjacent to the River at the end of Prince Street at elevation -0.61. This outfall is proposed to be demolished or abandoned in place.

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4.2.4 KING STREET

The existing King Street storm system outfalls into the existing bulkhead with a 24-inch RCP pipe (not field verified; pipe size/material per available records). The exact location of this outfall cannot be determined at this time. This outfall is proposed to be demolished or abandoned in place.

4.2.5 CAMERON STREET

The existing Cameron Street storm system outfalls into the existing bulkhead with an 18-inch RCP pipe (not field verified; pipe size/material per available records). The exact location of this outfall could not be determined at this time. In addition, there are some local drains from buildings in this area that will need to remain. It is the engineer's opinion that the last pipe run of this outfall should remain to maintain the existing drain connections. At the City's discretion, the outfall can be located and inspected, and an in-line valve could be installed for backflow prevention.

4.2.6 QUEEN STREET

The existing Queen Street storm system outfalls into the Potomac River with a RCP pipe (not field verified; pipe size/material per available records) at the north end of the Core Area, adjacent to Founder's Park. The exact location of this outfall could not be determined at the time of field survey, and is believed to be covered with silt and rip-rap. City of Alexandria Department of Transportation and Environmental Services has prepared a plan (Founder's Park Storm Sewer Repair, dated 11/10/2016) to remove and replace the existing 18-inch RCP pipe, which outfalls to the Potomac River at elevation -3.0. This work is scheduled for construction, but discussions are ongoing to incorporate this work with the improvements proposed in this report. In Alternative 3 (see Section 4.3.3), since all upstream flow is routed to the pump station, the bypass line can be upgraded to working condition as soon as possible. However, these improvements will be demolished or abandoned several years later at the time the pump station is put into commission (estimated in the year 2022).

4.3 BYPASS STORM SEWER SYSTEMS

For Alternatives 1 and 2 described below, a sealed storm sewer system will be proposed to convey upstream runoff directly to the river, which bypasses the pump stations. The bypass storm system will decrease the size of the drainage area to the pump station, such that higher runoff storm events will not overwhelm the pumps. The bypass storm systems will replace and upgrade the existing outfalls into the bulkhead. All structure tops along the bypass systems will need to be replaced with bolt-down tops to prevent uplift in the event the water level rises inside the structures. All concrete pipe should have watertight rubber gasketed joints in accordance with VDOT Road and Bridge Specifications Section 212. All storm sewer design intends to follow the City of Alexandria Design and Construction Standards Manual, and where applicable, Fairfax County Public Facilities Manual (PFM). Preliminary pipe computations for the bypass storm sewer system are shown in Appendix D. Preliminary hydraulic grade line (HGL)

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computations have been performed and are shown in Appendix D. All calculations and head losses will be updated based on final design for the selected Alternative.

When assessing the initial storm sewer design, the computations show that the hydraulic grade line (HGL) exceeds the rim of the inlets and manholes of the storm sewer system, which could cause ponding and local flooding conditions. Due to the physical constraints of the site, the HGL cannot be lowered to meet City requirements (two feet below the inlet throat elevation). A waiver will need to be applied for which requests exception to two feet clearance between HGL and throat elevation and proposes the acceptable HGL to be when the inlet water surface elevation is lower than the throat elevation (0 ft clearance). Due to the unacceptable HGL conditions, alternative designs to mitigate the risk of flooding of upstream inlets were evaluated. Alternative 1 shows the bypass system and local system as initially conceptualized by others. Alternative 2 shows the bypass system and local system, with inlets moved and additional changes made with the goal to eliminate HGL issues. Alternative 3 eliminates all bypass systems, except Duke Street, and routes all the stormwater to the pump stations.

4.3.1 ALTERNATIVE 1

Alternative 1 utilizes bypass systems to route upstream water directly to the Potomac River. The Duke Street outfall pipe will be replaced with new 24-inch RCP pipe. A preliminary storm pipe profile is shown in Appendix E.

At Prince Street, additional inlets along South Union Street will convey stormwater into the bypass system. The system will convey an area of approximately 4.5 Acres into a 36-inch pipe system. A preliminary storm pipe profile is shown in Appendix E. Preliminary HGL computations show that this solution is not acceptable.

At King Street, additional curb inlets will be provided to convey flow through the re-constructed bypass system. The bypass system will convey approximately 12.7 acres of upstream drainage area in a 48-inch pipe system. To alleviate the existing bypass system, additional inlets have been added at the intersection of King Street and Union Street, which convey flow to Pump Station 1 adjacent to Strand Street. A preliminary storm pipe profile is shown in Appendix E. Preliminary HGL computations show that this solution is not acceptable.

An additional grate inlet was shown in Thompsons Alley, north of Union Street, previously proposed by others. It is the engineer's opinion that this inlet is unnecessary due to the additional inlets proposed in Union Street for the local storm system, as well as the desire to limit disturbance in the Alley behind private homes.

At the intersection of Queen Street and North Union Street, the existing grate inlet will be replaced with a larger grate inlet or curb & grate combination inlet. The downstream pipe system will be replaced with 36-inch pipes. This bypass system will convey approximately 4.1 acres of upstream drainage. A preliminary storm pipe profile is shown in Appendix E. Preliminary HGL computations show that this solution is not acceptable.

Upstream drainage areas for Alternative 1 are shown based on GIS topographic information only, and do not consider the delineation of roof drains from each block. Detailed drainage

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area delineation would only increase the runoff to each storm system, creating a more unacceptable HGL within the system.

4.3.2 ALTERNATIVE 2

Alternative 2 shows the bypass system and local system, with inlets moved and additional changes made with the goal to eliminate HGL issues.

The outfall pipe at Duke Street will be replaced with new 30-inch and 36-inch RCP pipe. The existing grate inlet at Point Lumley will be routed to the outfall. Preliminary HGL computations show that this solution is still not acceptable due to the existing grades that constrain the area.

At Prince Street, additional inlets along South Union Street will convey stormwater into the bypass system. Storm pipes were upsized to 42" to achieve lower water surface elevations. Manholes along Prince Street have HGL elevations exceeding their tops, with the concern that more than 1' of differential will dislocate the top of the bolt-down frame and cover. Inlets at the end of this run are not considered acceptable under City of Alexandria standards (HGL is 2' below the throat of the inlet), but are still below the throat elevation.

Due to the grading constraints of King Street, upsizing the pipe system would not solve the HGL issues. Therefore, the only remaining option is to eliminate the King Street bypass system, and route all the upstream drainage to Pump Station 1. This results in approximately 21 acres (152 cfs) being routed to Pump Station 1.

At Queen Street, replacing the downstream pipes with 30" and 42" pipes does improve the HGL, but still results in unacceptable HGL at the existing inlets along North Union Street north of Queen Street.

Upstream drainage areas for Alternative 2 are shown based on GIS topographic information only, and do not consider the delineation of roof drains from each block. Detailed drainage area delineation would only increase the runoff to each storm system, creating a more unacceptable HGL within the system.

4.3.3 ALTERNATIVE 3

Alternative 3 eliminates all bypass systems, except for at Duke Street, and routes all the stormwater to the pump stations. This is the recommended solution to mitigate flooding in the Core Area.

The outfall pipe at Duke Street will be replaced with new 24-inch RCP pipe. The existing grate inlet at Point Lumley and the curb inlet at Strand and Duke will be routed to Pump Station 1. Upstream drainage from the Hotel Indigo and Robinson Terminal South will continue to be routed through the Duke Street Bypass system in an upsized 24" RCP pipe.

Routing all the Prince Street upstream drainage and the King Street bypass system to Pump Station 1 results in approximately 27.5 acres (198 cfs) to the Pump Station 1.



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The existing Cameron Street bypass system carries drainage from approximately 6.5 acres of upstream area. To help alleviate the existing bypass system, additional inlets have been added at the intersection of Cameron Street and Union Street, and along Union Street, which will convey flow to Pump Station 2 adjacent to Founder's Park. However, preliminary HGL computations performed on the existing bypass system show the inlet water surface elevation of the upstream curb inlet at Lee Street and Cameron Street to be approximately 15' above the rim elevation. Therefore, Cameron St bypass, north of Union Street will be routed to Pump Station 2. The last run of pipe which outfalls into the River shall remain such that the existing drainage from the adjacent buildings can still outfall.

At Queen Street, to achieve acceptable HGL, the entire upstream drainage area will be routed to Pump Station 2. By routing Cameron Street and Queen Street to Pump Station 2, this results in approximately 18.4 acres (132.5 cfs) to the Pump Station 2.

Upstream drainage areas for Alternative 3 were delineated based on actual existing condition roof drains and road drainage. This delineation was derived from visual observation of the area.

4.4 LOCAL STORM SEWER SYSTEMS

The local storm sewer system is defined as the storm inlets and pipe network that conveys runoff to the proposed pump stations. This storm system will have structures placed to mitigate the frequent flooding caused by storms smaller than the 10-year storm event. New inlets and pipes will replace existing structures and pipes to provide additional capacity and functionality. At the time of final storm sewer design, flanking inlets may be needed to provide additional capacity to reduce spread issues on the streets at times of intense local storms. A corrosion control review will be performed in future design phases as it relates to the storm sewer piping.

Some outfall locations at the existing bulkhead have been unable to be located and inspected due to debris and high water levels. Due to the age of the network, it is assumed some outfall pipes are full of debris and/or collapsed, and therefore will need to be replaced.

The local storm system to Pump Station 1 conveys runoff from Prince Street and King Street to the pump station located adjacent to Strand Street. Inlets are proposed along the east end of Prince Street, at the intersection of King Street and Union Street, and in Strand Street. The existing drainage pattern directs surface flow directly to the river. Due to the proposed bulkhead elevation at 6.0', grading will be proposed in the Waterfront Park to direct the surface flow into inlets and into Pump Station 1. Preliminary grading (dated 07/22/2014) in this area was previously provided by a City consultant.

Due to the existing historical cobblestone pavers along Prince Street, it is not advisable to disturb the road west of South Union Street. Additional curb inlets will be placed at the intersection with as little disturbance to Prince Street pavers as possible, and the storm system will be routed to Pump Station 1.

The local storm system to Pump Station 2 was suggested to have several curb inlets at the intersection of Cameron Street and Union Street, and the storm system alignment is expected to run west to east along Thompsons Alley, then outfall into Pump Station 2. Upon investigating the field survey conditions, there are several utility conflicts in Thompsons Alley, including sanitary



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sewer, water, and gas. Due to the proximity between buildings (approximately 20') and utility conflicts, it is proposed to align the local storm system in Union Street, running to the north, then turning east at Queen Street, where the local system will run parallel to the Queen Street bypass system. The common area to the north of Charthouse restaurant will be used as delivery truck loading and turn-around, and additional grate inlets will be provided in this area to convey runoff to Pump Station 2. Preliminary grading (dated 07/22/2014) in this area was previously provided by a City consultant.

Various alignments were considered for the local storm systems to balance the flows to each pump station. It was considered to convey flow from King Street north to Pump Station 2. This alternative is not recommended because it would cause additional disturbance to Union Street, and does not honor the natural drainage divides of the area.

In the 100-year storm event, overland relief will be provided by additional inlets, trench drains, and/or stormwater management and BMP facilities proposed in the Waterfront Park area and Thompsons Alley. This water will be directed to the pump stations. See Section 4.7.2 Overland Relief.

4.5 PUMP STATIONS

Two pump stations will be proposed within the Core Area to handle storm water. One pump station will be located at Waterfront Park, adjacent to Strand Street, and the other pump station will be located near the farthest east end of Thompsons Alley. Each pump station will contain a trash rack, wet well, pumps, back-up generator, back-up fuel source, force main piping to the bulkhead outfall, mechanical equipment, controls, and all related infrastructure. The basis of design for sizing the pump equipment is the peak runoff rate of the 10-year City of Alexandria design storm (see Section 3.3). Each pump station site will include a pair of park pavilion buildings to elevate the pump station equipment above the flood plain (100-year FEMA elevation of 10.2'). There is a concern that future sea level rise could affect the elevation of the 100-year flood plain, and therefore the elevation of the pump equipment. Preliminary designs elevate the equipment above 10.2' (see Appendix F and Appendix G). At the time of final design, the City can decide to raise the finished floor elevation of the equipment level to account for sea level rise, with consideration of increased building size, massing, and costs. The pump stations buildings will incorporate other uses, such as storage, restrooms, and service areas. City of Alexandria will provide final programming of the pavilion buildings at the time of final design.

Both pump stations have been configured to allow access to the trash removal area which City staff will frequent the most often. Staff will enter Pump Station 1 through a locked door, and inside will be a trash bin, screw conveyor and its related control panels, and an access hatch to the trash racks below. During small storm events, stormwater flows will enter the trash rack area and flow through a fine steel screen before entering the low flow pump station wet well. The retained trash and screenings will then be conveyed vertically into the trash rack room and into the trash bin. The vertical conveyance will allow the screenings to be dewatered to minimize the volume of waste screenings the City needs to handle and dispose. During larger storms, once flows exceed the capacity of the fine screen, stormwater will back up in the trash rack area until reaching a weir with coarser bar racks (screens). Stormwater will then enter the main wet well area. The retained screenings on the coarse bar rack will be conveyed to the same

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vertical screw conveyor for the fine screening. A set of access doors from the room down to the trash rack will be provided to allow inspection and removal of any debris caught on the screens larger than the screw conveyor can handle (example: tree branches, etc.).

The pump station wet well is located under a pavilion building with the vertical axial flow pumps, sump/low flow pumps, discharge force main, and associated valves. For small storms and groundwater infiltration into the conveyance systems, flows will enter the wet well from an inlet and through a low flow channel to the sump/low flow pumps. During high flows, the flows will enter from the inlet behind the coarse bar screens. From the inlet, a sloped floor leads from the forebay to the axial pump bays to provide steady uniform flow distribution. The wet well and all underground portions of the pump station will require final design buoyancy computations to ensure no issues arise due to the high water table.

The pumps shall be submersible, have a variable frequency drive (VFD), and be capable of handling solids. Each pump will be in its own bay to direct flow to the pump. Each pump will discharge to a force main with check valve, isolation valve, and pressure switch before connecting to the common pump header and force main to the Potomac River. The low flow pumps will be attached to guide rails with an attached chain and access hatch at grade to allow the pumps to be removed without confined space entry. Due to the weight of the pumps, a davit crane or truck-mounted crane will be necessary to hoist the pumps out of the wet well for maintenance.

The pumps will be activated by a series of water level sensors and controlled by a Programmable Logic Controller (PLC). Once the sump fills, a level sensor will activate whichever low flow pump the pump controller has assigned as the duty pump. The low flow pump will start and increase in speed as the depth of stormwater in the wet well increases. As the flows to the pump station exceed the capability of the duty low flow pump, the depth in the wet well will continue to increase. After reaching another pre-set depth, the axial (high) flow pumps will be activated and the duty low flow pump stopped. The pump controller will activate the first duty axial flow pump. As the depth in the wet well continues to increase the VFD for the first duty axial flow pump will increase the speed of the pump until reaching a third preset level in the wet well. At this point the second duty axial flow pump will be activated. The VFDs will then decrease the speed of both pumps and then slowly increase them as needed to match the incoming stormwater flow rate. As the storm subsides, the level sensors and controller will deactivate the pumps in reverse order. The low flow pumps will then be used to drain the wet well once the depth of flow is lower than the axial flow pumps can handle.

A force main from the pump station will be sloped toward the river to allow any debris in the force main that falls out of suspension to be flushed and moved toward the River. A valve and energy dissipation structure will be installed at the end of the force main at the river to prevent back flow and erosion as discussed in Section 4.2. Outfalls into the Potomac River. It will also prevent river flood water from backing up into the pipe and allowing any debris or ecological components, such as mussels, to accumulate that may lead to clogging.

Part of the first level (at grade) of the pump stations are available for alternate use programmed by the City. The second level of the pump stations shall be accessed by an interior ship's ladder. This level shall house the electrical and control equipment for the pumps including the motor control center, VFDs, pump controllers, alarm equipment, and generator. The electrical equipment is proposed to be housed within an enclosed air-conditioned space with the



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generator located outside the enclosure. Generators will require an automatic transfer switch in the event of power loss in the City.

The pump stations were evaluated for the use natural gas-powered generator or diesel-powered generator. Natural gas provides the benefit of having an indefinite period of back-up compared to diesel, without the need for City personnel to refill tanks. This will also remove the need for the maintenance of emptying and replacing the diesel fuel as the fuel ages if there is no power loss during operation. However, in the event of an emergency, there is a possibility that natural gas service will be interrupted. Natural gas alternatives have a disadvantage to diesel powered generators due to their higher initial costs and larger footprint. In the alternatives considered below, natural gas generators did appear to fit within the pavilion building 28' x 28' footprint for Pump Station 1 Alternative 1 and Pump Station 2 Alternatives 1 and 2. For the recommended Alternative 3, natural gas generators did not fit within the expanded 30' x 30' building and would require an additional 5' length to the building (final dimensions 30' x 35'). Due to sizing, cost, and reliability concerns of natural gas, it is recommended that the City use diesel-powered generators for both pump stations. The diesel fuel will be stored in the same enclosure as the generator equipment and stored above the 100-year flood elevation. Piping from the second level down to 3 feet above grade will be used for filling the tank.

Each pump station will have alarms to alert the City of any failures of equipment or power failures at the pump station. Alarms will also be provided to alert if storm flows exceed the capacity of the pump station and flooding will occur. SCADA (alarms and/or remote control) integration will be developed at final design. Protocols, commissioning, training, and operations & maintenance manuals for the pump stations and associated equipment will be provided with the final design.

In the event the Potomac River bulkhead overtops, it would be beneficial to keep the pumps running to continue to "bail out" the area to limit the flooding. As the river continues to rise, the flow coming in would surpass the pumps capacity and the flood level would start to increase. A level switch may be installed at the pump stations, and set to stop the pumps in the event the level increases to a point where the pumps are not providing any benefit. This will provide an efficient system and will safe-guard equipment from overuse during a catastrophic flood.

There are two unique situations that arise with pump stations operating within a wide range of flows. The first is dealing with catastrophic storms greater than the design storm. This is evaluated in Section 4.7 Catastrophic Storms Flooding Considerations. The second is for smaller storms or extended times between when the high-flow pumps are required. Smaller storms contain higher concentrations of organic pollutants and fine grit than during the peak flows of large storms. With the outfalls of the pump stations submerged below the Potomac River water level, this leaves the potential for the organic pollutants to turn the water septic within the pipe for extended storage times until the next time the high-flow pumps are required.

By connecting the low flow pumps into the force main shared by the high-flow pumps, there is regular flow of water through the force main that helps to keep this water from stagnating in the large force main. For Pump Station 1 in the Alternative 3 scenario, a 0.10" rain storm would provide enough runoff to completely flush the old water through the force main. Groundwater infiltration into the conveyance system would also provide a source of water for flushing the force main. As the conveyance system will consist of new piping and inlets with watertight gaskets at the joints, the expected infiltration quantities will be very low. During the very dry



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season or droughts, the provision of using dechlorinated potable water or a small pipe to extract fresh water from the river into the pump station to be pumped back into the river through the force main could provide flow through the force main. This would only be required under extreme drought and could be initiated automatically based on trigger conditions. The dechlorinated potable water approach would require around 40,000 gallons of water. Use of this much water during a drought would be a sensitive issue and may not be allowed by Virginia American Water. The use of Potomac River water would be considered a river extraction and will require a DEQ water withdrawal permit containing requirements for screening and pipe sizing to prevent adverse impacts to the adjacent flora and fauna. While the City could consider utilizing these solutions in the future, after discussions with municipal users of the CheckMate in-line valves, it does not appear this provisional water will be necessary.

Calculations have been performed to determine the initial sizing and configuration for the pump stations for the Alternatives listed below. For each Alternative, the design flow rate is based on the peak flow rate of the 10-year City of Alexandria storm. The pumps need to provide enough energy to overcome the Total Dynamic Head (TDH). TDH consists of 2 components: static head or the energy needed to lift the water a certain distance; and minor losses to overcome the friction through the force main and associated piping components. For a conservative design, the static head is the distance from the top of the bulkhead to the lowest elevation the high flow pumps can operate. This component makes up approximately 75% of the TDH. The minor losses the pumps need to overcome include the length of the force main, entrance and exit losses from the pipes, the check valves and isolation valves, and any bends. With components of this pipe diameter size, the losses for each component are not typically published and not all equipment types have been selected during the preliminary design presented in this report. Initial values have been included for the system based on experience. At the time of final design, consideration will be made for configuration of each pump to optimize the performance with respect to energy efficiency and account for all energy friction losses across the system.

4.5.1 Pump Station 1 Alternative 1

In Alternative 1, Pump Station 1 at Waterfront Park has an overall drainage area of approximately 8.55 acres. The flow during the 10-year storm is approximately 62 cfs or 28,000 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). A drainage area map to Pump Station 1 is shown in Appendix B. A preliminary pump station layout is provided in Appendix F.

The Pump Station 1 wet well is located under a pavilion building with the three (3) vertical axial flow pumps, two (2) sump pump/low flow pumps, discharge force main, and associated valves. During small storms, flows will enter the wet well from a 12-inch inlet and through a low flow channel to the two (2) sump/low flow pumps. During high flows, the flows will enter from the 12-inch inlet and a pair of 36-inch inlets behind the coarse bar screens. From the 36-inch inlets a sloped floor leads from the forebay to the axial pump bays to provide steady uniform flow distribution.

The sump (low flow) pumps have been sized for flows up to 5,000 gallons per minute (gpm) each with one (1) duty pump and one (1) standby. The three (3) axial flow (high flow) pumps have been sized for two (2) duty and one (1) standby during the 10-year storm peak flows. Each

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pump has a capacity of 16,000 gpm. The ultimate capacity of the pump station is 42,000 gpm or 93 cfs.

Pump Station 1 has two (2) duty pumps during the peak flow rate of the 10-year design storm, 284,000 gallons per minute (gpm), to allow the pumps to operate at better efficiency for the lower flow rate storms. The current design features three (3) large axial flow pumps at 100 horsepower, each with a capacity of 16,000 gpm for the design conditions. With a variable frequency drive, the flow range is from 10,500 to 16,000 gpm. A single higher horsepower pump could be used to meet the peak rate 10-year design storm. However, a larger pump would allow less turn down range. Designing using two pumps for the design storm will allow for a savings in the operation of the pump station over the life of the system. A single spare pump has been proposed instead of two due to a combination of space constraints for the site and overlap of pumps for the design storm. The low flow/sump pumps have a maximum capacity of approximately 6,000 gpm and in the event that both duty pumps failed, the single spare and two low flow/sump pumps would be able to meet the 10-year design flows.

The force main exiting Pump Station 1 to the Potomac River has been initially sized at 36-inch diameter. This is to minimize excess velocities over 8 feet per second (fps) during the 10-year storm peak. At ultimate pumping capacity, all three high flow pumps and both low flow pumps operating, the submerged velocity of Pump Station 1 is approximately 13.2 ft./sec.

The generator has been preliminary sized to allow for two (2) axial flow pumps to run for a minimum of approximately 24 hours, which is based on the generators running under 100% load. The generator has initially been oversized to allow for all equipment to be operating with a 50% buffer. During the 10-year design storm, two large pumps would be operating with the screening equipment during the peak flow period, which results in the generator under 50% load. When the generator runs at about 50% load, there would be about 36 hours of back-up, and at 25% load would be about 54 hours of back-up.

4.5.2 Pump Station 1 Alternative 2

In Alternative 2, Pump Station 1 at Waterfront Park has an overall drainage area of approximately 21.1 acres. The flow during the 10-year storm is approximately 152 cfs or 68,000 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). The pumping system has been set up with the same philosophy as Alternative 1 with 2 sump/low flow pumps for flows up to 5,000 gpm and 2 duty and 1 standby axial/high flow pumps. Under these design conditions, each axial flow pump has been sized to provide approximately 34,000 gpm. The pumps in this alternative are 240 horsepower with flow range from 26,000 to 41,500 gpm. The piping the individual force main and isolation valves increases to 48" in diameter and 60" diameter for the pump header and common force main. During the 10-year storm, the submerged exit velocity from the 60" force main will be approximately 7.8 ft./sec. The ultimate capacity of the pump station is 127,000 gpm or 283 cfs with a submerged exit velocity of 14.41 ft./sec.

To accommodate the large pumps and piping, the wet well size will increase. Depth of the wet well increases by 4.5 feet to a bottom elevation of -17.00, the length increases to 34' long, and the width increases from 28' to 37' wide. The aboveground building size will increase to 30' x 30' to accommodate the clear space required for the generators. At 48" diameter, the piping is



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too large to be supported by the ceiling and requires a separate exterior valve chamber. The isolation valves are proposed to be plug valves instead of gate valves to minimize the depth of the chamber. A preliminary layout is included in Appendix F.

The larger pumps require an increase in the generator capacity from 600 kW to 1,200 kW. Preliminary sizing of the diesel generators appears to fit within the 30' by 30' building envelope and the natural gas generators require additional room. At these capacities, the generator enclosures vary more between manufacturers and become site-specific so sizing is not as readily available at this time and will need to be resolved in final design. The height of the generator also increases due to the increase in the diesel storage volume. If the vertical height increases cannot be accommodated, underground diesel storage tank options will need to be investigated. Underground storage tanks will need to be approved by the City, and meet any specific design criteria of the City, FEMA, and Virginia Statewide Building Code/IBC (International Building Code). The Virginia Department of Environmental Quality maintains a list of underground storage tanks and inspects them every two years to ensure they are functioning. If there is a leak, DEQ will enforce remediation plans.

4.5.3 Pump Station 1 Alternative 3

In Alternative 3, Pump Station 1 at Waterfront Park has an overall drainage area of approximately 27.5 acres. The flow during the 10-year storm is approximately 198 cfs or 89,000 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). A similar size pump, with a larger 310 hp motor, and layout for Alternative 2 will meet the conditions for Alternative 3. Each axial flow pump would have a flow of 44,500 gpm during the 10-yr design storm with a capacity of approximately 47,000 gpm. The ultimate capacity of the pump station is 132,000 gpm or 294 cfs. The submerged exit velocity during the design storm would be 10.1 ft./sec, with an ultimate velocity of 14.98 ft./sec. Similar to Alternative 2, a 1,200-kW generator would be required, and the pump station building will need to be 30' x 30' to accommodate the generators and all associated equipment.

4.5.4 Pump Station 2 Alternative 1

Pump Station 2 at Thompsons Alley has an overall drainage area of approximately 2.4 Acres. The flow during the 10-year storm is approximately 17 cfs or 7,600 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). A drainage area map to Pump Station 2 is shown in Appendix C. A preliminary pump station layout is provided in Appendix G.

The Pump Station 2 layout and controls are similar to Pump Station 1. Maintaining as many common elements and philosophies as possible between the two stations will make operation and maintenance of the two pump stations easier for the city staff. Due to the smaller stormwater flows, the axial high flow pumps and low flow pumps are smaller than Pump Station 1. There are two (2) 45 horsepower axial (high) flow pumps with one (1) duty and one (1) standby with a capacity of 6,000 gpm each. With a VFD, the pumps would have a flow range of 3,600 to 7,600 gpm. The two (2) low flow pumps are also one (1) duty and one (1) standby with a capacity of 1,000 gpm each. The ultimate capacity of this pump station is 14,500 gpm or 32 cfs with a submerged exit velocity of 4.5 ft./sec.

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The pump station building is the same layout as Pump Station 1 with a minor difference in the wet well shape to accommodate the site constraints of the promenade.

4.5.5 Pump Station 2 Alternative 2

Pump Station 2 at Thompsons Alley has an overall drainage area of approximately 2.4 Acres. The flow during the 10-year storm is approximately 17 cfs or 7,600 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). The Pump Station 2 layout and controls are the same as Alternative 1 above. The ultimate capacity of this pump station is 14,500 gpm or 32 cfs with a submerged exit velocity of 4.5 ft./sec.

4.5.6 Pump Station 2 Alternative 3

Pump Station 2 at Thompsons Alley has an overall drainage area of approximately 18.4 Acres. The flow during the 10-year storm is approximately 132.5 cubic feet per second (cfs) or 60,000 gpm (assumes 10-yr storm intensity in City of Alexandria is 9.0 inches/hour). A similar size and layout for Pump Station 1 Alternative 3 has been utilized for Pump Station 2. The pumps have been changed to follow a two (2) duty and one (1) standby approach for the high flow pumps to provide a larger turndown range. Increasing the pump sizing to 200 horsepower meets the design point and provides capacity up to 34,000 gpm each. The sump/low flow pumps would be increased a 5,000 gpm capacity. The depth of the pump station wet well would need to increase with the lowest elevation at -19.00 ft. A separate valve chamber would be required for the 48" piping similar to Pump Station 1. The submerged exit velocity from the 60" force main would be 6.81 ft./sec for the design storm and 11.92 ft./sec for the ultimate capacity of 105,000 gpm or 234 cfs.

A 1,200-kW generator would be required and have the same constraints and issues as Pump Station 1 for Alternative 2 and 3, therefore the pump station building will need to be 30' x 30'.

4.6 STORM SYSTEM ALTERNATIVES COMPARISON

A comparison summary of all three pump station alternatives is provided in Appendix K. These cost estimates are based on Fairfax County 2017 Unit Price List for storm sewer pipes and structures, and manufacturer estimates for pumps, generators, valves, screening, and associated equipment. An additional overall cost summary is provided to show a rough estimate of the pump station buildings (shell only), equipment, storm system, and dredging for each alternative. These estimates are intended to show a rough order of magnitude difference between each alternative, and are provided for preliminary engineering purposes only. These estimates are not intended to provide a true construction cost. A total project cost will be provided for the design alternative selected in this phase. Cost estimates will be provided with final design at various stages of the design.

Alternative 1 employs the local system to the pump stations and bypass system approach. Pump Station 1 (pumps, generator, equipment, and valves) is estimated at \$780,000, Pump Station 2 is estimated at \$580,000, and the storm system is estimated at \$1,000,500 for a total cost of \$2,360,500. This alternative provides acceptable HGL in the local storm system to the pump



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stations, but unacceptable HGL for Duke Street bypass, Prince Street bypass, King Street bypass, Cameron Street Bypass, and Queen Street Bypass. Including the shell buildings and dredging, Alternative 1 is estimated at \$5.5M.

Alternative 2 shows the bypass system and local system, with inlets moved and additional changes made with the goal to eliminate HGL issues. Pump Station 1 (pumps, generator, equipment, and valves) is estimated at \$1,800,000, Pump Station 2 is estimated at \$580,000, and the storm system is estimated at \$976,500 for a total cost of \$3,356,500. This alternative provides acceptable HGL in the local storm system to the pump stations. HGL for Prince Street bypass improves such that the inlet water surface elevation is not above the throat elevations of the inlets, but manholes along Prince Street are of concern with HGL about 1.6' above the top. This alternative provides unacceptable HGL for Duke Street Bypass, Cameron Street Bypass, and Queen Street Bypass, but has significantly lower water surface elevations than Alternative 1. King Street bypass system was not able to be resolved by upsizing pipes or changing design approach, so the flow had to be directed to Pump Station 1. Including the shell buildings and dredging, Alternative 2 is estimated at \$6.63M, approximately 20% increase from Alternative 1.

Alternative 3 eliminates all bypass systems, except for at Duke Street, and routes all the stormwater to the pump stations. Pump Station 1 (pumps, generator, equipment, and valves) is estimated at \$1,800,000, Pump Station 2 is estimated at \$1,800,000, and the storm system is estimated at \$1,242,000 for a total cost of \$4,842,000. This alternative provides acceptable HGL in the local storm system to the pump stations. The upgraded Duke Street bypass remains, and provides an acceptable HGL. Including the shell buildings and dredging, Alternative 3 is estimated at \$8.14M. Alternative 3 is approximately 48% more than Alternative 1 and 23% more than Alternative 2.

Since the evaluation of the three alternatives, additional design information has been gathered regarding utility routings, coordination with Dominion Energy, and City input. These considerations have been incorporated into the design to create a refined version of Alternative 3. This iteration is labeled Alternative 3B and shows Pump Station 1 relocated to the corner of Strand Street and Prince Street, with inflows split into two separate storm systems. Pump Station 2 configuration has not been significantly changed per the previous Alternative 3 design. Both Pump Station 1 and 2 storm systems were lowered to account for the existing combined sewer system (CSS) in Union Street. Additional considerations will be made during final design for the status of future CSS upgrades or relocations. Alternative 3B storm computations and HGL calculations have been provided.

4.7 CATASTROPHIC STORM FLOODING CONSIDERATIONS

After an event in which the river level rises above the bulkhead and causes flooding, it is important to consider the draw-down time for the volume of water below the 10-year elevation of 6.0'. There is approximately 19,300 CY of water to Pump Station 1 at the 10-year storm elevation of 6.0'. To drain this volume of water, it would take approximately 30 minutes with all 3 axial pumps and both sump pumps operating at the ultimate capacity after the river levels subside (Alternative 3). At the design flowrate of 89,000 gpm with the 2 main pumps operating, this volume would take approximately 45 minutes to drain. Under Alternative 1, it would take 93 minutes for the ultimate capacity and 140 minutes in the design condition. There is approximately 3,200 CY of water to Pump Station 2 at the 10-year storm elevation of 6.0'. Under



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Alternative 3, it would take approximately 6 minutes to drain with all 3 axial pumps and both sump pumps running at 105,000 gpm and 11 minutes to drain with 2 pumps running at the design flow of 60,000 gpm. Under Alternative 1, the drain down time for the ultimate capacity is 45 minutes and 85 minutes for the design condition.

In Alternative 3, in the event of a catastrophic storm (100 year+), it is important to consider how the pumps act when the entire upstream drainage area enters the pump stations. The 100-year flood event, as analyzed in this report, assumes a local 100-year storm, and assumes the river level has not experienced its peak flow. The tables below show the total flow to each pump station for each catastrophic storm event. Pump Station 1 has a total drainage area of 27.5 Acres flowing to it during the catastrophic event when the entire system is flooded. Pump Station 2 has a total drainage area of 18.4 Acres flowing to it during the catastrophic event when the entire system is flooded. The City of Alexandria Intensity-Duration-Frequency (IDF) curve for storm sewer conveyance computations, which does not extend beyond the 100-year storm. To analyze larger storms, NOAA Atlas 14 data was utilized, though these intensities are typically considered for stormwater management purposes only. For comparison purposes, both the City of Alexandria IDF curve intensities and the NOAA Atlas 14 intensities are shown in the tables on the next page.

In Alternative 3, Pump Station 2, with both main pumps and low flow/sump pumps operating, has a maximum capacity through a 60-inch diameter force main of 105,000 gpm or 234 cfs. This has the capability to manage City of Alexandria 50-year storm and the NOAA Atlas 14 500-year storm. Neither Pump Station 1 nor Pump Station 2 in Alternative 1 can accommodate the 10-year storm if the bypass storm systems are flooded and the entire upstream drainage area enters the pump stations. In Alternative 2, Pump Station 1 can accommodate the City of Alexandria 25-year storm and the NOAA Atlas 500-year storm, but Pump Station 2 cannot accommodate the 10-year storm when the entire upstream drainage area enters the pump station.

Alternative 3: Pump Station 1

Total Drainage Area = 27.5 Acres

C = 0.80

Tc = 5 min

Recurrence Interval (yr.)	C _f	City of Alexandria (1989)		NOAA Atlas 14	
		Intensity (in/hr.)	Q (cfs)	Intensity (in/hr.)	Q (cfs)
10	1.0	9.00	198.00	6.83	104.72
25	1.1	10.80	261.36	7.74	143.99
50	1.2	12.50	330.00	8.41	185.06
100	1.25	13.80	379.50	9.07	225.78
500	1.25	-	-	10.50	319.00
1000	1.25	-	-	11.20	371.25

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Alternative 3: Pump Station 2

Total Drainage Area = 18.4 Acres

C = 0.80

Tc = 5 min

Recurrence Interval (yr.)	C _f	City of Alexandria (1989)		NOAA Atlas 14	
		Intensity (in/hr.)	Q (cfs)	Intensity (in/hr.)	Q (cfs)
10	1.0	9.00	132.48	6.83	70.07
25	1.1	10.80	174.87	7.74	96.34
50	1.2	12.50	220.80	8.41	123.82
100	1.25	13.80	253.92	9.07	151.06
500	1.25	-	-	10.50	213.44
1000	1.25	-	-	11.20	248.40

4.7.1 100-YEAR HYDRAULIC GRADE LINE ANALYSIS

Storm sewer pipe computations and HGL computations for the 100-year storm (City of Alexandria intensity (i) = 13.80 in/hr) have been shown for Alternative 3 in Appendix D. Initial HGL computations show unacceptable 100-year HGL for many of the structures to Pump Station 1 and Pump Station 2. The HGL elevations along the system range from 1-6 feet above the top of the inlet throats in the Pump Station 1 upstream system, and from 9-20 feet above the top of the inlet throats in the Pump Station 2 upstream system. In this case during 100-year local storm event where the bulkhead is not overtopped, flooding would occur at each curb inlet opening, and water would flow overland to the low points at Waterfront Park and Thompsons Alley. See Section 4.7.2 Overland Relief.

Various considerations could be made to attempt to accommodate the 100-year HGL in the system. For example, if every proposed pipe run was upsized to the next available pipe size (18" upsized to 21", 36" upsized to 42", etc), it would increase the cost by approximately 20%. While some pipe runs could accommodate a 100-year storm, the main trunk lines to each pump station will still be over capacity. The HGL benefit to Pump Station 1 would be a drop in HGL near the end of the system analysis (Structure EX4) of approximately 3.3 feet compared to the current preliminary design. The benefit for the HGL to Pump Station 2 would be a drop in HGL near the at the end of the system an analysis (Structure EX C6) of 11 feet compared to the current preliminary design. While there is benefit to upsizing all the pipes, careful consideration would need to be made during final design for which pipe runs provide the most drop in HGL and do not cause further vertical concerns. If all pipes are upsized, the invert into the pump station will likely need to drop to accommodate minimum cover, minimum slopes, and vertical clearances from other utilities.

Another consideration that could be made to accommodate the 100-year HGL in the system is to split the flows coming into Pump Station 1. In Alternative 3, flows combine into a single 60" pipe into the pump station wet well. If two connections into the pump station are established, flows from Duke and Prince Street could combine in a 42" pipe into the pump station and flows from King Street in a 54" pipe could go into the pump station separately. This change would decrease the HGL by 0.50 feet at Structure Ex4 on the King Street side of the system, and decrease the HGL by 2.5 feet at Structure D1 on the Duke/Prince Street side of the system. The



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storm system cost to do this would increase by approximately 2%, but considerations would need to be made for the size of the underground wet well into the trash rack room to accommodate two large entrance points. Additional costs and feasibility would need to be considered for this option as the underground excavation and wet well construction cost would increase. Alternative 3B considers this split flow scenario, and the HGL computations show improvement (see Attachment D).

Additionally, dropping the invert of the pipe coming into the pump stations will directly drop the HGL across the system. At final design, once vertical considerations of the storm system are made, the inverts could be lowered and the cost ramification would be an increase in underground excavation and wet well size, and increased operating energy costs to pump the water to a greater height.

4.7.2 OVERLAND RELIEF

In the 100-year storm event, overland relief will be provided by additional inlets, trench drains, and/or stormwater management and BMP facilities proposed in the Waterfront Park area and Thompsons Alley. Overland relief will only occur when the Potomac River is below elevation 6.0' and the bulkhead is not overtopped. At the low spot in Strand Street, a 20' curb inlet with approximately 0.25 Acres of surface flow to it would generate approximately 9.2 feet of spread in the 10-year storm on a roadway with a 0.5% cross-slope. In the 100-year storm, this inlet would generate 10.5 feet of spread. In this case, additional flanking combination curb and grate inlets would be provided, or trench drains along Strand Street to reduce the ponding at each inlet. Computations for 100-year flooding elevations of each sump structure will be provided at final design.

If the entire Waterfront Park area drains (to be located during final design) are clogged, there may be approximately 3.2 Acres flowing to the low spot in Strand Street (based on preliminary grading provided by Olin dated August 15, 2017). Assuming a C-factor of 0.60, inlets in the low spot along Strand Street would need to accommodate approximately 17 cfs for the 10-year storm or 33 cfs for the 100-year storm. To decrease the spread to less than $\frac{1}{2}$ the width of the travel lane (5.5' for 22'-width of Strand Street), the corresponding ponding depth would need to be 0.11 feet, which would require an equivalent curb opening length of 155 feet to intercept the entire 10-year storm, or 302 feet to intercept the entire 100-year storm (VDOT Drainage Manual equation 9.11 for curb inlets in sag). This length of curb opening will require a high number of structures that may be impractical based on cost, location with other utilities, and best practices. One recommendation would be to provide multiple high capacity grate inlets at the end of each low point in every main street (Prince, King, Cameron, and Queen Streets). High capacity grate inlets would be able to intercept flow during the larger storms which would reduce the risk of ponding in the park and pedestrian areas. During final design, consideration will be made for addition of combination curb and grate inlets and/or trench drains to increase the intercepted flow along the entire street and optimize the number of structures.

If the entire Thompsons Alley area drains are clogged, there may be approximately 1.2 Acres flowing to the low spot in the Alley. Assuming a C-factor of 0.80, inlets in the low point along Strand Street would need to accommodate approximately 9 cfs for the 10-year storm or 17 cfs for the 100-year storm. Based on preliminary grading, the low point in Thompsons Alley is at elevation 0.10', with the building finish floor elevation at 0.30'. One VDOT DI-7 grate inlet at this



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low point would generate 0.40 feet of ponding in the 10-year storm and 0.60 feet of ponding in the 100-year storm (VDOT Drainage Manual Appendix 9C-13, assuming full capacity). During final design, consideration will be made for additional grate inlets, yard inlets, and/or trench drains to increase the intercepted flow along the street and at the low point behind Pump Station 2 to the west.

5.0 FINAL DESIGN CONSIDERATIONS

5.1 HYDROLOGIC MODELING

The current storm sewer modeling was performed using the Rational Method, utilizing the City of Alexandria IDF curve and assumed c-factors of 0.80. This model provides a conservative peak runoff rate to size the conveyance pipes for preliminary design. Analysis has not yet been conducted using a method such as NRCS TR-55 which will model the entire storm event and the volume of water generated during these storms. A new model is intended to be completed during the final design. Using the NRCS 24-hour Type II storm distribution, most of the storm occurs between hours 11.5 to 12.5. A mass balance model would be created to include the incoming storm volume runoff, the storage volume availability in the pump station and storm sewer pipes, and the output of the pump station. Under this type of modeling, the pump station design for Alternative 3 will be optimized during the final design.

5.2 INFILTRATION AND INFLOW

Over the life of this project, there is potential for groundwater to infiltrate into the system. This water may enter through joints, seals, and other areas that may not have been constructed correctly at installation or have deteriorated over time. As the proposed conveyance system will consist of new piping and inlets with watertight gaskets at the joints, the expected infiltration quantities are anticipated to be very low. The infiltration and inflow that will enter system will be a negligible amount and will be pumped out, when needed, by the low flow pumps in the pump stations.

There is a potential to create mounding of the groundwater behind the newly installed bulkhead. This will be assessed further at final design, and a gravity drain to the pump station and the low flow pump can be designed to create an equilibrium with the groundwater, if deemed necessary.

5.3 WATER QUALITY & BEST MANAGEMENT PRACTICES (BMPs)

This project will provide water quality and quantity compliance under Part IIB Technical Criteria of the Virginia Stormwater Management Program (9VAC25-870-63). The post-development total phosphorus reduction requirement is approximately 2.7 lb/yr for Alternative 3, utilizing the DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet (version 3.0). All 15 Virginia Stormwater BMP Clearinghouse non-proprietary post-construction BMP practices will be evaluated for applicability on this project. Infiltration practices require separation between the bottom of the practice and the seasonal high water table. Preliminary borings show groundwater was encountered at 4 ft below grade in Point Lumley, 3 ft below grade at



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Waterfront Park, and 8 ft below grade at the Strand along Waterfront Park. The City generally assumes groundwater is encountered about 2 ft below grade at the end of King Street. Further infiltration borings need to be performed to finalize selection of specific practices and design their implementation. During the preliminary design of the project, passive storm water management solutions were evaluated. Many of these solutions were removed from consideration due to the high water table that would limit the effectiveness of the passive solutions. Other issues are the HGL and the ponding of water within the parks around the drains when the outfall is submerged.

A combination of the following practices are preliminarily suggested to be employed on site: urban bioretention, wet swale, rooftop disconnection to soil amended filter path, and sheet flow to vegetated filter strip. The remaining phosphorus reduction requirement could be met through addition of proprietary/manufactured treatment devices or nutrient credit purchase. Nutrient credit purchase is available in accordance with Alexandria Zoning Ordinance 13-109.8.b (or 9VAC25-870-69.B.2), pending confirmation of credit availability. Credit prices in the Potomac Watershed (HUC 020470010) at the time of this report are approximately \$16,000 per pound.

It is the understanding of the engineer that the City of Alexandria does not prefer to implement manufactured BMP devices as a primary source of pollutant removal per the Memorandum to Industry No 01-18, subject: Use of Manufactured/Proprietary Stormwater BMPs. These devices are not recognized by the US EPA for addressing TMDL requirements and do not reduce volume of stormwater runoff. These devices could be considered, as they typically have less restrictions regarding the depth of the water table, have a smaller footprint, and a higher rate of phosphorus removal. Devices considered would be from the approved list issued by the Virginia Stormwater BMP Clearinghouse. Additional proprietary BMPs that could be applicable to this project include: Filterra, Silva Cell, BayFilter, Jellyfish Filter, or other manufactured filtering device. In accordance with the Memorandum to Industry No 01-18, a maximum of 35% of the total phosphorus removal required may be achieved using manufactured treatment devices (MTDs). A waiver could be requested from the Director of T&ES in the event the use of additional MTDs is preferred. Nutrient credit purchase is available in accordance with Alexandria Zoning Ordinance 13-109.8.b (or 9VAC25-870-69.B.2), pending confirmation of credit availability. Credit prices in the Potomac Watershed (HUC 020470010) at the time of this report are approximately \$16,000 per pound.

Final design will implement best management practices, water reuse, and/or other practices throughout the project area based on feasibility and project costs.

5.4 LOW FLOW STORM WATER SOLUTIONS

At the time of final design, this project will consider the use of passive or low flow storm water solutions. This could be the implementation of small area drains within Point Lumley and Waterfront Park that outfall directly into the Potomac River. A large consideration is the HGL and the ponding of water within the parks around the drains when the outfall is submerged. Additionally, even if low flow storm water system is employed, the pump stations would still need to be sized for the entire drainage area draining to it and assume the low flow system is clogged.

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WATER QUALITY IMPACT ASSESSMENT (WQIA)

6.0 WATER QUALITY IMPACT ASSESSMENT (WQIA)

Stantec has been retained by the City of Alexandria to prepare the necessary support documentation for this proposed project regarding potential impacts to lands within designated Chesapeake Bay Preservation Areas (CBPAs). The Core Area development to implement the MSWMP proposed in this report has approximately 3 acres of disturbance within the Resource Protection Area (RPA) adjacent to the Potomac River, therefore a water quality major impact assessment is required. The limits of the RPA are shown on the Overall Drainage Divides graphic in Appendix A. This section of the WQIA represents the required assessment of the potential environmental impacts resulting from the proposed development as referenced in Article XIII. – Environmental Management of the City of Alexandria Code of Ordinances (Section 13-117).

The Chesapeake Bay Preservation requirements are administered in the City of Alexandria through Article XIII (Article) of the City of Alexandria Code of Ordinances (Code). This article is entitled Environmental Management, and contains the development standards for these areas. A water quality major impact assessment is "required for development or redevelopment within RPAs or under an exception that involves more than 5,000 square feet of land disturbance; or for any development or redevelopment within the RMA which involves more than 5,000 square feet of land disturbance adjacent to an RPA, if required by the director of T&ES due to the presence or proximity of wetlands, potential for harmful discharge of contaminants from the property, or slopes greater than 15 percent which are proposed to be disturbed," per the Article. A major WQIA generally consists of a narrative that describes and site drawings that show the construction footprint, RPA components, wetlands and other jurisdictional features, any encroachments into the RPA, location of existing vegetation on-site and a plan for re-vegetation, and the type and location of any potential measures to mitigate the effect of the proposed development within the RPA. The following sections of the WQIA present this narrative, as well as a hydrogeological element and a vegetative element.

A WQIA will be submitted separately to the City of Alexandria, and a draft is shown as Appendix H in this report. The WQIA draft has been prepared with consideration of storm sewer design Alternative 1. Once the City of Alexandria makes the final decision regarding with which alternative to proceed, the WQIA will be finalized and submitted with the final design.

A stormwater management compliance matrix has been developed to show the anticipated ways this project will comply with water quality requirements, RPA encroachment, Chesapeake Bay Tree Removal, Dredging/USACE, Erosion and Sediment Control, and Hydrologic Conditions. See Appendix L for this draft compliance matrix.

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CONCLUSION

7.0 CONCLUSION

Implementing this flood mitigation program will reduce the risk of nuisance flooding in the Core Area of the Alexandria Waterfront. Stantec suggests implementing Alternative 3 to have the most impact on the flood risk reduction. Alternative 3 and the refined Alternative 3B routes all local and upstream drainage to two pump stations, and proposes a bulkhead to elevation 6.0'.

The information provided in this report will be summarized in a project-wide white paper. The paper will summarize the archeological review, architecture, land survey, bathymetric survey, geotechnical, environmental, water quality, stormwater, utilities, updated cost, and bulkhead considerations for the project. The reports, investigations, assessments, and reviews will allow for the City of Alexandria and the design team to move forward with the next step in the design phase.

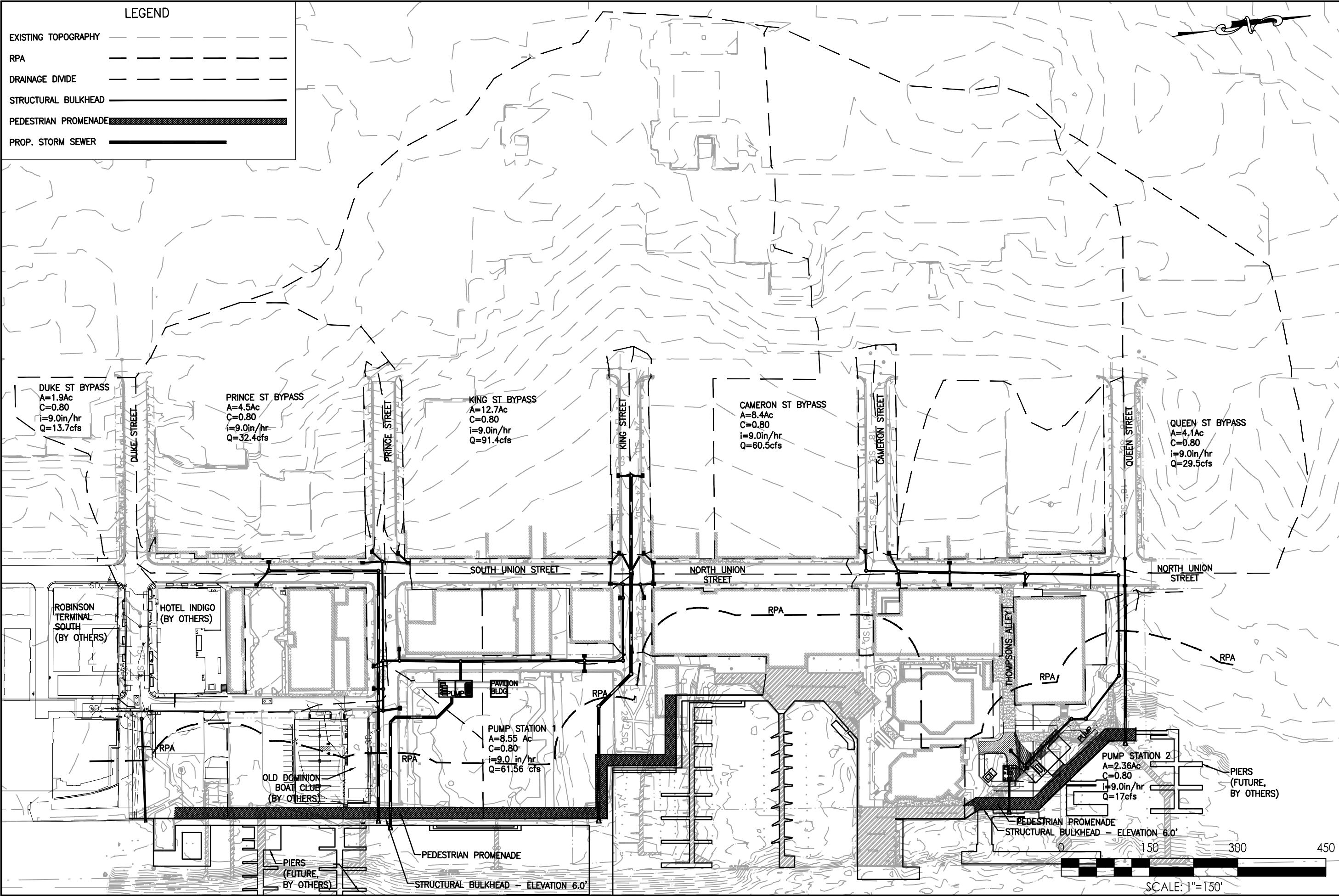
At the end of the preliminary phase the City of Alexandria will have the information and have made the critical design concept decisions to begin the 30 percent design plans. Stantec and the other members of the design team will provide design and construction documents which will include a structural bulkhead, pedestrian promenade, restructured storm drain system, two pump houses with adjacent pavilion buildings for use by the City, new and upgraded parks, as well as realigned streets and sidewalks to improve pedestrian mobility. Once the design is implemented, the Core Area will be a major attraction in Alexandria.

APPENDICES

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix A OVERALL DRAINAGE DIVIDES

Appendix A OVERALL DRAINAGE DIVIDES





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OVERALL DRAINAGE DIVIDES - ALT 1

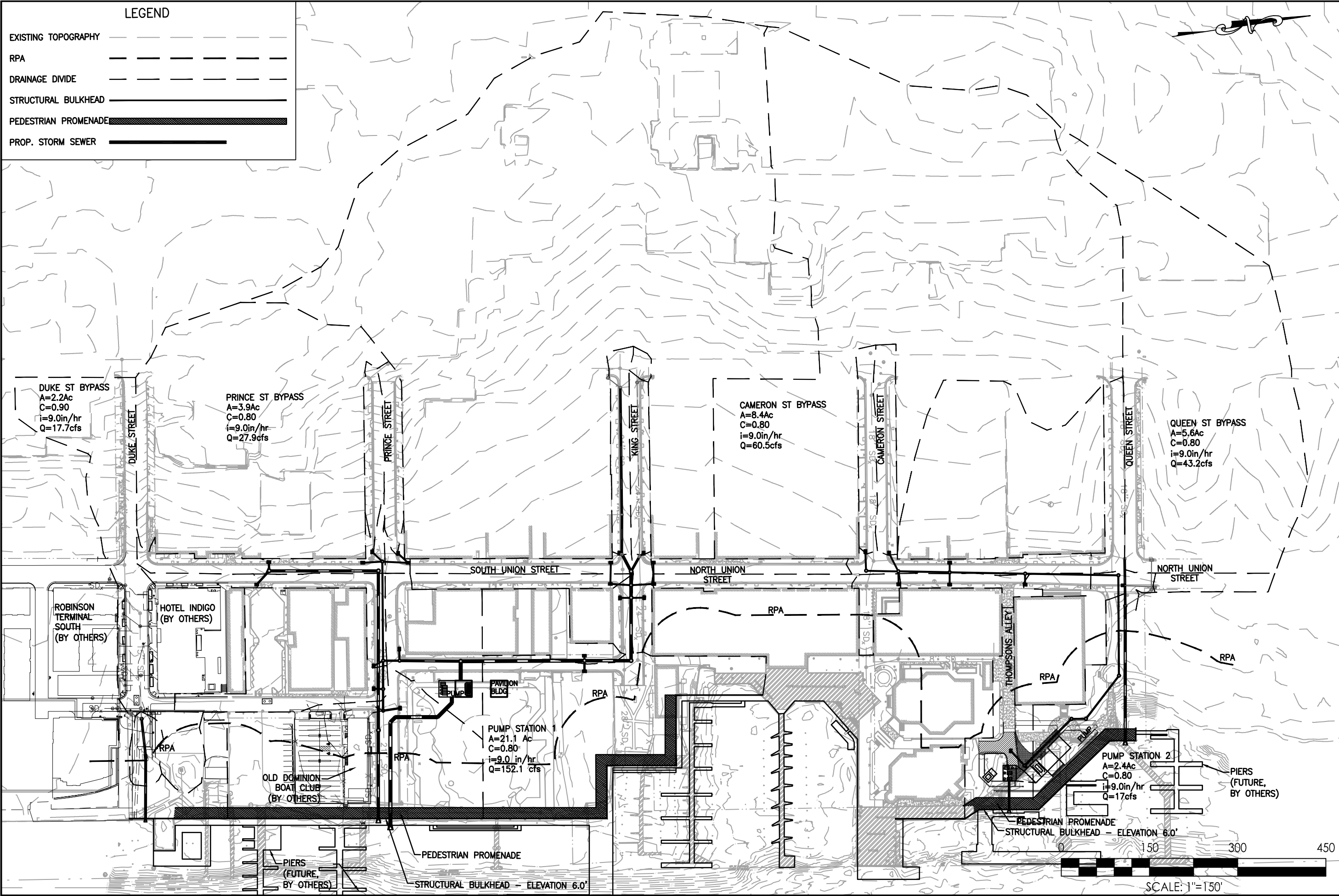
WATERFRONT FLOOD MITIGATION IMPLEMENTATION

CITY OF ALEXANDRIA, VIRGINIA

Department of Project Implementation
P. O. Box 178
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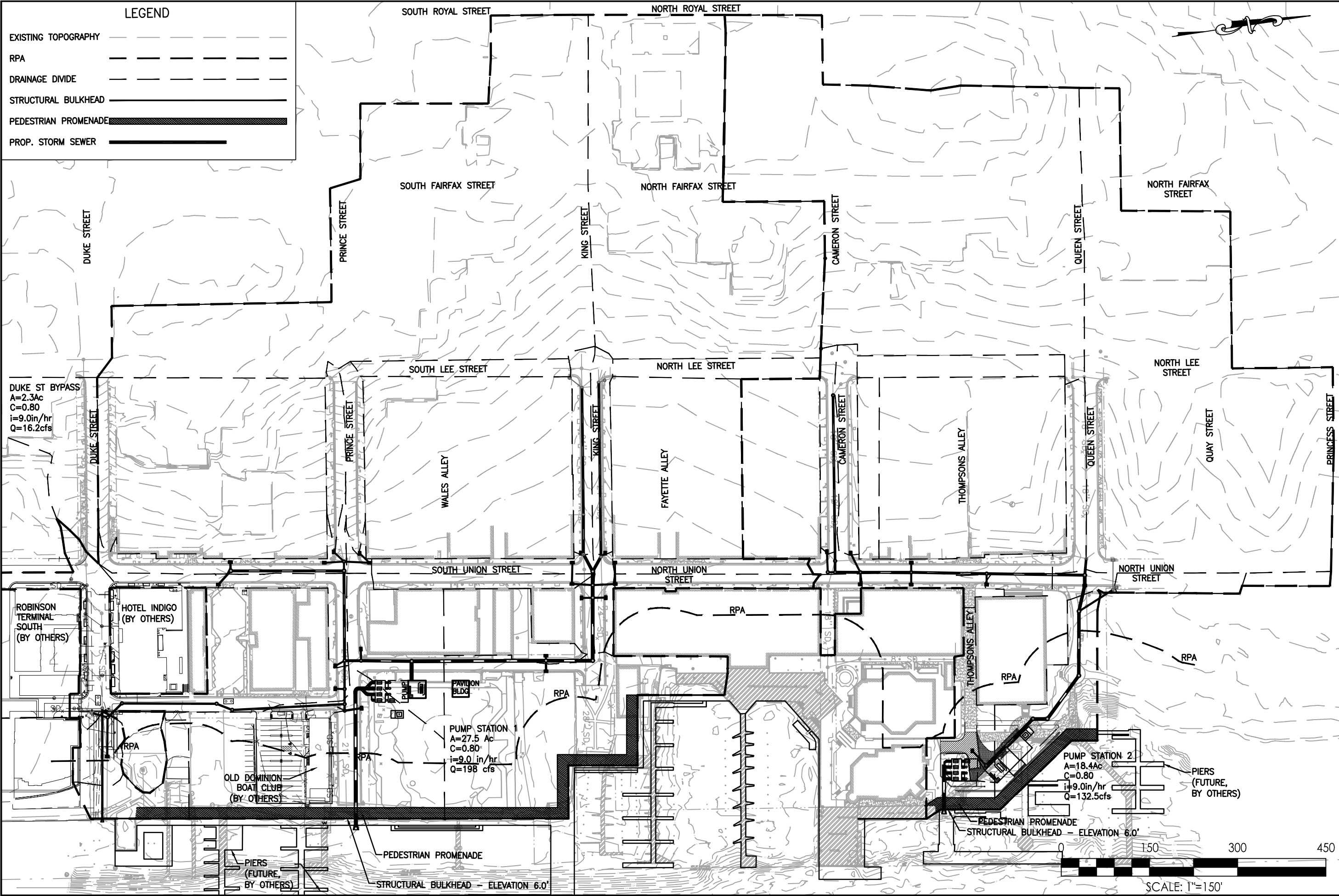
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OVERALL DRAINAGE DIVIDES - ALT 3

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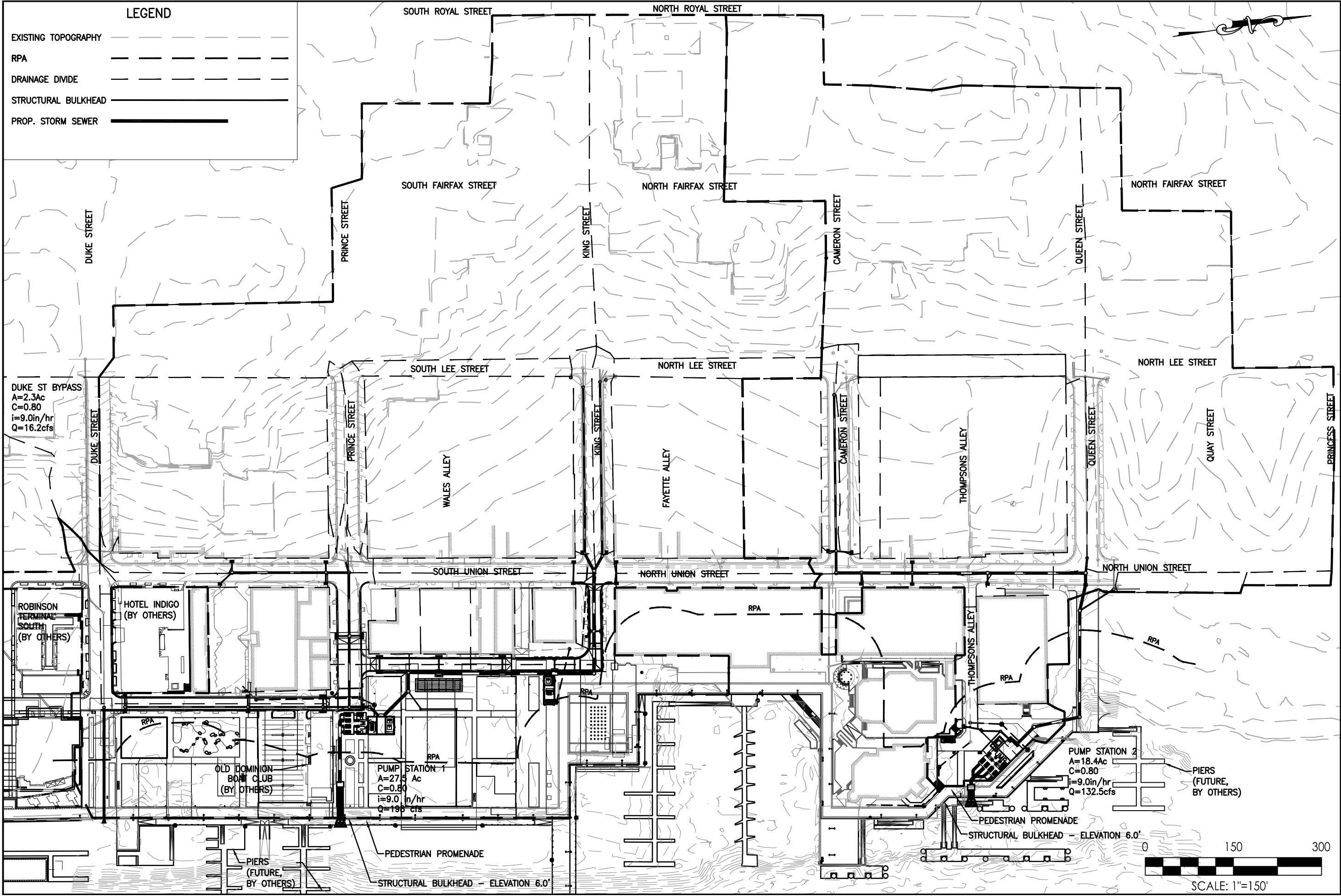
Date: OCTOBER 2017

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OVERALL DRAINAGE
DIVIDES - ALT 3B
WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION

CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313



Date: OCTOBER 2018

Scale: 1" = 150'

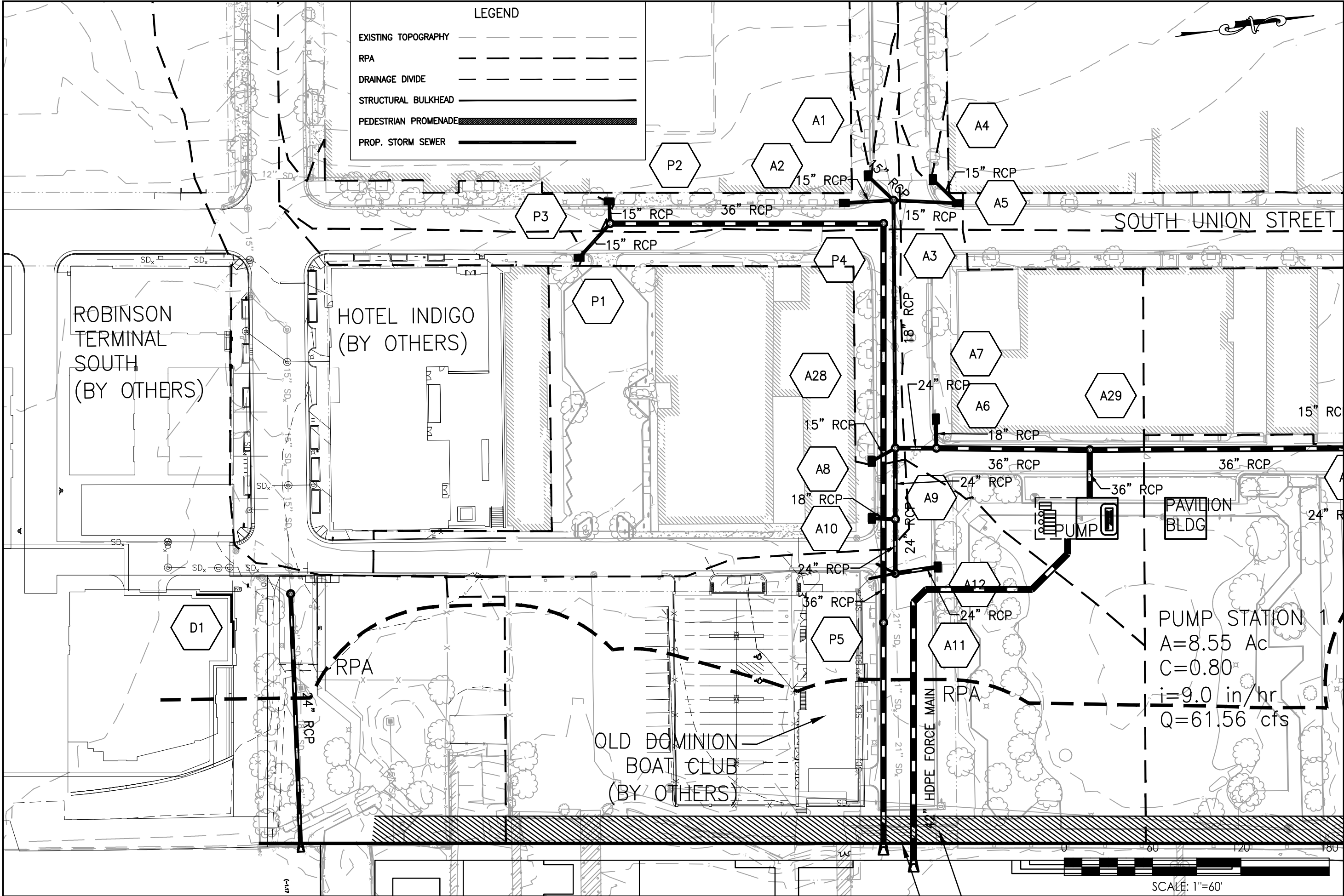
Project No.: 2029041842

Sheet No.
1

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix B PUMP STATION 1 DRAINAGE DIVIDES

Appendix B PUMP STATION 1 DRAINAGE DIVIDES





DUKE STREET - ALT 1

WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION

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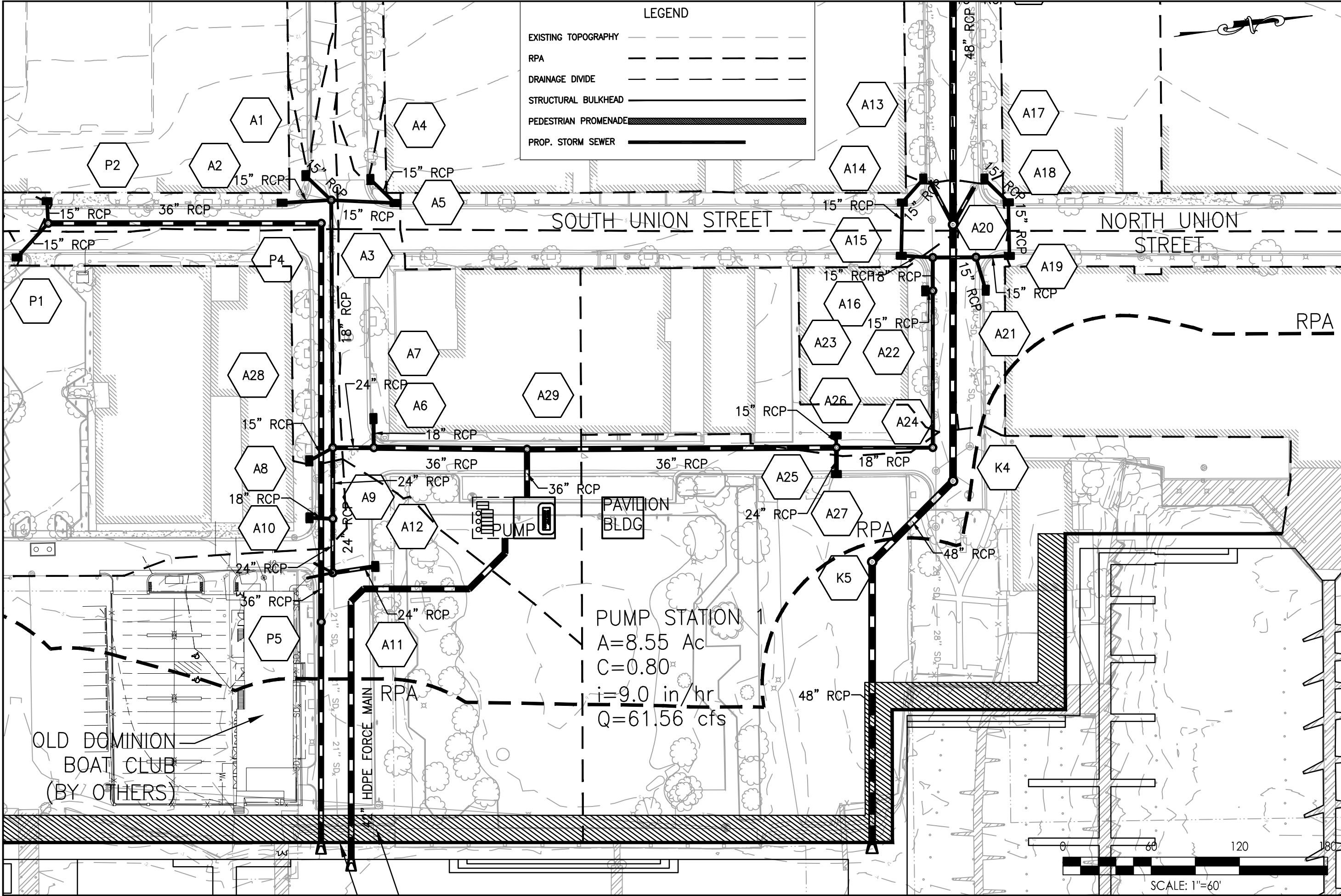


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Scale: 1" = 60'

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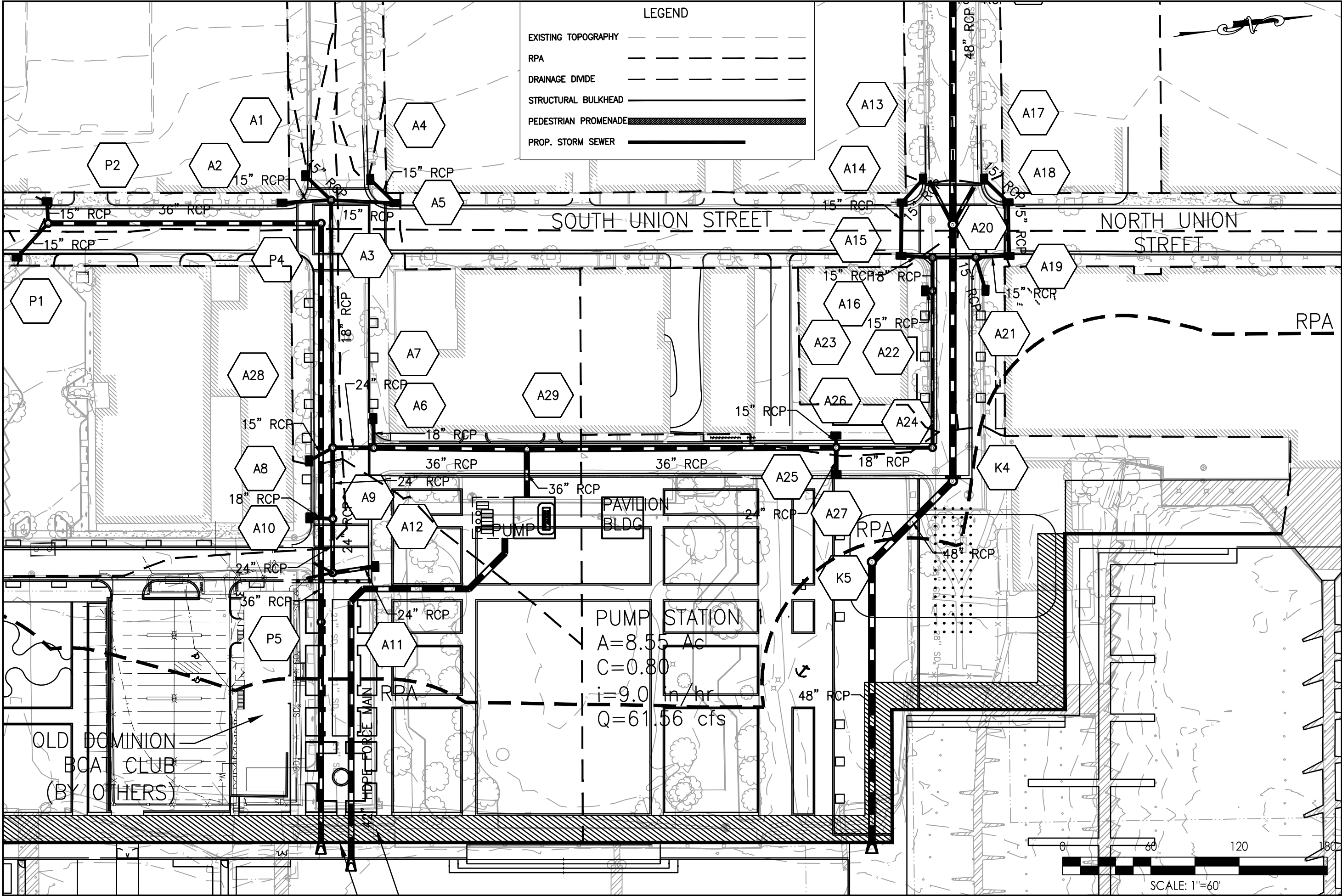
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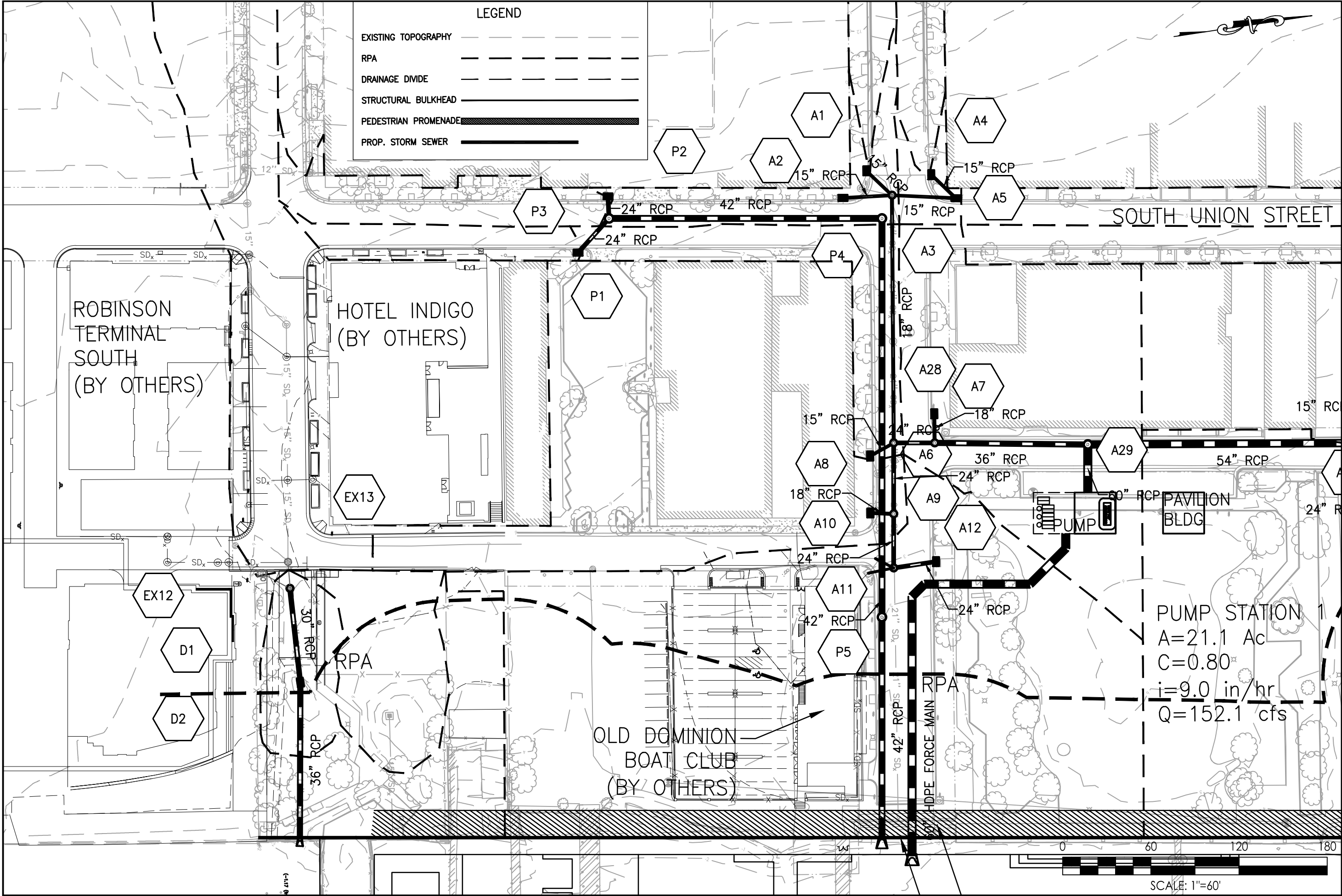
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DUKE STREET - ALT 2

WATERFRONT
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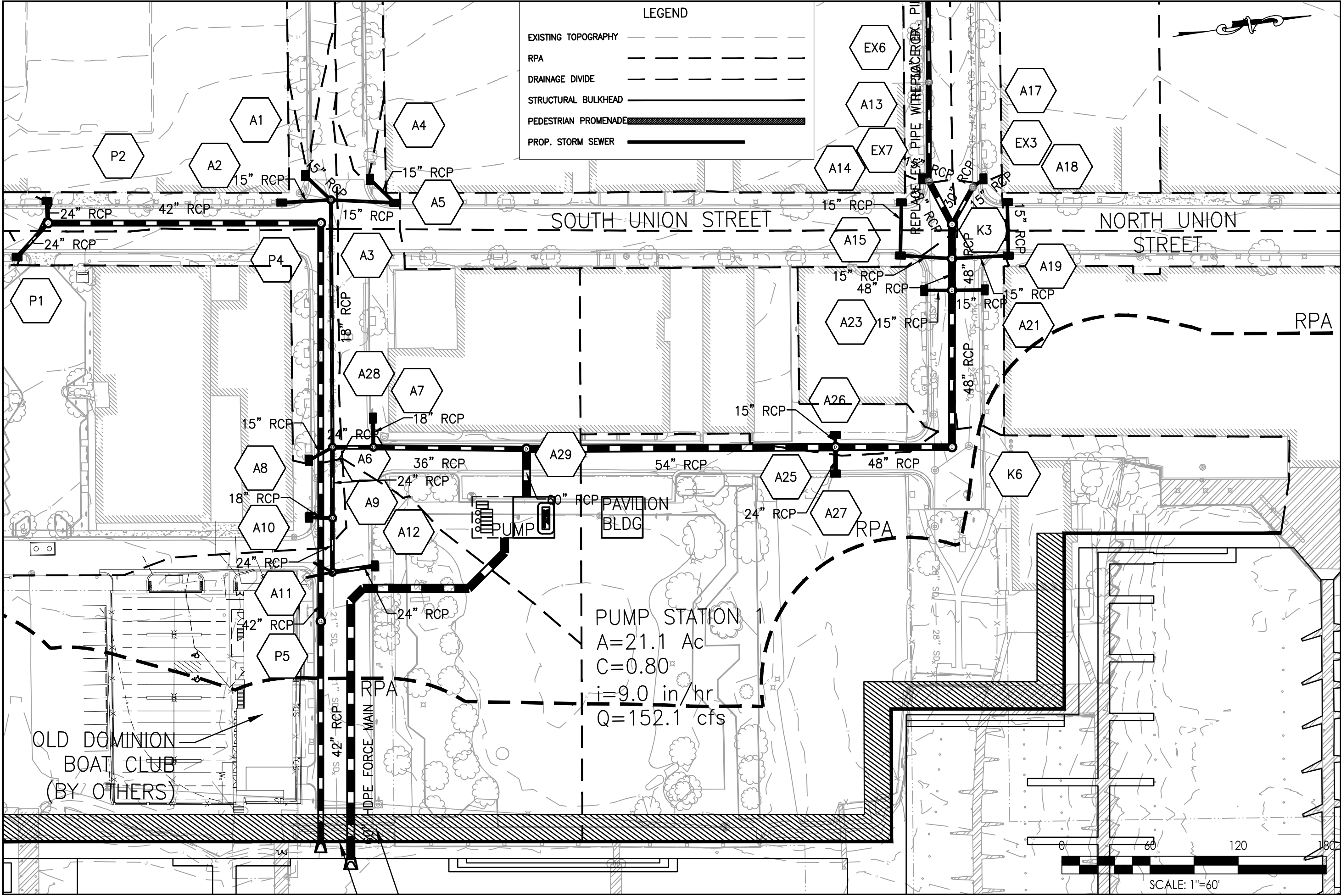


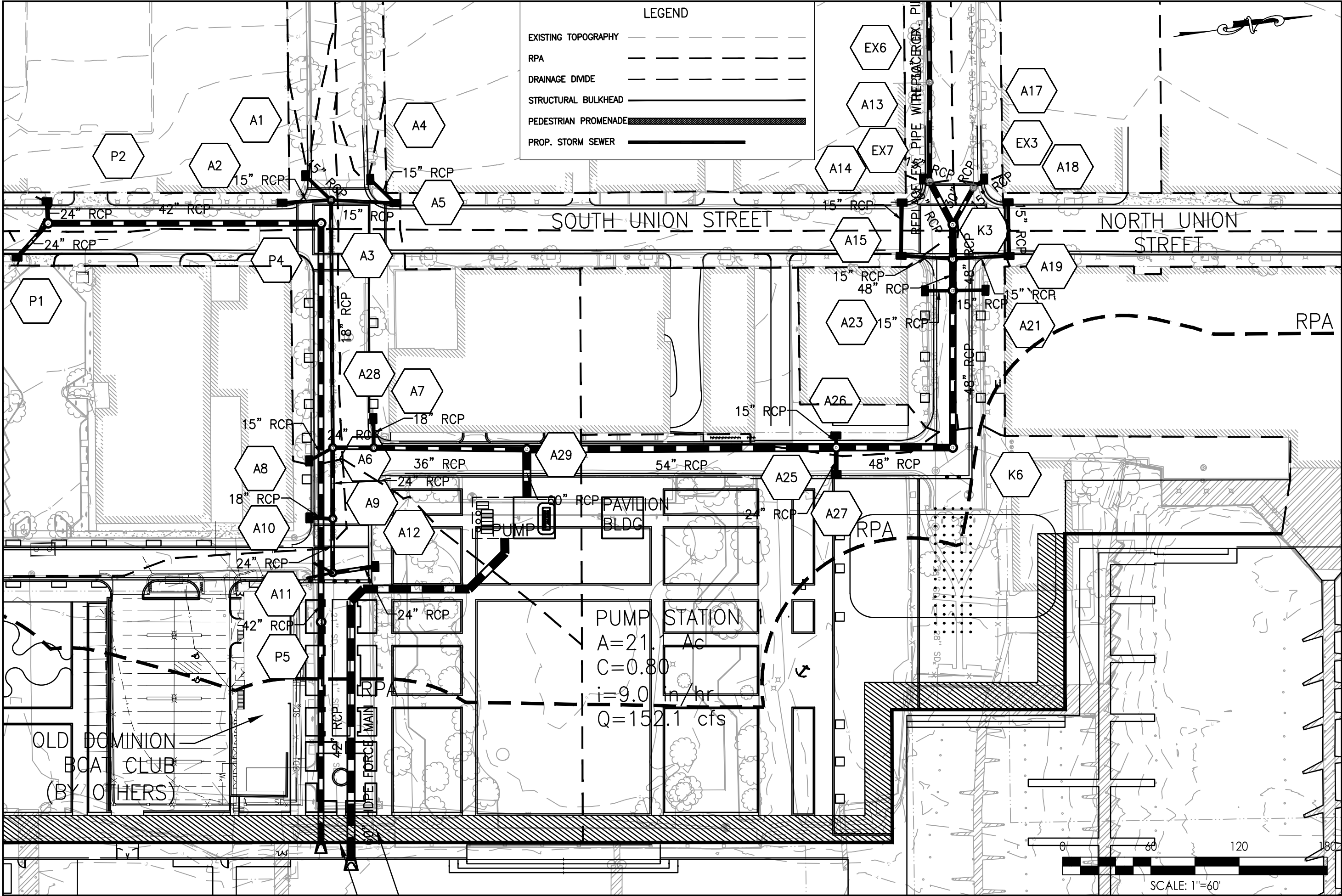
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PUMP STATION 1 - ALT 2

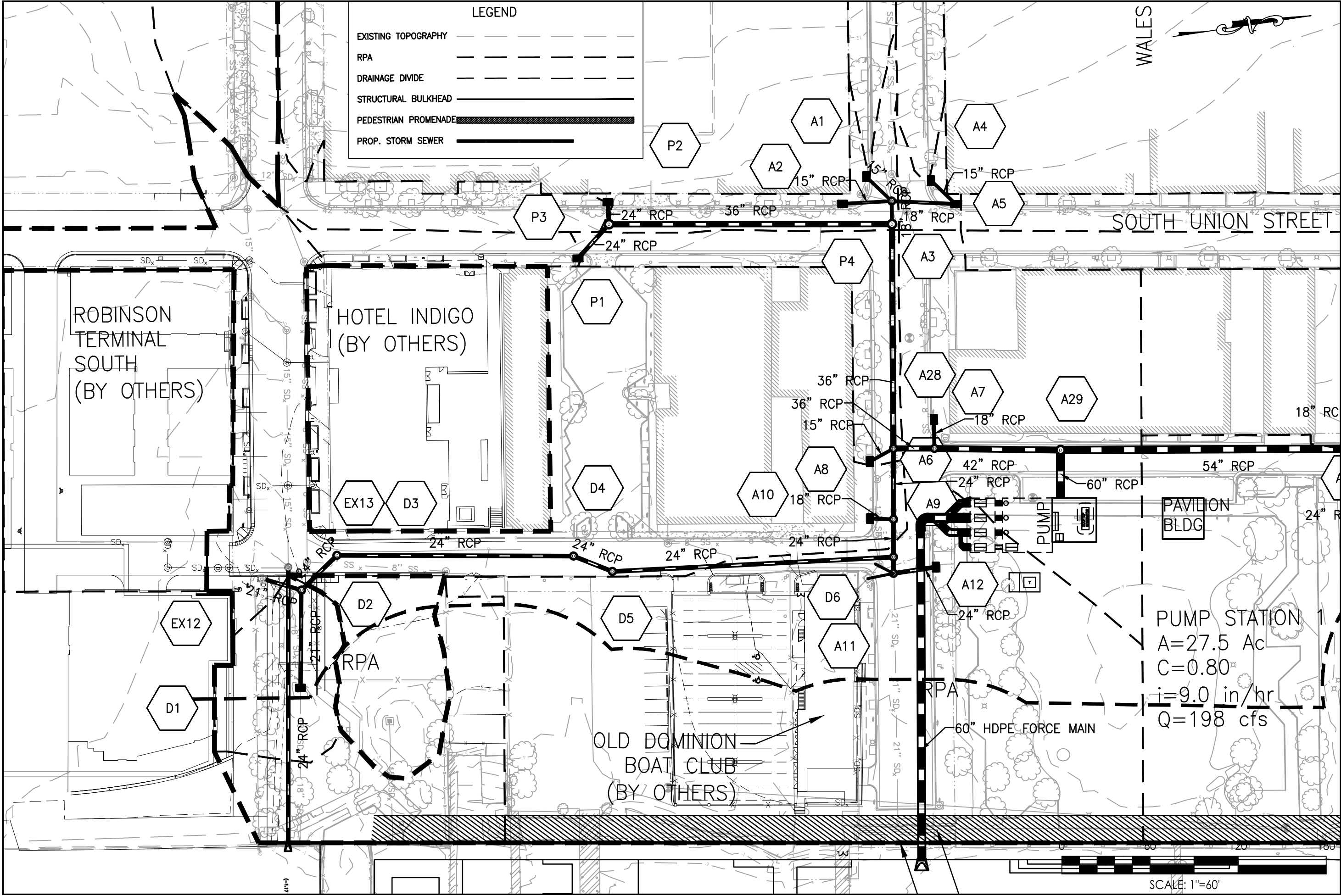
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FLOOD MITIGATION
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DUKE STREET - ALT 3

WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION

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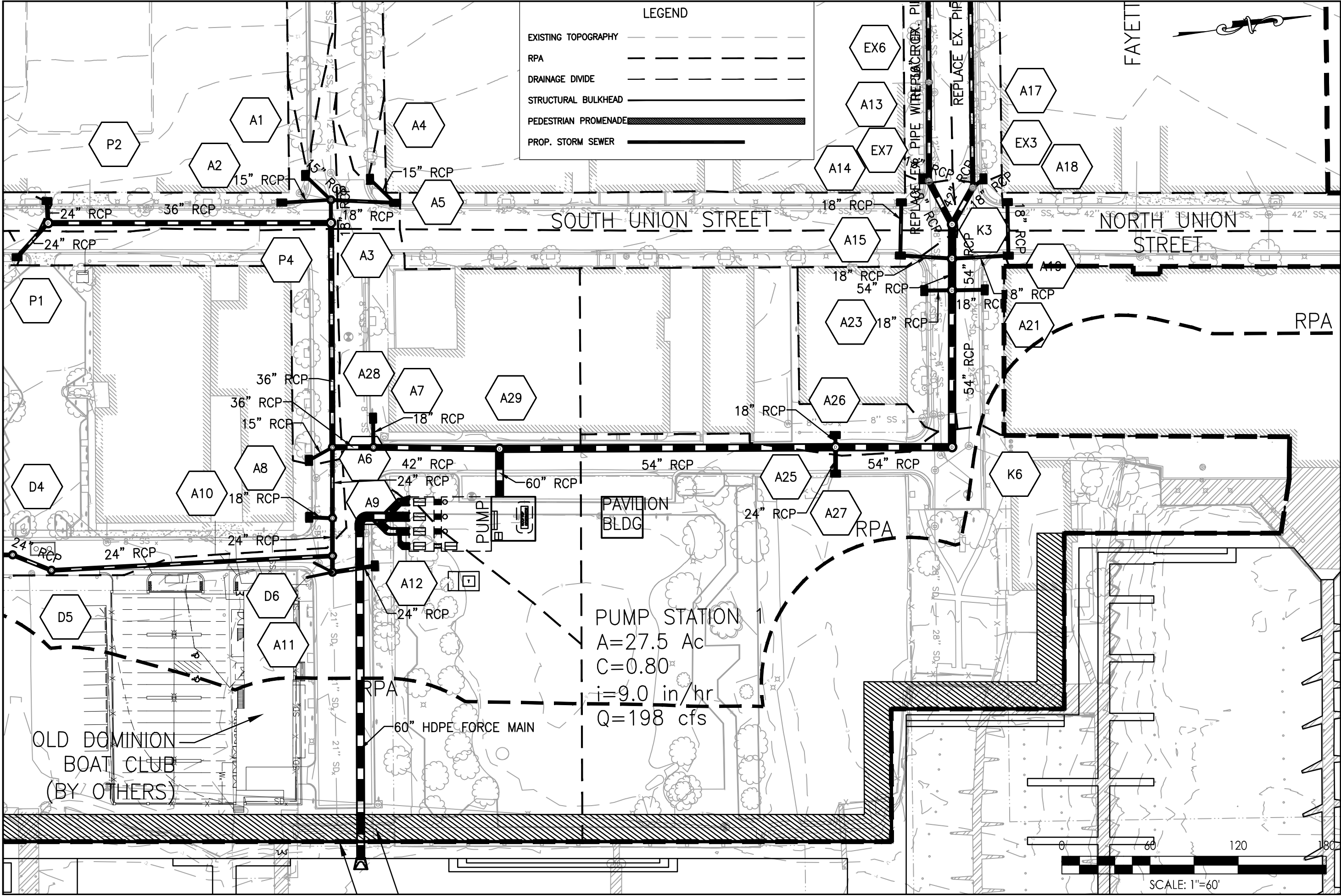
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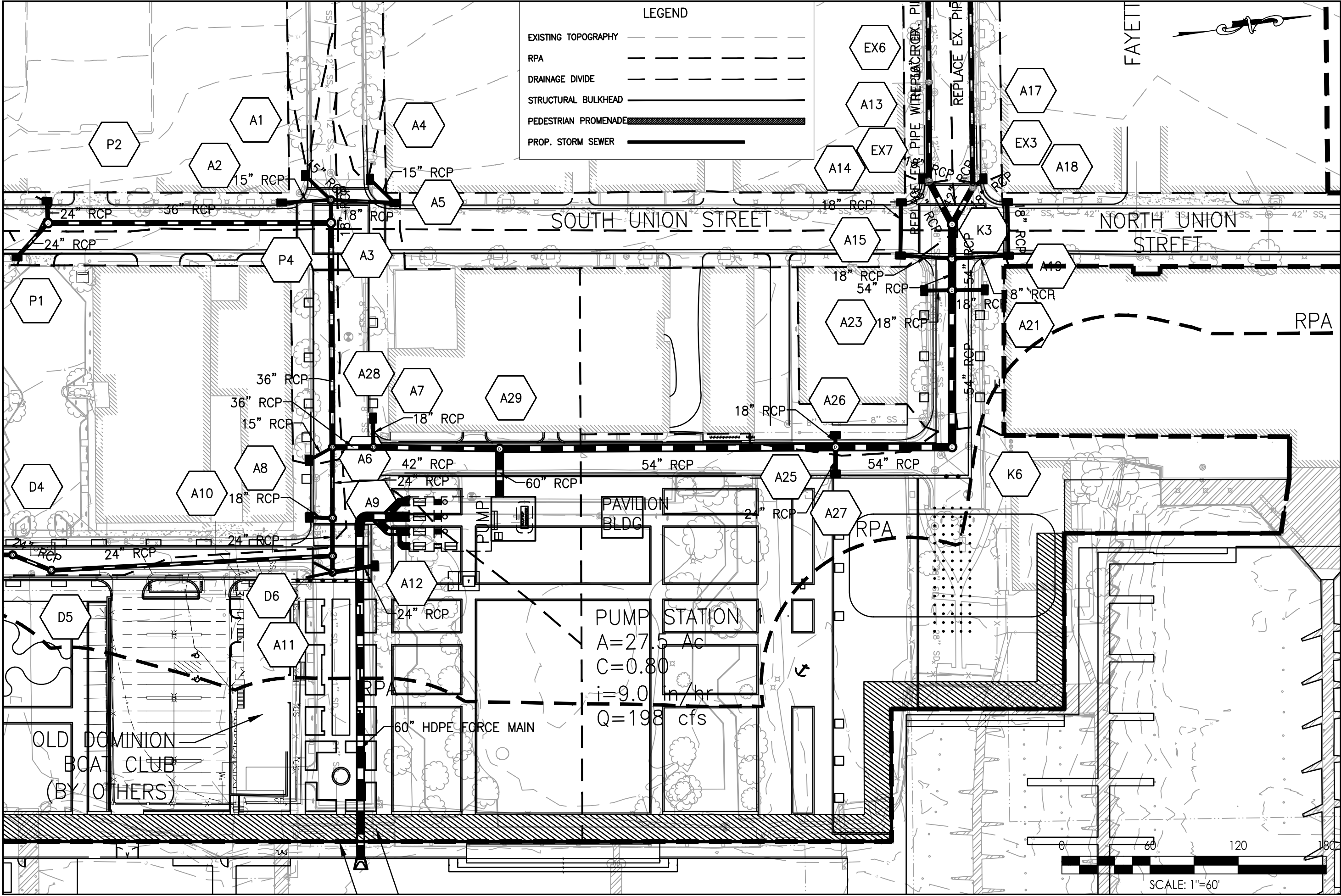
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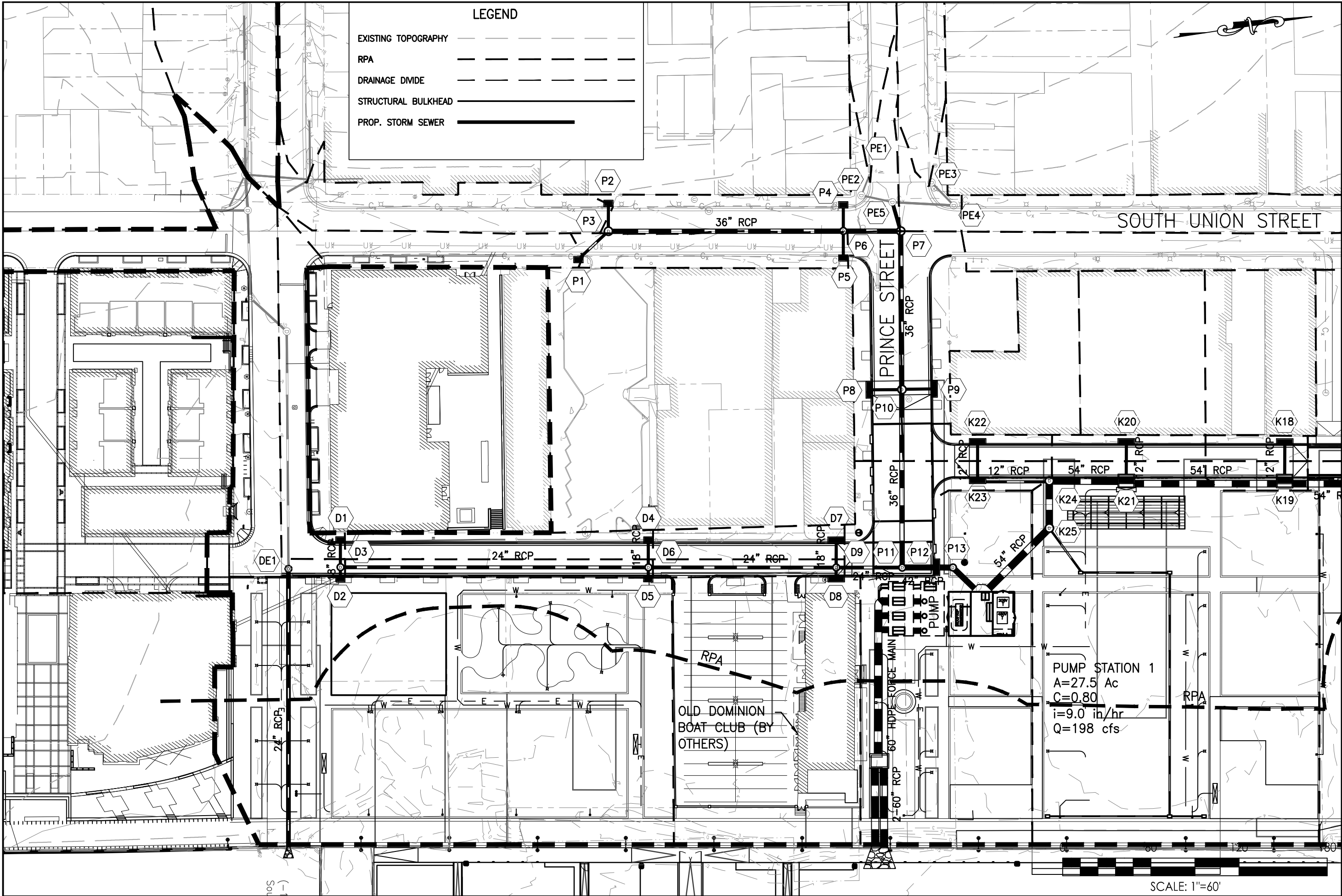
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DUKE STREET - ALT 3B

WATERFRONT
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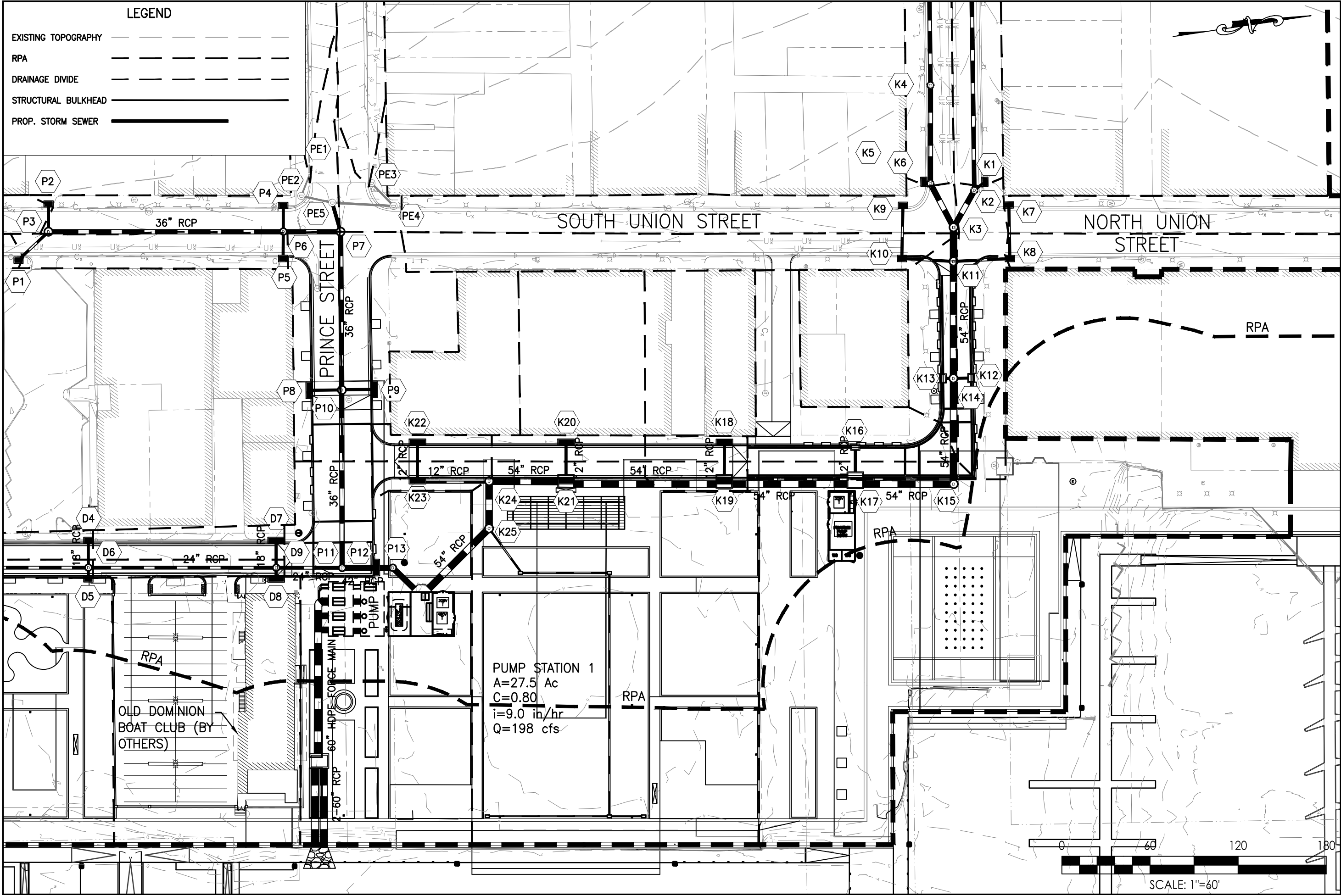


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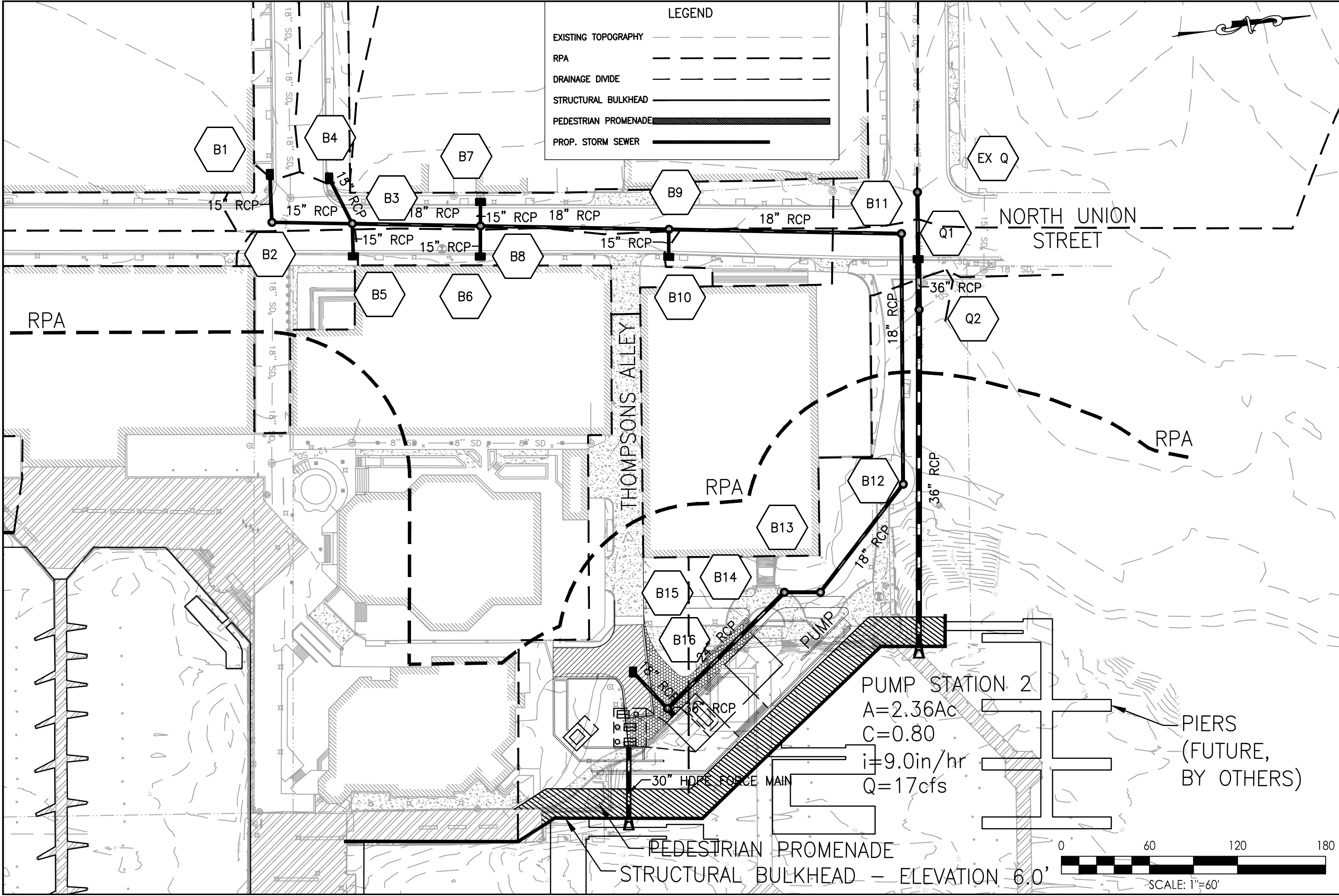
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**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix C PUMP STATION 2 DRAINAGE DIVIDES

Appendix C PUMP STATION 2 DRAINAGE DIVIDES





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WATERFRONT FLOOD MITIGATION IMPLEMENTATION

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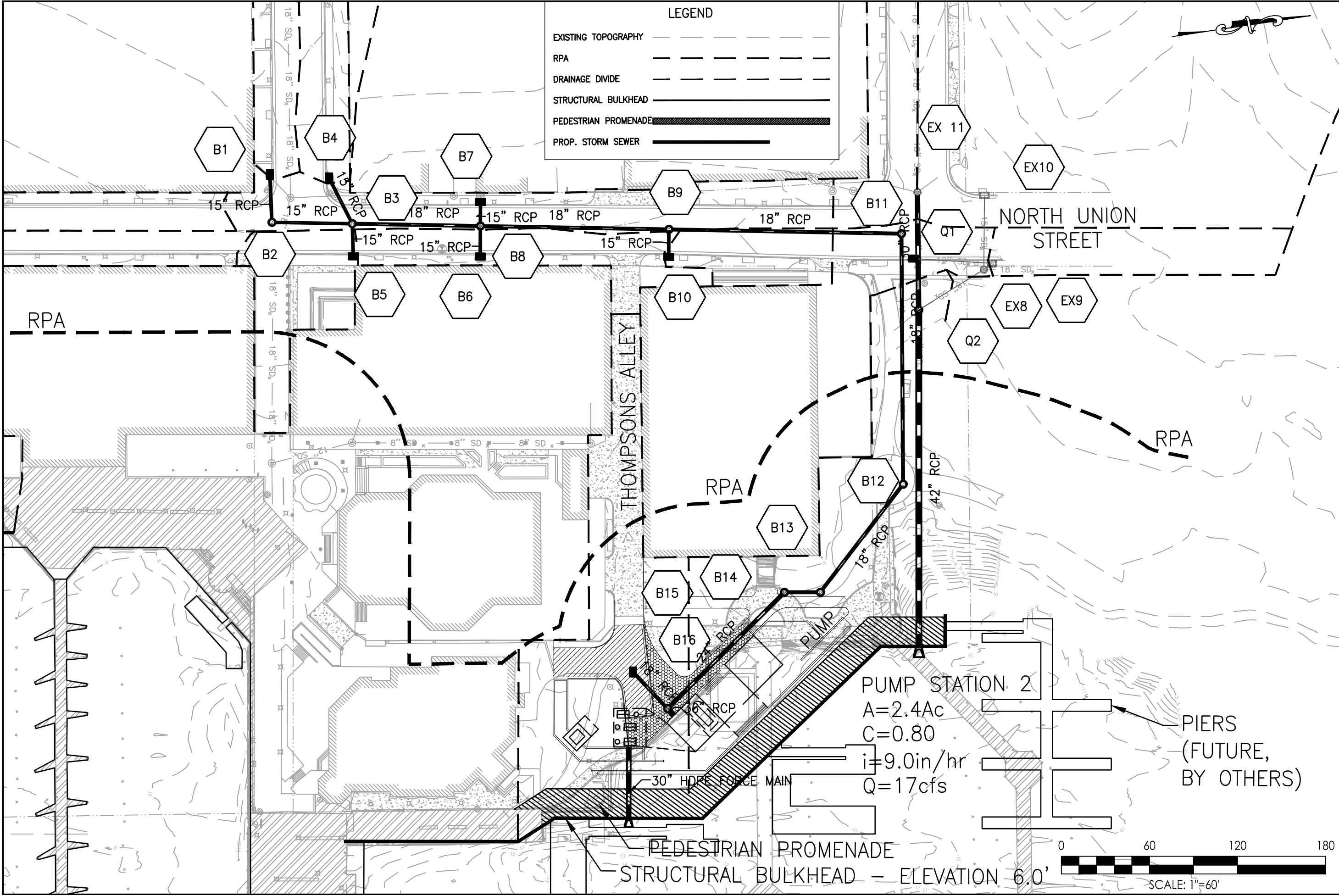


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PUMP STATION 2 - ALT 2

**WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION**

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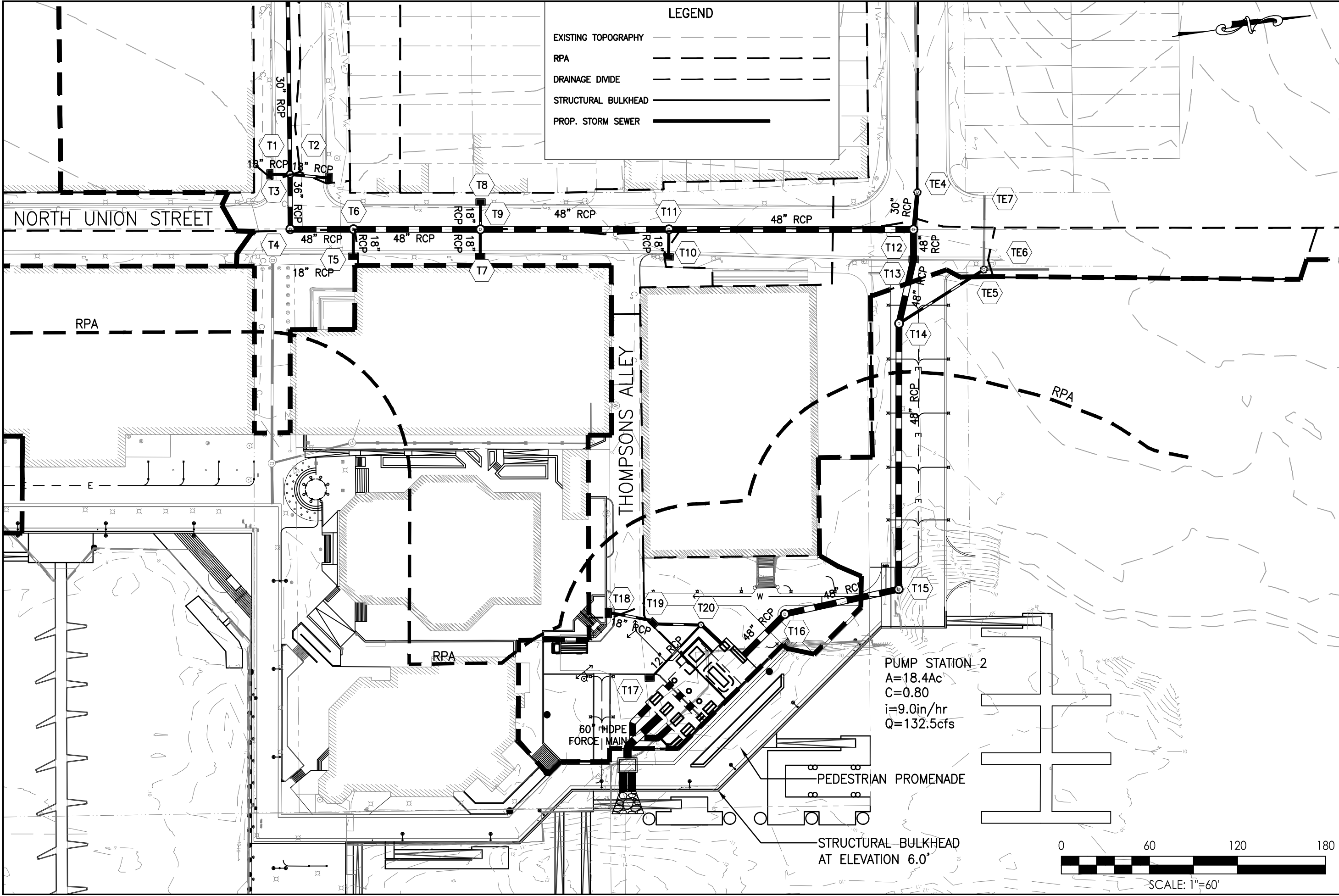
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LEGEND

- EXISTING TOPOGRAPHY
- RPA
- DRAINAGE DIVIDE
- STRUCTURAL BULKHEAD
- PROP. STORM SEWER



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PUMP STATION 2 - ALT 3B

**WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION**

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Date: OCTOBER 2018

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Project No.: 2029041842

Sheet No.

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**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix D PRELIMINARY STORM COMPUTATIONS

Appendix D PRELIMINARY STORM COMPUTATIONS

STORM SEWER COMPUTATIONS - ALTERNATE 1																															
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT	
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN			FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
DUKE ST BYPASS																															
D1	MH	OUTFALL			1.90	1.90	0.80	0.00	1.52	1.52	5.00	9.00	0.00	13.68	13.68	24	CL. IV	RCP	0.0100	169.64	0.013	22.57	7.19	0.61	7.54	1.69	8.00	6.41	-0.41	-2.10	
PRINCE ST BYPASS																															
P1	DI	P3	MH	0.10		0.10	0.90	0.09		0.09	5.00	9.00	0.81		0.81	15	CL. IV	RCP	0.0050	31.43	0.013	4.58	3.73	0.18	2.65	0.16	8.22	2.22	4.75	4.59	
P2	DI	P3	MH	0.16		0.26	0.90	0.14		0.23	5.00	9.00	1.30		1.30	15	CL. IV	RCP	0.0050	15.00	0.013	4.57	3.72	0.28	3.13	0.08	8.02	2.02	4.75	4.68	
P3	MH	P4	MH		4.50	4.76	0.80		3.60	3.83	5.00	9.00		32.40	34.51	36	CL. IV	RCP	0.0100	185.68	0.013	66.55	9.42	0.52	9.51	1.85	7.86	6.91	-2.05	-3.90	
P4	MH	P5	MH			4.76				3.83	5.00	9.00			34.51	36	CL. IV	RCP	0.0050	271.26	0.013	47.04	6.66	0.73	7.25	1.35	6.00	6.90	-3.90	-5.25	
P5	MH	OUTFALL				4.76				3.83	5.00	9.00			34.51	36	CL. IV	RCP	0.0050	150.00	0.013	47.15	6.68	0.73	7.27	0.75	4.69	6.94	-5.25	-6.00	
KING ST BYPASS																															
K1	DI	K3	MH	0.17		0.17	0.90	0.15		0.15	5.00	9.00	1.38		1.38	15	CL. IV	RCP	0.0050	21.76	0.013	4.57	3.72	0.30	3.20	0.11	6.31	2.00	3.06	2.95	
K2	DI	K3	MH	0.16		0.33	0.90	0.14		0.30	5.00	9.00	1.30		1.30	15	CL. IV	RCP	0.0055	19.74	0.013	4.79	3.91	0.27	3.24	0.11	6.18	2.00	2.93	2.82	
K3	MH	K4	MH		12.70	13.03	0.80		10.16	10.46	5.00	9.00		91.44	94.11	48	CL. IV	RCP	0.0050	337.32	0.013	101.94	8.12	0.92	9.33	1.70	6.19	4.99	-2.80	-4.50	
K4	MH	K5	MH			13.03				10.46	5.00	9.00			94.11	48	CL. IV	RCP	0.0050	77.82	0.013	101.78	8.11	0.92	9.31	0.39	5.02	5.53	-4.51	-4.90	
K5	MH	OUTFALL				13.03				10.46	5.00	9.00			94.11	48	CL. IV	RCP	0.0058	190.90	0.013	109.00	8.68	0.86	9.80	1.10	5.19	6.09	-4.90	-6.00	
QUEEN ST BYPASS																															
Q1	DI	Q2	MH	0.74	4.10	4.84	0.90	0.67	3.28	3.95	5.00	9.00	5.99	29.52	35.51	36	CL. IV	RCP	0.0100	34.37	0.013	66.51	9.42	0.53	9.50	0.34	7.00	7.36	-3.36	-3.70	
Q2	MH	OUTFALL				4.84				3.95	5.00	9.00			35.51	36	CL. IV	RCP	0.0100	229.31	0.013	66.78	9.45	0.53	9.54	2.30	6.17	6.87	-3.70	-6.00	
PUMP STATION 1																															
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	9.00	1.37		1.37	15	CL. IV	RCP	0.0050	24.14	0.013	4.57	3.72	0.30	3.16	0.12	6.29	2.00	3.04	2.92	
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	9.00	1.15		1.15	15	CL. IV	RCP	0.0050	33.41	0.013	4.57	3.72	0.25	3.01	0.17	5.85	2.00	2.60	2.43	
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	15	CL. IV	RCP	0.0050	23.16	0.013	4.57	3.72	0.36	3.39	0.12	6.20	2.00	2.95	2.83	
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	9.00	0.36		2.02	15	CL. IV	RCP	0.0050	43.53	0.013	4.57	3.72	0.44	3.57	0.22	5.70	1.62	2.83	2.62	
A3	MH	A6	MH			0.63				0.50	5.00	9.00			4.54	18	CL. IV	RCP	0.0050	177.80	0.013	7.40	4.19	0.61	4.40	0.88	6.07	2.39	2.18	1.30	
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	9.00	1.58		1.58	15	CL. IV	RCP	0.0050	15.99	0.013	4.57	3.72	0.35	3.31	0.08	3.62	2.00	0.37	0.29	
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	9.00	13.97		13.97	24	CL. IV	RCP	0.0050	29.16	0.013	16.06	5.12	0.87	5.78	0.15	3.45	2.00	-0.55	-0.70	
A11	MH	A9	DI			1.94				1.55	5.00	9.00			13.97	24	CL. IV	RCP	0.0050	36.82	0.013	15.94	5.08	0.88	5.79	0.18	3.42	2.12	-0.70	-0.88	
A10	DI	A9	MH	1.10		1.10	0.80	0.88		0.88	5.00	9.00	7.92		7.92	18	CL. IV	RCP	0.0075	15.84	0.013	9.10	5.15	0.87	5.87	0.12	3.50	2.00	0.00	-0.12	
A9	MH	A6	MH			3.04				2.43	5.00	9.00			21.89	24	CL. IV	RCP	0.0150	48.27	0.013	27.73	8.84	0.79	9.80	0.73	3.10	1.98	-0.88	-1.61	
A6	MH	A28	MH			3.89				3.11	5.00	9.00			28.01	24	CL. IV	RCP	0.0200	27.88	0.013	31.99	10.19	0.88	11.61	0.56	3.31	2.92	-1.61	-2.16	
A7	DI	A28	MH	0.74		0.74	0.80	0.59		0.59	5.00	9.00	5.33		5.33	18	CL. IV	RCP	0.0050	19.85	0.013	7.45	4.22	0.71	4.60	0.10	3.70	2.00	0.20	0.10	
A28	MH	A29	MH			4.63				3.70	5.00	9.00			33.34	36	CL. IV	RCP	0.0050	104.21	0.013	47.37	6.71	0.70	7.24	0.53	3.28	2.44	-2.16	-2.69	
A13	DI	A14	DI	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	15	CL. IV	RCP	0.0050	21.51	0.013	4.57	3.72	0.16	2.53	0.11	3.50	2.00	0.25	0.14	
A14	DI	A15	DI	0.23		0.33	0.80	0.18		0.26	5.00	9.00	1.66		2.38	15	CL. IV	RCP	0.0050	36.21	0.013	4.58	3.74	0.52	3.77	0.18	3.68	2.29	0.14	-0.04	
A15	DI	A16	MH	0.21		0.54	0.80	0.17		0.43	5.00	9.00	1.51		3.89	15	CL. IV	RCP	0.0050	21.42	0.013	4.57	3.72	0.85	4.20	0.11	3.90	2.69	-0.04	-0.15	
A17	DI	A18	DI	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	15	CL. IV	RCP	0.0050	22.74	0.013	4.57	3.72	0.16	2.53	0.11	3.93	2.00	0.68	0.57	
A18	DI	A19	DI	0.20		0.30	0.80	0.16		0.24	5.00	9.00	1.44		2.16	15	CL. IV	RCP	0.0050	36.49	0.013	4.57	3.72	0.47	3.65	0.18	3.72	1.90	0.57	0.38	
A19	DI	A20	MH	0.19		0.49	0.80	0.15		0.39	5.00	9.00	1.37		3.53	15	CL. IV	RCP	0.0050	22.76	0.013	4.57	3.72	0.77	4.13	0.11	3.90	2.27	0.38	0.27	
A21	DI	A20	MH	0.13		0.13	0.80	0.10		0.10	5.00	9.00	0.94		0.94	15	CL. IV	RCP	0.0050	23.33	0.013	4.57	3.72	0.20	2.79	0.12	3.30	2.00	0.05	-0.07	
A20	MH	A16	MH			0.62				0.50	5.00	9.00			4.46	18	CL. IV	RCP	0.0050	29.41	0.013	7.43	4.21	0.60	4.41	0.15	3.26	2.08	-0.32	-0.46	
A16	MH	A22	MH			1.16				0.93	5.00	9.00			8.35	18	CL. IV	RCP	0.0075	22.55	0.013	9.09	5.15	0.92	5.92	0.17	3.42	2.38	-0.46	-0.63	
A23	DI	A22	MH	0.25		0.25	0.80	0.20		0.20	5.00	9.00	1.80		1.80	15	CL. IV	RCP	0.0050	5.09	0.013	4.57	3.72	0.39	3.46	0.03	3.26	2.00	0.01	-0.02	

A22	MH	A24	MH			1.41				1.13	5.00	9.00			10.15	18	CL. IV	RCP	0.0100	106.73	0.013	10.50	5.95	0.97	6.89	1.07	2.80	1.57	-0.27	-1.33	
A24	MH	A25	MH			1.41				1.13	5.00	9.00			10.15	18	CL. IV	RCP	0.0100	65.55	0.013	10.51	5.96	0.97	6.90	0.66	3.00	2.83	-1.33	-1.99	
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	9.00	3.31		3.31	18	CL. IV	RCP	0.0050	8.27	0.013	7.43	4.21	0.45	4.03	0.04	2.09	2.00	-1.41	-1.45	
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	9.00	14.76		14.76	24	CL. IV	RCP	0.0050	17.99	0.013	15.99	5.09	0.92	5.85	0.09	2.09	2.00	-1.91	-2.00	
A25	MH	A29	MH			3.92				3.14	5.00	9.00			28.22	36	CL. IV	RCP	0.0050	210.39	0.013	47.33	6.70	0.60	7.03	1.06	2.35	2.35	-3.00	-4.06	
A29	MH	PUMP 1				8.55				6.84	5.00	9.00			61.56	36	CL. IV	RCP	0.0119	32.65	0.013	72.87	10.32	0.84	11.65	0.39	3.45	4.51	-4.06	-4.45	
PUMP 1		OUTFALL				8.55	0.80			6.84	5.00	9.00			61.56	42	CL. IV	RCP	0.0051	303.75	0.013	71.84	7.47	0.86	8.44	1.55	5.00	5.95	-4.45	-6.00	
PUMP STATION 2																															
B1	DI	B2	MH	0.24		0.24	0.80	0.19		0.19	5.00	9.00	1.73		1.73	15	CL. IV	RCP	0.0050	32.65	0.013	4.57	3.72	0.38	3.42	0.16	5.00	2.00	1.75	1.59	
B2	MH	B3	MH			0.24				0.19	5.00	9.00			1.73	15	CL. IV	RCP	0.0051	54.75	0.013	4.59	3.74	0.38	3.44	0.28	5.02	2.18	1.59	1.31	
B4	DI	B3	MH	0.29		0.29	0.80	0.23		0.23	5.00	9.00	2.09		2.09	15	CL. IV	RCP	0.0050	35.03	0.013	4.57	3.72	0.46	3.61	0.18	5.06	2.00	1.81	1.63	
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	15	CL. IV	RCP	0.0050	22.17	0.013	4.57	3.72	0.24	2.94	0.11	5.00	2.00	1.75	1.64	
B3	MH	B8	MH			0.68				0.54	5.00	9.00			4.90	18	CL. IV	RCP	0.0050	87.28	0.013	7.46	4.22	0.66	4.51	0.44	4.80	2.24	1.06	0.62	
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	15	CL. IV	RCP	0.0050	20.68	0.013	4.57	3.72	0.24	2.94	0.10	4.90	2.00	1.65	1.55	
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	9.00	2.02		2.02	15	CL. IV	RCP	0.0050	16.43	0.013	4.57	3.72	0.44	3.57	0.08	4.96	2.00	1.71	1.63	
B8	MH	B9	MH			1.11				0.89	5.00	9.00			7.99	18	CL. IV	RCP	0.0075	128.38	0.013	9.08	5.14	0.88	5.86	0.96	4.75	2.63	0.62	-0.34	
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	9.00	0.65		0.65	15	CL. IV	RCP	0.0050	107.69	0.013	4.57	3.73	0.14	2.50	0.54	5.30	2.00	2.05	1.51	
B9	MH	B11	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	158.44	0.013	9.10	5.15	0.95	5.92	1.19	6.30	5.14	-0.34	-1.53	
B11	MH	B12	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	170.71	0.013	9.09	5.15	0.95	5.92	1.28	7.30	7.33	-1.53	-2.81	
B12	MH	B13	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	92.70	0.013	9.09	5.15	0.95	5.91	0.69	7.00	8.31	-2.81	-3.50	
B13	MH	B14	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	24.47	0.013	9.11	5.16	0.95	5.93	0.18	6.00	8.00	-3.50	-3.69	
B14	MH	B16	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	112.30	0.013	9.09	5.15	0.95	5.92	0.84	5.50	7.69	-3.69	-4.53	
B15	DI	B16	MH	1.16		1.16	0.80	0.93		0.93	5.00	9.00	8.35		8.35	18	CL. IV	RCP	0.0102	34.33	0.013	10.60	6.00	0.79	6.66	0.35	3.85	2.00	0.35	0.00	
B16	MH	PUMP 2				2.36				1.89	5.00	9.00			16.99	24	CL. IV	RCP	0.0100	6.27	0.013	22.67	7.22	0.75	7.94	0.06	4.00	7.03	-5.03	-5.09	
PUMP 2		OUTFALL				2.36	0.80			1.89	5.00	9.00			16.99	30	CL. IV	RCP	0.0187	48.62	0.013	56.00	11.42	0.30	9.81	0.91	6.00	8.59	-5.09	-6.00	

HGL COMPUTATIONS - ALTERNATE 1																								
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev. (2)	D _o (3)	Q _o (4)	L _o (5)	S _{io} ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance
	V _o (8)							H _o (9)	Q _i (10)	V _i (11)	Q/Vi (12)	$\frac{V_i^2}{2g}$ (2g)	H _i (13)	Angle (14)	H _Δ (15)	H _l (16)	1.3 H _l (17)	0.5 H _l (18)						
DUKE ST BYPASS																								
D1	6.00	24	13.68	169.64	0.0037	0.0100	0.62	7.19	0.20	13.68	7.19	98.4	0.8029	0.28	0	0.00	0.48	0.63	0.24	0.86	6.86	8.00	1.14	Acceptable
PRINCE ST BYPASS																								
P5	6.00	36	34.51	150.00	0.0027	0.0050	0.40	6.68	0.17	34.51	6.66	229.8	0.6887	0.24	0	0.00	0.41	0.54	0.21	0.61	6.61	4.69	-1.92	Unacceptable
P4	6.61	36	34.51	271.26	0.0027	0.0050	0.73	6.66	0.17	34.51	9.42	325.2	1.3788	0.48	0	0.00	0.65	0.85	0.33	1.05	7.66	6.00	-1.66	Unacceptable
P3	7.66	36	34.51	185.68	0.0027	0.0100	0.50	9.42	0.34	1.30	3.72	4.8	0.2153	0.08	90	0.15	0.57	0.74	0.29	0.78	8.44	7.86	-0.58	Unacceptable
P2	8.44	15	1.30	15.00	0.0004	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.05	0.07	0.03	0.03	8.48	7.56	-0.92	Unacceptable
P1	8.44	15	0.81	31.43	0.0002	0.0050	0.00	3.73	0.05	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.05	0.07	0.03	0.03	8.48	7.76	-0.72	Unacceptable
KING ST BYPASS																								
K5	6.00	48	94.11	190.90	0.0043	0.0058	0.82	8.68	0.29	94.11	8.11	762.9	1.0204	0.36	45	0.39	1.04	1.35	0.52	1.34	7.34	5.19	-2.15	Unacceptable
K4	7.34	48	94.11	77.82	0.0043	0.0050	0.33	8.11	0.26	94.11	8.12	764.1	1.0235	0.36	45	0.39	1.00	1.30	0.50	0.83	8.17	5.02	-3.16	Unacceptable
K3	8.17	48	94.11	337.32	0.0043	0.0050	1.45	8.12	0.26	2.67	3.91	10.4	0.2372	0.08	90	0.17	0.50	0.66	0.25	1.70	9.87	6.19	-3.68	Unacceptable
K2	9.87	15	1.30	19.74	0.0004	0.0055	0.01	3.91	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.04	9.91	5.72	-4.19	Unacceptable
K1	9.87	15	1.38	21.76	0.0005	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	9.91	5.85	-4.06	Unacceptable
QUEEN ST BYPASS																								
Q2	6.00	36	35.51	229.31	0.0028	0.0100	0.65	9.45	0.35	35.51	9.42	334.4	1.3770	0.48	0	0.00	0.83	1.08	0.41	1.06	7.06	6.17	-0.89	Unacceptable
Q1	7.06	36	35.51	34.37	0.0028	0.0100	0.10	9.42	0.34	35.51	9.42	334.4	1.3770	0.48	0	0.00	0.83	1.07	0.41	0.51	7.57	6.54	-1.03	Unacceptable
PUMP 1																								
A29	-4.50	36	61.56	32.65	0.0085	0.0119	0.28	10.32	0.41	61.56	6.70	412.5	0.6973	0.24	90	0.49	1.15	1.49	0.57	0.85	-3.65	3.45	7.10	Acceptable
A25	-3.65	36	28.22	210.39	0.0018	0.0050	0.38	6.70	0.17	28.22	5.96	168.1	0.5507	0.19	0	0.00	0.37	0.48	0.18	0.56	-3.09	2.35	5.44	Acceptable
A27	-3.09	24	14.76	17.99	0.0043	0.0050	0.08	5.09	0.10	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.10	0.13	0.05	0.13	-2.96	1.63	4.59	Acceptable
A26	-3.09	18	3.31	8.27	0.0010	0.0050	0.01	4.21	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.09	0.03	0.04	-3.05	1.63	4.68	Acceptable
A24	-3.09	18	10.15	65.55	0.0093	0.0100	0.61	5.96	0.14	10.15	5.95	60.4	0.5492	0.19	90	0.38	0.71	0.93	0.36	0.97	-2.12	3.00	5.12	Acceptable
A22	-2.12	18	10.15	106.73	0.0093	0.0100	1.00	5.95	0.14	10.15	5.15	52.3	0.4119	0.14	0	0.00	0.28	0.37	0.14	1.14	-0.98	2.80	3.78	Acceptable
A23	-0.98	15	1.80	5.09	0.0008	0.0050	0.00	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.03	-0.95	2.80	3.75	Acceptable
A16	-0.98	18	8.35	22.55	0.0063	0.0075	0.14	5.15	0.10	4.46	4.21	18.8	0.2746	0.10	90	0.19	0.39	0.51	0.20	0.34	-0.65	3.42	4.07	Acceptable
A20	-0.65	18	4.46	29.41	0.0018	0.0050	0.05	4.21	0.07	4.46	3.72	16.6	0.2153	0.08	0	0.00	0.14	0.19	0.07	0.13	-0.52	3.26	3.78	Acceptable
A21	-0.52	15	0.94	23.33	0.0002	0.0050	0.00	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	74	0.00	0.05	0.07	0.03	0.03	-0.49	2.84	3.33	Acceptable
A19	-0.52	15	3.53	22.76	0.0030	0.0050	0.07	3.72	0.05	2.16	3.72	8.0	0.2153	0.08	89	0.15	0.28	0.36	0.14	0.21	-0.31	3.44	3.75	Acceptable
A18	-0.31	15	2.16	36.49	0.0011	0.0050	0.04	3.72	0.05	0.72	3.72	2.7	0.2153	0.08	45	0.08	0.21	0.27	0.11	0.15	-0.17	3.26	3.43	Acceptable
A17	-0.17	15	0.72	22.74	0.0001	0.0050	0.00	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.05	0.07	0.03	0.03	-0.14	3.47	3.61	Acceptable
A15	-0.65	15	3.89	21.42	0.0036	0.0050	0.08	3.72	0.05	2.38	3.74	8.9	0.2170	0.08	87	0.15	0.28	0.37	0.14	0.22	-0.43	3.44	3.87	Acceptable
A14	-0.43	15	2.38	36.21	0.0014	0.0050	0.05	3.74	0.05	0.72	3.72	2.7	0.2153	0.08	40	0.08	0.21	0.27	0.11	0.15	-0.27	3.22	3.49	Acceptable
A13	-0.27	15	0.72	21.51	0.0001	0.0050	0.00	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.05	0.07	0.03	0.03	-0.24	3.04	3.28	Acceptable
A28	-3.65	36	33.34	104.21	0.0025	0.0050	0.26	6.71	0.17	33.34	10.19	339.8	1.6131	0.56	90	1.13	1.87	2.43	0.93	1.19	-2.46	3.28	5.74	Acceptable
A7	-2.46	18	5.33	19.85	0.0026	0.0050	0.05	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.09	0.03	0.09	-2.37	3.24	5.61	Acceptable
A6	-2.46	24	28.01	27.88	0.0153	0.0200	0.43	10.19	0.40	28.01	8.84	247.5	1.2122	0.42	90	0.85	1.68	2.18	0.84	1.27	-1.19	3.31	4.50	Acceptable
A9	-1.19	24	21.89	48.27	0.0094	0.0150	0.45	8.84	0.30	21.89	5.15	112.8	0.4126	0.14	90	0.29	0.74	0.96	0.37	0.82	-0.37	3.10	3.47	Acceptable
A10	-0.37	18	7.92	15.84	0.0057	0.0075	0.09	5.15	0.10	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.10	0.13	0.05	0.14	-0.23	3.04	3.27	Acceptable
A11	-0.37	24	13.97	36.82	0.0038	0.0050	0.14	5.08	0.10	13.97	5.12	71.4	0.4063	0.14	0	0.00	0.24	0.32	0.12	0.26	-0.11	3.42	3.53	Acceptable
A12	-0.11	24	13.97	29.16	0.0038	0.0050	0.11	5.12	0.10	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.10	0.13	0.05	0.16	0.05	2.99	2.94	Acceptable
A8	-1.19	15	1.58	15.99	0.0006	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	30	0.00	0.05	0.07	0.03	0.04	-1.15	3.16	4.31	Acceptable
A3	-1.19	18	4.54	177.80	0.0019	0.0050	0.33	4.19	0.07	4.54	3.72	16.9	0.2153	0.08	0	0.00	0.14	0.19	0.07	0.40	-0.79	6.07	6.86	Acceptable
A5	-0.79	15	2.02	43.53	0.0010	0.0050	0.04	3.72	0.05	1.66	3.72	6.2	0.2153	0.08	90	0.15	0.28	0.36	0.14	0.18	-0.60	5.24	5.84	Acceptable
A4	-0.60	15	1.66	23.16	0.0007	0.0050	0.02	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.05	0.07	0.03	0.04	-0.56	5.74	6.30	Acceptable
A2	-0.79	15	1.15	33.41	0.0003	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	-0.75	5.39	6.14	Acceptable
A1	-0.79	15	1.37	24.14	0.0004	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.05	0.07	0.03	0.04	-0.75	5.83	6.58	Acceptable

PUMP 2																								
B16	-6.50	24	16.99	6.27	0.0056	0.0100	0.04	7.22	0.20	16.99	6.00	102.0	0.5599	0.20	0	0.00	0.40	0.52	0.20	0.23	-6.27	4.00	10.27	Acceptable
B15	-6.27	18	8.35	34.33	0.0063	0.0102	0.22	6.00	0.14	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.14	0.18	0.07	0.29	-5.98	3.39	9.37	Acceptable
B14	-5.98	18	8.64	112.30	0.0068	0.0075	0.76	5.15	0.10	8.64	5.16	44.6	0.4130	0.14	45	0.16	0.40	0.53	0.20	0.96	-5.02	5.50	10.52	Acceptable
B13	-5.02	18	8.64	24.47	0.0068	0.0075	0.17	5.16	0.10	8.64	5.15	44.5	0.4112	0.14	53	0.19	0.44	0.57	0.22	0.39	-4.63	6.00	10.63	Acceptable
B12	-4.63	18	8.64	92.70	0.0068	0.0075	0.63	5.15	0.10	8.64	5.15	44.5	0.4118	0.14	38	0.12	0.36	0.47	0.18	0.81	-3.82	7.00	10.82	Acceptable
B11	-3.82	18	8.64	170.71	0.0068	0.0075	1.15	5.15	0.10	8.64	5.15	44.5	0.4125	0.14	90	0.29	0.54	0.70	0.27	1.42	-2.40	7.30	9.70	Acceptable
B9	-2.40	18	8.64	158.44	0.0068	0.0075	1.07	5.15	0.10	8.64	5.14	44.4	0.4107	0.14	0	0.00	0.25	0.32	0.12	1.19	-1.21	6.30	7.51	Acceptable
B10	-1.21	15	0.65	107.69	0.0001	0.0050	0.01	3.73	0.05	7.99	5.14	41.1	0.4107	0.14	90	0.29	0.49	0.63	0.24	0.25	-0.95	4.84	5.79	Acceptable
B8	-0.95	18	7.99	128.38	0.0058	0.0075	0.74	5.14	0.10	7.99	4.22	33.7	0.2769	0.10	0	0.00	0.20	0.26	0.10	0.84	-0.11	4.75	4.86	Acceptable
B7	-0.11	15	2.02	16.43	0.0010	0.0050	0.02	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	-0.07	4.50	4.57	Acceptable
B6	-0.07	15	1.08	20.68	0.0003	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.03	-0.04	4.44	4.48	Acceptable
B3	-0.04	18	4.90	87.28	0.0022	0.0050	0.19	4.22	0.07	4.90	3.74	18.3	0.2177	0.08	0	0.00	0.15	0.19	0.07	0.26	0.23	4.80	4.57	Acceptable
B5	0.23	15	1.08	22.17	0.0003	0.0050	0.01	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.03	0.26	4.54	4.28	Acceptable
B4	0.26	15	2.09	35.03	0.0010	0.0050	0.04	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	62	0.00	0.05	0.07	0.03	0.06	0.32	4.60	4.28	Acceptable
B2	0.32	15	1.73	54.75	0.0007	0.0051	0.04	3.74	0.05	1.73	3.72	6.4	0.2153	0.08	0	0.00	0.13	0.17	0.06	0.10	0.43	5.02	4.59	Acceptable
B1	0.43	15	1.73	32.65	0.0007	0.0050	0.02	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.05	0.48	4.54	4.06	Acceptable

*Lesser of the Rim Elevation or the Rim Elevation minus 0.46' (Throat Elevation)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 9" (0.75') from the throat of the inlet.

STORM SEWER COST ESTIMATE - ALTERNATIVE 1

Item	Quantity	Unit	Unit Price	Total	
15" RCP CI IV	707.11	LF	\$ 59.53	\$ 42,094.26	
18" RCP CI IV	1254.61	LF	\$ 73.14	\$ 91,762.18	
24" RCP CI IV	336.03	LF	\$ 105.62	\$ 35,491.49	
30" RCP CI IV	48.62	LF	\$ 129.95	\$ 6,318.17	
36" RCP CI IV	1217.87	LF	\$ 180.45	\$ 219,764.64	
42" RCP CI IV	303.75	LF	\$ 227.72	\$ 69,169.95	
48" RCP CI IV	606.04	LF	\$ 259.24	\$ 157,109.81	
60" RCP CI IV	0	LF	\$ 366.83	\$ -	
Manhole	28	EA	\$ 4,611.50	\$ 129,122.00	(MH-2 with watertight frame and cover)
Inlet	30	EA	\$ 6,000.00	\$ 180,000.00	(DI-3B, 8' throat is \$5,984.01)
Outfall Valve 24"	1	EA	\$ 5,086.00	\$ 5,086.00	
Outfall Valve 30"	1	EA	\$ 9,449.00	\$ 9,449.00	
Outfall Valve 36"	2	EA	\$ 9,449.00	\$ 18,898.00	
Outfall Valve 42"	1	EA	\$ 14,088.00	\$ 14,088.00	
Outfall Valve 48"	1	EA	\$ 21,859.00	\$ 21,859.00	
Outfall Valve 60"	0	EA	\$ 43,782.00	\$ -	
TOTAL				\$ 1,000,212.49	

Tideflex valve unit prices from sales rep

All other prices from Fairfax County 2017 Unit Price Schedule

STORM SEWER COMPUTATIONS - ALTERNATE 2																																
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		RE MARK	
								INC.	ADD	TOTAL			UPPER INVERT	LOWER INVERT																		
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN				FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
EX GRATE	MH	EX OUTFALL		0.21		0.21	0.80	0.17	0.00	0.17	5.00	9.00	1.51	0.00	1.51	15	CL. IV	RCP	0.0212	84.07	0.013	9.40	7.66	0.16	5.36	1.78	2.57	1.20	0.12	-1.66		
DUKE ST BYPASS																																
EX13	MH	D1			1.65	1.65	0.90		1.49	1.49	5.00	9.00		13.37	13.37	15	CL. IV	RCP	0.0271	18.10	0.013	10.62	8.67	1.26	9.96	0.49	6.00	3.30	1.45	0.96		
EX12	MH	D1		0.42		0.42	0.90	0.38		0.38	5.00	9.00	3.40		3.40	12	CL. IV	RCP	0.0005	21.73	0.013	0.76	0.97	4.45	1.12	0.01	6.46	4.30	1.16	1.17		
D1	MH	D2				2.07	0.80			1.86	5.00	9.00			16.77	30	CL. IV	RCP	0.0101	64.36	0.013	41.21	8.40	0.41	7.81	0.65	8.00	5.89	-0.39	-1.04		
D2	MH	OUTFALL		0.13		2.20	0.80	0.10		1.97	5.00	9.00	0.94		17.70	36	CL. IV	RCP	0.0100	105.53	0.013	66.82	9.46	0.26	7.75	1.06	4.58	2.62	-1.04	-2.10		
PRINCE ST BYPASS																																
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	24	CL. IV	RCP	0.0050	31.43	0.013	16.03	5.11	0.04	2.35	0.16	8.22	1.47	4.75	4.59		
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	9.00	1.15		1.87	24	CL. IV	RCP	0.0050	15.00	0.013	15.99	5.09	0.12	3.10	0.08	8.02	1.27	4.75	4.68		
P3	MH	P4	MH		3.62	3.88	0.80		2.90	3.10	5.00	9.00		26.06	27.94	42	CL. IV	RCP	0.0100	185.68	0.013	100.39	10.44	0.28	8.66	1.85	7.86	6.41	-2.05	-3.90		
P4	MH	P5	MH			3.88	0.80			3.10	5.00	9.00			27.94	42	CL. IV	RCP	0.0050	271.26	0.013	70.95	7.38	0.39	6.86	1.35	5.99	6.39	-3.90	-5.25		
P5	MH	OUTFALL				3.88	0.80			3.10	5.00	9.00			27.94	42	CL. IV	RCP	0.0050	150.00	0.013	71.12	7.40	0.39	6.87	0.75	4.69	6.44	-5.25	-6.00		
QUEEN ST BYPASS																																
Q1	GRATE	EX9	DI	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	12	CL. IV	RCP	0.0103	53.48	0.013	3.61	4.60	0.20	3.40	0.55	6.36	0.60	4.76	4.21		
EX9	DI	EX8	DI	0.15		0.25	0.80	0.12		0.20	5.00	9.00	1.08		1.80	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	2.99	0.77	3.29	0.03	7.21	2.25	3.96	3.99		
EX10	DI	EX8	DI	0.14		0.14	0.80	0.11		0.11	5.00	9.00	1.01		1.01	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	6.45	0.13	4.06	0.76	7.00	4.09	1.66	0.90		
EX8	MH	Q2				0.39	0.80			0.31	5.00	9.00			2.81	18	CL. IV	RCP	0.0130	52.21	0.013	11.98	6.79	0.23	5.36	0.68	7.25	5.80	-0.05	-0.73		
EX11	DI	Q2	MH		4.62	4.62	0.80		3.70	4.01	5.00	9.00		33.26	36.07	30	CL. IV	RCP	0.0261	80.13	0.013	66.22	13.50	0.54	13.76	2.09	7.16	4.20	0.46	-1.63		
Q2	MH	OUTFALL			0.60	5.61	0.80		0.48	4.80	5.00	9.00		4.32	43.20	42	CL. IV	RCP	0.0050	229.15	0.013	71.25	7.41	0.61	7.78	1.15	6.17	7.52	-4.85	-6.00		
PUMP STATION 1																																
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	9.00	1.37		1.37	15	CL. IV	RCP	0.0050	24.14	0.013	4.57	3.72	0.30	3.16	0.12	6.29	2.00	3.04	2.92		
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	9.00	1.15		1.15	15	CL. IV	RCP	0.0050	33.41	0.013	4.57	3.72	0.25	3.01	0.17	5.85	2.00	2.60	2.43		
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	15	CL. IV	RCP	0.0050	23.16	0.013	4.57	3.72	0.36	3.39	0.12	6.20	2.00	2.95	2.83		
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	9.00	0.36		2.02	15	CL. IV	RCP	0.0050	43.53	0.013	4.57	3.72	0.44	3.57	0.22	5.70	1.62	2.83	2.62		
A3	MH	A6	MH			0.63				0.50	5.00	9.00			4.54	18	CL. IV	RCP	0.0050	177.80	0.013	7.40	4.19	0.61	4.40	0.88	6.07	2.39	2.18	1.30		
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	9.00	1.58		1.58	15	CL. IV	RCP	0.0050	15.99	0.013	4.57	3.72	0.35	3.31	0.08	3.62	2.00	0.37	0.29		
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	9.00	13.97		13.97	24	CL. IV	RCP	0.0050	29.16	0.013	16.06	5.12	0.87	5.78	0.15	3.45	2.00	-0.55	-0.70		
A11	MH	A9	DI			1.94				1.55	5.00	9.00			13.97	24	CL. IV	RCP	0.0050	36.82	0.013	15.94	5.08	0.88	5.79	0.18	3.42	2.12	-0.70	-0.88		
A10	DI	A9	MH	1.10		1.10	0.80	0.88		0.88	5.00	9.00	7.92		7.92	18	CL. IV	RCP	0.0075	15.84	0.013	9.10	5.15	0.87	5.87	0.12	3.50	2.00	0.00	-0.12		
A9	MH	A6	MH			3.04				2.43	5.00	9.00			21.89	24	CL. IV	RCP	0.0150	48.27	0.013	27.73	8.84	0.79	9.80	0.73	3.10	1.98	-0.88	-1.61		
A6	MH	A28	MH			3.89				3.11	5.00	9.00			28.01	24	CL. IV	RCP	0.0200	27.88	0.013	31.99	10.19	0.88	11.61	0.56	3.31	2.92	-1.61	-2.16		
A7	DI	A28	MH	0.74		0.74	0.80	0.59		0.59	5.00	9.00	5.33		5.33	18	CL. IV	RCP	0.0050	19.85	0.013	7.45	4.22	0.71	4.60	0.10	3.70	2.00	0.20	0.10		
A28	MH	A29	MH			4.63				3.70	5.00	9.00			33.34	36	CL. IV	RCP	0.0050	104.21	0.013	47.37	6.71	0.70	7.24	0.53	3.28	2.44	-2.16	-2.69		

A14	DI	A15	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	15	CL. IV	RCP	0.0050	36.21	0.013	4.55	3.71	0.36	3.38	0.18	3.68	2.29	0.14	-0.04	
A15	DI	K4	MH	0.21		0.44	0.80	0.17		0.35	5.00	9.00	1.51		3.17	15	CL. IV	RCP	0.0054	35.24	0.013	4.74	3.87	0.67	4.13	0.19	3.90	2.69	-0.04	-0.23	
A18	DI	A19	DI	0.20		0.20	0.80	0.16		0.16	5.00	9.00	1.44		1.44	15	CL. IV	RCP	0.0052	36.49	0.013	4.66	3.80	0.31	3.27	0.19	3.72	1.90	0.57	0.38	
A19	DI	K4	MH	0.19		0.39	0.80	0.15		0.31	5.00	9.00	1.37		2.81	15	CL. IV	RCP	0.0053	22.76	0.013	4.69	3.82	0.60	4.01	0.12	3.90	2.27	0.38	0.26	
K4	MH	K5	MH			13.6	0.80			10.88	5.00	9.00			97.92	48	CL. IV	RCP	0.0051	21.61	0.013	102.45	8.16	0.96	9.38	0.11	3.50	0.74	-1.24	-1.35	
A21	DI	K5	MH	0.13		0.13	0.80	0.10		0.10	5.00	9.00	0.94		0.94	15	CL. IV	RCP	0.0051	23.33	0.013	4.63	3.78	0.20	2.83	0.12	3.30	2.00	0.05	-0.07	
A23	DI	K5	MH	0.25		0.25	0.80	0.20		0.20	5.00	9.00	1.80		1.80	15	CL. IV	RCP	0.0059	5.09	0.013	4.96	4.04	0.36	3.68	0.03	3.26	2.00	0.01	-0.02	
K5	MH	K6	MH			13.98	0.80			11.18	5.00	9.00			100.66	48	CL. IV	RCP	0.0050	106.82	0.013	101.15	8.06	1.00	9.34	0.53	3.20	0.55	-1.35	-1.88	
K6	MH	A25	MH			13.98				11.18	5.00	9.00			100.66	48	CL. IV	RCP	0.0050	79.34	0.013	101.96	8.12	0.99	9.41	0.40	3.15	1.03	-1.88	-2.28	
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	9.00	3.31		3.31	18	CL. IV	RCP	0.0060	8.27	0.013	8.16	4.62	0.41	4.30	0.05	2.09	2.00	-1.41	-1.46	
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	9.00	14.76		14.76	24	CL. IV	RCP	0.0100	17.99	0.013	22.62	7.21	0.65	7.70	0.18	2.09	2.00	-1.91	-2.09	
A25	MH	A29	MH			16.49				13.19	5.00	9.00			118.73	54	CL. IV	RCP	0.0050	210.39	0.013	138.87	8.74	0.85	9.87	1.05	2.35	0.63	-2.78	-3.83	
A29	MH	PUMP 1				21.12				16.90	5.00	9.00			152.06	60	CL. IV	RCP	0.0052	32.65	0.013	187.86	9.58	0.81	10.72	0.17	3.45	2.78	-4.33	-4.50	
PUMP 1		OUTFALL				21.12	0.80			16.90	5.00	9.00			152.06	60	CL. IV	RCP	0.0049	303.75	0.013	182.96	9.33	0.83	10.53	1.50	5.00	4.50	-4.50	-6.00	
PUMP STATION 2																															
B1	DI	B2	MH	0.24		0.24	0.80	0.19		0.19	5.00	9.00	1.73		1.73	15	CL. IV	RCP	0.0050	32.65	0.013	4.57	3.72	0.38	3.42	0.16	5.00	2.00	1.75	1.59	
B2	MH	B3	MH			0.24				0.19	5.00	9.00			1.73	15	CL. IV	RCP	0.0051	54.75	0.013	4.59	3.74	0.38	3.44	0.28	5.02	2.18	1.59	1.31	
B4	DI	B3	MH	0.29		0.29	0.80	0.23		0.23	5.00	9.00	2.09		2.09	15	CL. IV	RCP	0.0050	35.03	0.013	4.57	3.72	0.46	3.61	0.18	5.06	2.00	1.81	1.63	
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	15	CL. IV	RCP	0.0050	22.17	0.013	4.57	3.72	0.24	2.94	0.11	5.00	2.00	1.75	1.64	
B3	MH	B8	MH			0.68				0.54	5.00	9.00			4.90	18	CL. IV	RCP	0.0050	87.28	0.013	7.46	4.22	0.66	4.51	0.44	4.80	2.24	1.06	0.62	
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	15	CL. IV	RCP	0.0050	20.68	0.013	4.57	3.72	0.24	2.94	0.10	4.90	2.00	1.65	1.55	
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	9.00	2.02		2.02	15	CL. IV	RCP	0.0050	16.43	0.013	4.57	3.72	0.44	3.57	0.08	4.96	2.00	1.71	1.63	
B8	MH	B9	MH			1.11				0.89	5.00	9.00			7.99	18	CL. IV	RCP	0.0075	128.38	0.013	9.08	5.14	0.88	5.86	0.96	4.75	2.63	0.62	-0.34	
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	9.00	0.65		0.65	15	CL. IV	RCP	0.0050	107.69	0.013	4.57	3.73	0.14	2.50	0.54	5.30	2.00	2.05	1.51	
B9	MH	B11	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	158.44	0.013	9.10	5.15	0.95	5.92	1.19	6.30	5.14	-0.34	-1.53	
B11	MH	B12	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	170.71	0.013	9.09	5.15	0.95	5.92	1.28	7.30	7.33	-1.53	-2.81	
B12	MH	B13	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	92.70	0.013	9.09	5.15	0.95	5.91	0.69	7.00	8.31	-2.81	-3.50	
B13	MH	B14	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	24.47	0.013	9.11	5.16	0.95	5.93	0.18	6.00	8.00	-3.50	-3.69	
B14	MH	B16	MH			1.20				0.96	5.00	9.00			8.64	18	CL. IV	RCP	0.0075	112.30	0.013	9.09	5.15	0.95	5.92	0.84	5.50	7.69	-3.69	-4.53	
B15	DI	B16	MH	1.16		1.16	0.80	0.93		0.93	5.00	9.00	8.35		8.35	18	CL. IV	RCP	0.0102	34.33	0.013	10.60	6.00	0.79	6.66	0.35	3.85	2.00	0.35	0.00	
B16	MH	PUMP 2				2.36				1.89	5.00	9.00			16.99	24	CL. IV	RCP	0.0100	6.27	0.013	22.67	7.22	0.75	7.94	0.06	4.00	7.03	-5.03	-5.09	
PUMP 2		OUTFALL				2.36	0.80			1.89	5.00	9.00			16.99	30	CL. IV	RCP	0.0187	48.62	0.013	56.00	11.42	0.30	9.81	0.91	6.00	8.59	-5.09	-6.00	

HGL COMPUTATIONS - ALTERNATE 2																									
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev.	D _o (3)	Q _o (4)	L _o (5)	S _{io} ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance	
	V _o (8)							H _o (9)	Q _i (10)	V _i (11)	Q _i V _i (12)	$\frac{V_i^2}{2g}$ (2g) (13)	H _i (13)	Angle (14)	H _Δ (15)	H _i (16)	1.3 H _i (17)	0.5 H _i (18)							
EX GRATE	6.00	15	1.51	84.07	0.0011	0.0212	0.09	5.36	0.11	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.11	0.14	0.06	0.17	6.17	2.57	-3.60	Unacceptable	*
DUKE ST BYPASS																									
D2	6.00	36	17.70	105.53	0.0010	0.0100	0.11	7.75	0.23	16.77	7.81	130.9	0.9464	0.33	0	0.00	0.56	0.73	0.28	0.39	6.39	4.58	-1.81	Unacceptable	*
D1	6.39	30	16.77	64.36	0.0019	0.0101	0.12	7.81	0.24	16.77	7.81	130.9	0.9464	0.33	0	0.00	0.57	0.74	0.28	0.41	6.80	8.00	1.20	Acceptable	
EX12	6.80	12	3.40	21.73	0.0069	0.0005	0.15	1.12	0.00	0.00	0.00	0.0	0.0000	0.00	60	0.00	0.00	0.01	0.00	0.15	6.95	6.00	-0.95	Unacceptable	*
EX13	6.80	15	13.37	18.10	0.0324	0.0271	0.59	9.96	0.38	13.37	9.96	133.1	1.5393	0.54	0	0.00	0.92	1.20	0.46	1.05	7.85	6.00	-1.85	Unacceptable	
PRINCE ST BYPASS																									
P5	6.00	42	27.94	150.00	0.0009	0.0050	0.13	6.87	0.18	27.94	6.86	191.6	0.7304	0.26	0	0.00	0.44	0.57	0.22	0.35	6.35	4.69	-1.66	Unacceptable	
P4	6.35	42	27.94	271.26	0.0009	0.0050	0.24	6.86	0.18	27.94	8.66	241.9	1.1647	0.41	0	0.00	0.59	0.77	0.30	0.54	6.89	5.99	-0.90	Unacceptable	
P3	6.89	42	27.94	185.68	0.0011	0.0100	0.21	8.66	0.29	1.87	3.10	5.8	0.1497	0.05	90	0.10	0.45	0.58	0.22	0.50	7.39	7.86	0.47	Unacceptable	
P2	7.39	24	1.87	15.00	0.0002	0.0050	0.00	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.04	0.05	0.02	0.03	7.42	7.56	0.14	Unacceptable	*
P1	7.39	24	0.72	31.43	0.0000	0.0050	0.00	2.35	0.02	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.02	0.03	0.01	0.02	7.41	7.76	0.35	Unacceptable	*
QUEEN ST BYPASS																									
Q2	6.00	42	43.20	229.15	0.0017	0.0050	0.38	7.78	0.23	38.88	13.76	535.0	2.9400	1.03	0	0.00	1.26	1.64	0.63	1.02	7.02	6.17	-0.85	Unacceptable	
EX11	7.02	30	36.07	80.13	0.0074	0.0261	0.60	13.76	0.74	33.26	13.76	457.7	2.9400	1.03	0	0.00	1.76	2.29	0.88	1.48	8.49	6.70	-1.79	Unacceptable	
EX8	7.02	18	2.81	52.21	0.0011	0.0130	0.06	5.36	0.11	2.81	4.06	11.4	0.2564	0.09	58	0.12	0.32	0.42	0.16	0.22	7.24	7.25	0.01	Unacceptable	
EX10	7.24	15	1.01	50.59	0.0006	0.0150	0.03	4.06	0.06	0.00	0.00	0.0	0.0000	0.00	58	0.00	0.06	0.08	0.03	0.07	7.31	6.54	-0.77	Unacceptable	*
EX9	7.24	12	1.80	6.91	0.0021	0.0043	0.01	3.29	0.04	0.00	0.00	0.0	0.0000	0.00	6	0.00	0.04	0.05	0.02	0.04	7.28	6.75	-0.53	Unacceptable	*
Q1	7.28	12	0.72	53.48	0.0007	0.0103	0.04	3.40	0.04	0.00	0.00	0.0	0.0000	0.00	138	0.00	0.04	0.06	0.02	0.07	7.35	5.90	-1.45	Unacceptable	*
PUMP 1																									
A29	-4.50	60	152.06	32.65	0.0027	0.0052	0.09	10.72	0.45	152.06	9.87	1500.4	1.5118	0.53	90	1.06	2.03	2.64	1.02	1.11	-3.39	3.45	6.84	Acceptable	
A25	-3.39	54	118.73	210.39	0.0029	0.0050	0.60	9.87	0.38	118.73	9.41	1117.4	1.3754	0.48	0	0.00	0.86	1.12	0.43	1.03	-2.36	2.35	4.71	Acceptable	
A27	-2.36	24	14.76	17.99	0.0037	0.0100	0.07	7.70	0.23	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.23	0.30	0.12	0.22	-2.15	1.63	3.78	Acceptable	*
A26	-2.36	18	3.31	8.27	0.0012	0.0060	0.01	4.30	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.09	0.04	0.06	-2.31	1.63	3.94	Acceptable	*
K6	-2.36	48	100.66	79.34	0.0037	0.0050	0.29	9.41	0.34	100.66	9.34	939.8	1.3536	0.47	0	0.00	0.82	1.06	0.41	0.70	-1.67	3.15	4.82	Acceptable	
K5	-1.67	48	100.66	106.82	0.0037	0.0050	0.39	9.34	0.34	100.66	9.38	943.7	1.3649	0.48	0	0.00	0.82	1.06	0.41	0.80	-0.87	3.20	4.07	Acceptable	
A23	-0.87	15	1.80	5.09	0.0009	0.0059	0.00	3.68	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	-0.83	2.80	3.63	Acceptable	*
A21	-0.87	15	0.94	23.33	0.0004	0.0051	0.01	2.83	0.03	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.03	0.04	0.02	0.03	-0.84	2.84	3.68	Acceptable	*
K4	-0.87	48	97.92	21.61	0.0035	0.0051	0.08	9.38	0.34	97.92	9.36	917.0	1.3617	0.48	0	0.00	0.82	1.06	0.41	0.48	-0.38	3.50	3.88	Acceptable	
A19	-0.38	15	2.81	22.76	0.0017	0.0053	0.04	4.01	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.08	-0.30	3.44	3.74	Acceptable	*
A18	-0.30	15	1.44	36.49	0.0007	0.0052	0.02	3.27	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.05	-0.25	3.26	3.51	Acceptable	*
A15	-0.38	15	3.17	35.24	0.0021	0.0054	0.07	4.13	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.09	0.03	0.12	-0.26	3.44	3.70	Acceptable	*
A14	-0.26	15	1.66	36.21	0.0008	0.0050	0.03	3.38	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.06	0.02	0.06	-0.21	3.22	3.43	Acceptable	*
K3	-0.38	48	91.94	23.22	0.0032	0.0052	0.07	9.36	0.34	91.94	11.23	1032.2	1.9571	0.68	0	0.00	1.03	1.33	0.51	0.59	0.20	3.70	3.50	Acceptable	
EX3	0.20	30	35.93	28.94	0.0065	0.0152	0.19	11.23	0.49	30.46	8.22	250.2	1.0482	0.37	30	0.29	1.15	1.49	0.57	0.76	0.97	3.52	2.55	Acceptable	
A17	0.97	15	1.66	9.29	0.0008	0.0054	0.01	3.44	0.05	0.00	0.00	0.0	0.0000	0.00	22	0.00	0.05	0.06	0.02	0.04	1.00	3.47	2.47	Acceptable	*
EX2	0.97	24	28.80	296.43	0.0123	0.0099	3.64	8.22	0.26	1.80	4.58	8.2	0.3251	0.11	72	0.21	0.59	0.77	0.30	4.02	4.99	9.00	4.01	Acceptable	
EX1	4.99	12	1.80	10.59	0.0026	0.0104	0.03	4.58	0.08	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.08	0.11	0.04	0.08	5.07	8.89	3.82	Acceptable	*
EX7	0.20	42	56.02	33.66	0.0025	0.0051	0.08	8.25	0.26	43.06	10.22	440.0	1.6219	0.57	28	0.26	1.09	1.42	0.55	0.79	1.00	3.50	2.50	Acceptable	
A13	1.00	15	1.94	4.62	0.0013	0.0108	0.01	4.60	0.08	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.08	0.11	0.04	0.06	1.06	3.51	2.45	Acceptable	*
EX6	1.00	30	41.11	67.14	0.0076	0.0113	0.51	10.22	0.41	37.66	11.00	414.3	1.8799	0.66	0	0.00	1.06	1.38	0.53	1.04	2.04	4.78	2.74	Acceptable	
EX5	2.04	30	37.66	215.87	0.0068	0.0141	1.48	11.00	0.47	1.44	4.30	6.2	0.2874	0.10	51	0.14	0.71	0.92	0.35	1.94	3.98	9.00	5.02	Acceptable	
EX4	3.98	12	1.44	26.91	0.0019	0.0104	0.05	4.30	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.04	0.10	4.07	9.43	5.36	Acceptable	*

A28	-3.39	36	33.34	104.21	0.0021	0.0050	0.22	7.24	0.20	33.34	11.61	387.0	2.0928	0.73	90	1.46	2.40	3.12	1.20	1.42	-1.97	3.28	5.25	Acceptable
A7	-1.97	18	5.33	19.85	0.0022	0.0050	0.04	4.60	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.11	0.04	0.10	-1.87	3.24	5.11	Acceptable
A6	-1.97	24	28.01	27.88	0.0118	0.0200	0.33	11.61	0.52	28.01	9.80	274.5	1.4910	0.52	90	1.04	2.09	2.72	1.04	1.37	-0.60	3.31	3.91	Acceptable
A9	-0.60	24	21.89	48.27	0.0076	0.0150	0.37	9.80	0.37	21.89	5.87	128.5	0.5353	0.19	90	0.37	0.93	1.22	0.47	0.83	0.24	3.10	2.86	Acceptable
A10	0.24	18	7.92	15.84	0.0044	0.0075	0.07	5.87	0.13	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.13	0.17	0.07	0.16	0.39	3.04	2.65	Acceptable
A11	0.24	24	13.97	36.82	0.0029	0.0050	0.11	5.79	0.13	13.97	5.78	80.7	0.5179	0.18	0	0.00	0.31	0.40	0.16	0.26	0.50	3.42	2.92	Acceptable
A12	0.50	24	13.97	29.16	0.0030	0.0050	0.09	5.78	0.13	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.13	0.17	0.06	0.17	0.67	2.99	2.32	Acceptable
A8	-0.60	15	1.58	15.99	0.0008	0.0050	0.01	3.31	0.04	0.00	0.00	0.0	0.0000	0.00	30	0.00	0.04	0.06	0.02	0.04	-0.56	3.16	3.72	Acceptable
A3	-0.60	18	4.54	177.80	0.0017	0.0050	0.30	4.40	0.08	4.54	3.57	16.2	0.1981	0.07	0	0.00	0.14	0.19	0.07	0.37	-0.22	6.07	6.29	Acceptable
A5	-0.22	15	2.02	43.53	0.0011	0.0050	0.05	3.57	0.05	1.66	3.39	5.6	0.1780	0.06	90	0.12	0.24	0.31	0.12	0.20	-0.02	5.24	5.26	Acceptable
A4	-0.02	15	1.66	23.16	0.0008	0.0050	0.02	3.39	0.04	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.04	0.06	0.02	0.05	0.02	5.74	5.72	Acceptable
A2	-0.22	15	1.15	33.41	0.0005	0.0050	0.02	3.01	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.04	-0.18	5.39	5.57	Acceptable
A1	-0.22	15	1.37	24.14	0.0006	0.0050	0.01	3.16	0.04	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.04	0.05	0.02	0.04	-0.18	5.83	6.01	Acceptable
PUMP 2																								
B16	-6.50	24	16.99	6.27	0.0047	0.0100	0.03	7.94	0.24	16.99	6.66	113.2	0.6887	0.24	0	0.00	0.49	0.63	0.24	0.27	-6.23	4.00	10.23	Acceptable
B15	-6.23	18	8.35	34.33	0.0051	0.0102	0.18	6.66	0.17	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.17	0.22	0.09	0.29	-5.94	3.39	9.33	Acceptable
B14	-5.94	18	8.64	112.30	0.0051	0.0075	0.58	5.92	0.14	8.64	5.93	51.2	0.5452	0.19	45	0.21	0.53	0.69	0.27	0.84	-5.10	5.50	10.60	Acceptable
B13	-5.10	18	8.64	24.47	0.0051	0.0075	0.13	5.93	0.14	8.64	5.91	51.1	0.5428	0.19	53	0.26	0.58	0.76	0.29	0.42	-4.68	6.00	10.68	Acceptable
B12	-4.68	18	8.64	92.70	0.0051	0.0075	0.47	5.91	0.14	8.64	5.92	51.1	0.5437	0.19	38	0.15	0.48	0.62	0.24	0.71	-3.97	7.00	10.97	Acceptable
B11	-3.97	18	8.64	170.71	0.0051	0.0075	0.87	5.92	0.14	8.64	5.92	51.2	0.5446	0.19	90	0.38	0.71	0.92	0.35	1.23	-2.74	7.30	10.04	Acceptable
B9	-2.74	18	8.64	158.44	0.0051	0.0075	0.81	5.92	0.14	8.64	5.86	50.6	0.5328	0.19	0	0.00	0.32	0.42	0.16	0.97	-1.77	6.30	8.07	Acceptable
B10	-1.77	15	0.65	107.69	0.0002	0.0050	0.02	2.50	0.02	7.99	5.86	46.8	0.5328	0.19	90	0.37	0.58	0.76	0.29	0.32	-1.45	4.84	6.29	Acceptable
B8	-1.45	18	7.99	128.38	0.0045	0.0075	0.57	5.86	0.13	7.99	4.51	36.1	0.3164	0.11	0	0.00	0.24	0.32	0.12	0.69	-0.76	4.75	5.51	Acceptable
B7	-0.76	15	2.02	16.43	0.0011	0.0050	0.02	3.57	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.05	-0.71	4.50	5.21	Acceptable
B6	-0.71	15	1.08	20.68	0.0004	0.0050	0.01	2.94	0.03	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.03	0.04	0.02	0.03	-0.68	4.44	5.12	Acceptable
B3	-0.68	18	4.90	87.28	0.0019	0.0050	0.17	4.51	0.08	4.90	3.44	16.9	0.1840	0.06	0	0.00	0.14	0.19	0.07	0.24	-0.44	4.80	5.24	Acceptable
B5	-0.44	15	1.08	22.17	0.0004	0.0050	0.01	2.94	0.03	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.03	0.04	0.02	0.03	-0.41	4.54	4.95	Acceptable
B4	-0.41	15	2.09	35.03	0.0011	0.0050	0.04	3.61	0.05	0.00	0.00	0.0	0.0000	0.00	62	0.00	0.05	0.07	0.03	0.07	-0.34	4.60	4.94	Acceptable
B2	-0.34	15	1.73	54.75	0.0008	0.0051	0.05	3.44	0.05	1.73	3.42	5.9	0.1820	0.06	0	0.00	0.11	0.14	0.05	0.10	-0.23	5.02	5.25	Acceptable
B1	-0.23	15	1.73	32.65	0.0008	0.0050	0.03	3.42	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.06	-0.18	4.54	4.72	Acceptable

*Lesser of the Rim Elevation or the Rim Elevation minus 0.46' (Throat Elevation)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 9" (0.75') from the throat of the inlet.

STORM SEWER COST ESTIMATE - ALTERNATIVE 2

Item	Quantity	Unit	Unit Price	Total	
15" RCP CI IV	602.66	LF	\$ 59.53	\$ 35,876.35	
18" RCP CI IV	1030.37	LF	\$ 73.14	\$ 75,361.26	
24" RCP CI IV	212.82	LF	\$ 105.62	\$ 22,478.05	
30" RCP CI IV	203	LF	\$ 129.95	\$ 26,377.25	
36" RCP CI IV	209.74	LF	\$ 180.45	\$ 37,847.58	
42" RCP CI IV	683	LF	\$ 227.72	\$ 155,441.67	
48" RCP CI IV	230.99	LF	\$ 259.24	\$ 59,881.85	
54" RCP CI IV	210.39	LF	\$ 312.08	\$ 65,658.51	
60" RCP CI IV	336.4	LF	\$ 366.83	\$ 123,401.61	
Manhole	25	EA	\$ 4,611.50	\$ 115,287.50	(MH-2 with watertight frame and cover)
Inlet	28	EA	\$ 6,000.00	\$ 168,000.00	(DI-3B, 8' throat is \$5,984.01)
Outfall Valve 24"	0	EA	\$ 5,086.00	\$ -	
Outfall Valve 30"	1	EA	\$ 9,449.00	\$ 9,449.00	
Outfall Valve 36"	1	EA	\$ 9,449.00	\$ 9,449.00	
Outfall Valve 42"	2	EA	\$ 14,088.00	\$ 28,176.00	
Outfall Valve 48"	0	EA	\$ 21,859.00	\$ -	
Outfall Valve 60"	1	EA	\$ 43,782.00	\$ 43,782.00	
TOTAL \$				976,467.64	

Tideflex valve unit prices from sales rep

All other prices from Fairfax County 2017 Unit Price Schedule

10-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3																															
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT	
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN			FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
CAMERON ST BYPASS																															
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	9.00		4.75	4.75	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	2.69	0.45	5.77	2.38	7.15	8.22	-2.57	-4.95	outfall unknown
DUKE ST																															
EX GRATE	MH	EX OUTFALL		0.21		0.21	0.80	0.17		0.17	5.00	9.00	1.51		1.51	15	CL. IV	RCP	0.0212	84.07	0.013	9.40	1.23	0.16	5.36	1.78	2.57	1.20	0.12	-1.66	
DUKE ST BYPASS																															
EX13	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	9.00		16.20	16.20	24	CL. IV	RCP	0.0100	187.55	0.013	22.64	5.16	0.72	7.86	1.88	8.44	4.99	1.45	-0.43	
PUMP STATION 1																															
EX12	EX DI	D2	MH	0.54		0.54	0.80	0.43		0.43	5.00	9.00	3.89		3.89	21	CL. IV	RCP	0.0050	27.89	0.013	11.22	1.62	0.35	4.15	0.14	6.46	3.55	1.16	1.02	
D1	GRATE	D2	MH	0.19	0.35	0.54	0.80	0.15	0.28	0.43	5.00	9.00	1.37	2.52	3.89	21	CL. IV	RCP	0.0050	66.51	0.013	11.16	1.62	0.35	4.13	0.33	4.80	1.72	1.33	1.00	
D2	MH	D3	MH			1.08				0.86	5.00	9.00			7.78	24	CL. IV	RCP	0.0050	33.82	0.013	16.03	2.48	0.48	5.05	0.17	7.00	4.00	1.00	0.83	
D3	MH	D4	MH			1.08				0.86	5.00	9.00			7.78	24	CL. IV	RCP	0.0050	161.07	0.013	16.04	2.48	0.48	5.05	0.81	6.77	3.94	0.83	0.02	
D4	MH	D5	MH			1.08				0.86	5.00	9.00			7.78	24	CL. IV	RCP	0.0049	28.44	0.013	15.87	2.48	0.49	5.00	0.14	5.40	3.38	0.02	-0.12	
D5	MH	D6	MH			1.08				0.86	5.00	9.00			7.78	24	CL. IV	RCP	0.0050	191.66	0.013	16.00	2.48	0.49	5.04	0.96	5.70	3.82	-0.12	-1.08	
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	24	CL. IV	RCP	0.0050	31.43	0.013	16.03	0.23	0.04	2.35	0.16	8.22	1.47	4.75	4.59	
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	9.00	1.15		1.87	24	CL. IV	RCP	0.0050	15.00	0.013	15.99	0.60	0.12	3.10	0.08	8.02	1.27	4.75	4.68	
P3	MH	P4	MH		1.45	1.71	0.80		1.16	1.37	5.00	9.00		10.44	12.31	36	CL. IV	RCP	0.0050	185.68	0.013	47.19	1.74	0.26	5.47	0.93	7.86	4.78	0.08	-0.85	
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	9.00	1.37		1.37	15	CL. IV	RCP	0.0154	24.14	0.013	8.00	1.11	0.17	4.63	0.37	6.29	1.75	3.29	2.92	
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	9.00	1.15		1.15	15	CL. IV	RCP	0.0050	33.41	0.013	4.57	0.94	0.25	3.01	0.17	5.85	2.00	2.60	2.43	
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	15	CL. IV	RCP	0.0050	23.16	0.013	4.57	1.35	0.36	3.39	0.12	6.20	2.00	2.95	2.83	
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	9.00	0.36		2.02	18	CL. IV	RCP	0.0049	43.53	0.013	7.35	1.14	0.27	3.45	0.21	5.70	1.37	2.83	2.62	
A3	MH	P4	MH			0.63				0.50	5.00	9.00			4.54	18	CL. IV	RCP	0.0051	15.73	0.013	7.49	2.57	0.61	4.45	0.08	6.07	1.95	2.62	2.54	
P4	MH	A6	MH		1.26	2.97	0.80		1.01	2.38	5.00	9.00		9.07	25.92	36	CL. IV	RCP	0.0050	152.77	0.013	47.03	3.67	0.55	6.85	0.76	5.99	3.84	-0.85	-1.61	
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	9.00	1.58		1.58	15	CL. IV	RCP	0.0044	18.30	0.013	4.27	1.29	0.37	3.20	0.08	3.62	2.00	0.37	0.29	
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	9.00	13.97		13.97	24	CL. IV	RCP	0.0050	29.16	0.013	16.06	4.45	0.87	5.78	0.15	3.45	2.00	-0.55	-0.70	
A11	MH	D6	DI			1.94				1.55	5.00	9.00			13.97	24	CL. IV	RCP	0.0054	11.12	0.013	16.61	4.45	0.84	5.97	0.06	3.42	2.12	-0.70	-0.76	
D6	MH	A9	MH			3.02				2.42	5.00	9.00			21.74	24	CL. IV	RCP	0.0101	25.70	0.013	22.75	6.92	0.96	8.33	0.26	4.42	4.25	-1.83	-2.09	
A10	DI	A9	MH	0.05	1.06	1.11	0.80	0.04	0.85	0.89	5.00	9.00	0.36	7.63	7.99	18	CL. IV	RCP	0.0095	15.84	0.013	10.22	4.52	0.78	6.42	0.15	3.50	3.45	-1.45	-1.60	
A9	MH	A6	MH			4.13				3.30	5.00	9.00			29.74	36	CL. IV	RCP	0.0155	48.27	0.013	83.11	4.21	0.36	10.58	0.75	3.12	2.21	-2.09	-2.84	
A6	MH	A28	MH			7.95				6.36	5.00	9.00			57.24	42	CL. IV	RCP	0.0100	27.88	0.013	100.79	5.95	0.57	10.79	0.28	3.31	3.51	-3.70	-3.98	
A7	DI	A28	MH	0.17		0.17	0.80	0.14		0.14	5.00	9.00	1.22		1.22	18	CL. IV	RCP	0.0101	19.85	0.013	10.54	0.69	0.12	3.64	0.20	3.70	2.00	0.20	0.00	
A28	MH	A29	MH		0.57	8.69	0.80		0.46	6.95	5.00	9.00		4.10	62.57	42	CL. IV	RCP	0.0061	85.88	0.013	78.26	6.50	0.80	9.03	0.52	3.28	3.76	-3.98	-4.50	
EX4	EX Inlet	EX5	EX MH	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	12	CL. IV	RCP	0.0104	26.91	0.013	3.63	2.11	0.46	4.49	0.28	9.89	3.79	5.10	4.82	
EX5	EX MH	EX6	EX MH		5.91	6.14	0.80		4.73	4.91	5.00	9.00		42.55	44.21	30	CL. IV	RCP	0.0141	215.87	0.013	48.66	9.01	0.91	11.40	3.04	9.00	2.57	3.93	0.89	
EX6	EX MH	EX7	EX MH		0.52	6.66	0.80		0.42	5.33	5.00	9.00		3.74	47.95	36	CL. IV	RCP	0.0113	67.14	0.013	70.94	6.78	0.68	10.74	0.76	4.78	0.96	0.82	0.06	
A13	DI	EX7	DI	0.27		0.27	0.80	0.22		0.22	5.00	9.00	1.94		1.94	18	CL. IV	RCP	0.0108	4.62	0.013	10.92	1.10	0.18	4.39	0.05	3.97	1.77	0.70	0.65	
EX7	EX MH	K3	MH		2.00	8.93	0.80		1.60	7.14	5.00	9.00		14.40	64.30	42	CL. IV	RCP	0.0051	33.66	0.013	71.48	6.68	0.90	8.47	0.17	3.50	0.45	-0.45	-0.62	
EX1	EX MH	EX2	EX MH		0.27	0.27	0.80		0.22	0.22	5.00	9.00		1.94	1.94	12	CL. IV	RCP	0.0104	10.59	0.013	3.63	2.48	0.54	4.67	0.11	9.35	3.60	4.75	4.64	
EX2	EX MH	EX3	EX MH		4.09	4.36	0.80		3.27	3.49	5.00	9.00		29.45	31.39	30	CL. IV	RCP	0.0099	296.43	0.013	40.70	6.40	0.77	9.20	2.92	9.00	3.69	2.81	-0.11	
A17	DI	EX3	DI	0.27		0.27	0.80	0.22		0.22	5.00	9.00	1.94		1.94	18	CL. IV	RCP	0.0054	9.29	0.013	7.70	1.10	0.25	3.53	0.05	3.93	1.63	0.80	0.75	
EX3	EX MH	K3	MH		1.57	6.20	0.80		1.26	4.96	5.00	9.00		11.30	44.64	42	CL. IV	RCP	0.0152	28.94	0.013	124.01	4.64	0.36	11.60	0.44	3.52	0.52	-0.50	-0.94	
K3	MH	K4	MH			15.13	0.80			12.10	5.00	9.00			108.94	54	CL. IV	RCP	0.0052	23.22	0.013	141.32	6.85	0.77	9.86	0.12	3.70	0.32	-1.1		

A15	DI	K4	MH	0.21		0.44	0.80	0.17		0.35	5.00	9.00	1.51		3.17	18	CL. IV	RCP	0.0054	35.24	0.013	7.71	1.79	0.41	4.10	0.19	3.90	2.44	-0.04	-0.23		
A18	DI	A19	DI	0.20		0.20	0.80	0.16		0.16	5.00	9.00	1.44		1.44	18	CL. IV	RCP	0.0052	36.49	0.013	7.58	0.81	0.19	3.17	0.19	3.72	1.65	0.57	0.38		
A19	DI	K4	MH	0.19		0.39	0.80	0.15		0.31	5.00	9.00	1.37		2.81	18	CL. IV	RCP	0.0053	22.76	0.013	7.62	1.59	0.37	3.93	0.12	3.90	2.02	0.38	0.26		
K4	DI	K5	MH			16.0	0.80			12.77	5.00	9.00			114.91	54	CL. IV	RCP	0.0051	21.61	0.013	140.25	7.23	0.82	9.88	0.11	3.50	0.24	-1.24	-1.35		
A21	DI	K5	MH	0.13		0.13	0.80	0.10		0.10	5.00	9.00	0.94		0.94	18	CL. IV	RCP	0.0051	23.33	0.013	7.53	0.53	0.12	2.68	0.12	3.30	1.75	0.05	-0.07		
A23	DI	K5	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	9.00	0.65	1.15	1.80	18	CL. IV	RCP	0.0059	5.09	0.013	8.06	1.02	0.22	3.51	0.03	3.26	1.75	0.01	-0.02		
K5	MH	K6	MH			16.34				13.07	5.00	9.00			117.65	54	CL. IV	RCP	0.0050	106.82	0.013	138.47	7.40	0.85	9.84	0.53	3.20	0.05	-1.35	-1.88		
K6	MH	A25	MH			16.34				13.07	5.00	9.00			117.65	54	CL. IV	RCP	0.0050	79.34	0.013	139.58	7.40	0.84	9.92	0.40	3.15	0.53	-1.88	-2.28		
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	9.00	3.31		3.31	18	CL. IV	RCP	0.0060	8.27	0.013	8.16	1.87	0.41	4.30	0.05	2.09	2.00	-1.41	-1.46		
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	9.00	14.76		14.76	24	CL. IV	RCP	0.0100	17.99	0.013	22.62	4.70	0.65	7.70	0.18	2.09	2.00	-1.91	-2.09		
A25	MH	A29	MH			18.85				15.08	5.00	9.00			135.72	54	CL. IV	RCP	0.0050	210.39	0.013	138.87	8.53	0.98	10.13	1.05	2.35	0.63	-2.78	-3.83		
A29	MH	PUMP 1				27.54				22.03	5.00	9.00			198.29	60	CL. IV	RCP	0.0061	32.65	0.013	203.77	10.10	0.97	12.04	0.20	3.45	4.25	-5.80	-6.00		
PUMP 1		OUTFALL				27.54	0.80			22.03	5.00	9.00			198.29	60	CL. IV	RCP	0.0065	271.27	0.013	209.11	10.10	0.95	12.25	1.75	5.00	4.25	-4.25	-6.00		
PUMP STATION 2																																
EX C6		EX C5		0.30		0.30	0.80	0.24		0.24	5.00	9.00	2.16		2.16	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	6.19	1.03	6.89	0.89	12.46	4.01	7.78	6.89		
EX C5		EX C4				0.30	0.80			0.24	5.00	9.00			2.16	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	2.75	0.25	8.80	1.34	11.29	4.30	5.99	4.65		
EX C4	MH	EX C3	MH		5.85	6.15	0.80		4.68	4.92	5.00	9.00		42.12	44.28	30	CL. IV	RCP	0.0122	281.77	0.013	45.37	9.02	0.98	10.72	3.45	10.85	3.90	4.45	1.00		
EX C3	MH	B2A	MH		0.93	7.08	0.80		0.74	5.66	5.00	9.00		6.70	50.98	30	CL. IV	RCP	0.0204	19.15	0.013	58.51	10.38	0.87	13.59	0.39	5.10	2.07	0.53	0.14		
B1	DI	B2	MH	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	18	CL. IV	RCP	0.0049	32.65	0.013	7.35	0.94	0.23	3.20	0.16	5.00	2.24	1.26	1.10		
B2	MH	B2A	MH			0.23	0.80			0.18	5.00	9.00			1.66	18	CL. IV	RCP	0.0048	12.42	0.013	7.30	0.94	0.23	3.18	0.06	5.02	2.42	1.10	1.04		
B2A	MH	B3	MH			7.31	0.80			5.85	5.00	9.00			52.63	48	CL. IV	RCP	0.0051	42.94	0.013	102.78	4.19	0.51	8.26	0.22	5.00	0.86	0.14	-0.08		
B4	DI	B3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	9.00	2.09	1.80	3.89	18	CL. IV	RCP	0.0095	36.88	0.013	10.23	2.20	0.38	5.38	0.35	5.06	2.25	1.31	0.96		
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	18	CL. IV	RCP	0.0104	22.17	0.013	10.70	0.61	0.10	3.63	0.23	5.00	2.25	1.25	1.02		
B3	MH	B8	MH			8.00	0.80			6.40	5.00	9.00			57.60	48	CL. IV	RCP	0.0060	86.54	0.013	111.31	4.58	0.52	8.95	0.52	4.80	0.88	-0.08	-0.60		
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	18	CL. IV	RCP	0.0103	20.46	0.013	10.64	0.61	0.10	3.61	0.21	4.90	2.25	1.15	0.94		
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	9.00	2.02		2.02	18	CL. IV	RCP	0.0103	16.43	0.013	10.68	1.14	0.19	4.41	0.17	4.96	2.25	1.21	1.04		
B8	MH	B9	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	9.00		15.98	76.68	48	CL. IV	RCP	0.0075	128.38	0.013	124.17	6.10	0.62	10.38	0.96	4.75	1.35	-0.60	-1.56		
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	9.00	0.65		0.65	18	CL. IV	RCP	0.0102	18.66	0.013	10.60	0.37	0.06	3.06	0.19	5.30	4.37	-0.57	-0.76		
B9	MH	B11	MH			10.74	0.80			8.59	5.00	9.00			77.33	48	CL. IV	RCP	0.0075	158.44	0.013	124.44	6.15	0.62	10.50	1.19	5.33	2.89	-1.56	-2.75		
EX11	DI	B11	MH		3.86	3.86	0.80		3.09	3.09	5.00	9.00		27.79	27.79	30	CL. IV	RCP	0.0103	28.16	0.013	41.61	5.66	0.67	9.07	0.29	7.16	4.20	0.46	0.17		
B11	DI	Q1	MH			14.60	0.80			11.68	5.00	9.00			105.12	48	CL. IV	RCP	0.0051	17.53	0.013	102.89	8.37	1.02	9.42	0.09	7.00	6.15	-3.15	-3.24		
Q1	DI	Q2	MH	0.10		14.70	0.80	0.08		11.76	5.00	9.00	0.72		105.84	48	CL. IV	RCP	0.0051	45.00	0.013	102.66	8.42	1.03	9.39	0.23	6.82	6.06	-3.24	-3.47		
EX9	EX DI	EX8	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	9.00	1.22		1.22	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	1.56	0.52	3.02	0.03	7.21	2.25	3.96	3.99		
EX10	EX DI	EX8	MH	0.17		0.17	0.80	0.14		0.14	5.00	9.00	1.22		1.22	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	1.00	0.15	4.39	0.76	7.00	4.09	1.66	0.90		
EX8	EX DI	Q2	MH		1.53	1.87	0.80		1.22	1.50	5.00	9.00		11.02	13.46	18	CL. IV	RCP	0.0101	68.55	0.013	10.54	7.62	1.28	6.86	0.69	7.25	5.80	-0.05	-0.74		
Q2	MH	B12	MH		0.60	17.17	0.80		0.48	13.74	5.00	9.00		4.32	123.62	48	CL. IV	RCP	0.0080	109.46	0.013	128.75	9.84	0.96	11.88	0.88	6.40	5.87	-3.47	-4.35		
B12	MH	B13	MH			17.17	0.80			13.74	5.00	9.00			123.62	48	CL. IV	RCP	0.0081	92.70	0.013	129.16	9.84	0.96	11.82	0.75	4.50	4.85	-4.35	-5.10		
B13	MH	B14	MH			17.17	0.80			13.74	5.00	9.00			123.62	48	CL. IV	RCP	0.0082	24.47	0.013	129.82	9.84	0.95	11.88	0.20	6.00	7.10	-5.10	-5.30		
B14	MH	B16	MH			17.17	0.80			13.74	5.00	9.00			123.62	48	CL. IV	RCP	0.0100	112.30	0.013	143.40	9.84	0.86	12.89	1.12	5.50	6.80	-5.30	-6.42		
B15	DI	B16	MH	0.52	0.71	1.23	0.80	0.42	0.57	0.98	5.00	9.00	3.74	5.11	8.86	18	CL. IV	RCP	0.0102	34.33	0.013	10.60	5.01	0.84	6.78	0.35	4.50	3.00	0.00	-0.35		
B16	MH	PUMP 2				18.40	0.80			14.72	5.00	9.00			132.48	48	CL. IV	RCP	0.0187	4.28	0.013	196.32	10.54	0.67	16.72	0.08	6.00	9.92	-7.92	-8.00		
PUMP 2		OUTFALL				18.40	0.80			14.72	5.00	9.00			132.48	60	CL. IV	RCP	0.0103	48.62	0.013	264.02	6.75	0.50	13.45	0.50	6.00	7.50	-6.50	-7.00		

10-YEAR HGL COMPUTATIONS - ALTERNATE 3																									
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev. (2)	D _o (3)	Q _o (4)	L _o (5)	S _{fo} ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim (22)	Clearance (23)	Remarks
								V _o (8)	H _o (9)	Q _i (10)	V _i (11)	Q _i /V _i (12)	$\frac{V_i^2}{(2g)}$ (2g) (13)	H _i (13)	Angle (14)	H _Δ (15)	H _t (16)	1.3 H _t (17)	0.5 H _t (18)						
CAMERON ST																									
EX C1	6.00	18	4.75	237.53	0.0022	0.0100	0.52	5.77	0.13	4.75	5.77	27.4	0.5169	0.18	0	0.00	0.31	0.40	0.16	0.67	6.67	7.15	0.48	Acceptable	Outfall unknown; Starting HGL at 10-yr WSE of River
DUKE ST																									
EX GRATE	6.00	15	1.51	84.07	0.0011	0.0212	0.09	5.36	0.11	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.11	0.14	0.06	0.17	6.17	2.57	-3.60	Unacceptable	To be removed or upgraded during improvements to Point Lumley Park; Starting HGL at 10-yr WSE of River
DUKE ST BYPASS																									
EX13	6.00	24	16.20	187.55	0.0043	0.0100	0.81	7.86	0.24	16.20	7.86	127.3	0.9582	0.34	0	0.00	0.57	0.75	0.29	1.10	7.10	8.44	1.34	Acceptable	Starting HGL at 10-yr WSE of River
PUMP 1																									
A29	-2.00	60	198.29	32.65	0.0061	0.0061	0.20	10.10	0.40	198.29	10.13	2008.5	1.5931	0.56	90	1.12	2.07	2.69	1.03	1.23	-0.77	3.45	4.22	Acceptable	Starting HGL assumed at normal depth of the pipe
A25	-0.77	54	135.72	210.39	0.0035	0.0050	0.75	10.13	0.40	135.72	9.92	1346.0	1.5272	0.53	0	0.00	0.93	1.21	0.47	1.21	0.45	2.35	1.90	Acceptable	
A27	0.45	24	14.76	17.99	0.0100	0.0100	0.18	4.70	0.09	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.09	0.11	0.04	0.24	0.68	1.67	0.99	Acceptable	*
A26	0.45	18	3.31	8.27	0.0060	0.0060	0.05	1.87	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.06	0.51	1.67	1.16	Acceptable	*
K6	0.45	54	117.65	79.34	0.0028	0.0050	0.22	9.92	0.38	117.65	9.84	1157.4	1.5029	0.53	0	0.00	0.91	1.18	0.45	0.68	1.12	3.15	2.03	Acceptable	
K5	1.12	54	117.65	106.82	0.0028	0.0050	0.30	9.84	0.38	117.65	9.88	1162.0	1.5147	0.53	0	0.00	0.91	1.18	0.45	0.75	1.88	3.20	1.32	Acceptable	
A23	1.88	18	1.80	5.09	0.0059	0.0059	0.03	1.02	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.01	0.00	0.03	1.91	2.84	0.93	Acceptable	*
A21	1.88	18	0.94	23.33	0.0051	0.0051	0.12	0.53	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.12	2.00	2.88	0.88	Acceptable	*
K4	1.88	54	114.91	21.61	0.0027	0.0051	0.06	9.88	0.38	114.91	6.85	787.1	0.7285	0.25	0	0.00	0.63	0.82	0.32	0.38	2.25	3.50	1.25	Acceptable	
A19	2.25	18	2.81	22.76	0.0053	0.0053	0.12	1.59	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.13	2.38	3.48	1.10	Acceptable	*
A18	2.38	18	1.44	36.49	0.0052	0.0052	0.19	0.81	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.19	2.57	3.30	0.73	Acceptable	*
A15	2.25	18	3.17	35.24	0.0054	0.0054	0.19	1.79	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.20	2.45	3.48	1.03	Acceptable	*
A14	2.45	18	1.66	36.21	0.0050	0.0050	0.18	0.94	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.18	2.63	3.26	0.63	Acceptable	*
K3	2.25	54	108.94	23.22	0.0052	0.0052	0.12	6.85	0.18	108.94	4.64	505.4	0.3343	0.12	0	0.00	0.30	0.39	0.15	0.27	2.52	3.70	1.18	Acceptable	
EX3	2.52	42	44.64	28.94	0.0152	0.0152	0.44	4.64	0.08	33.34	6.40	213.2	0.6351	0.22	30	0.18	0.48	0.63	0.24	0.75	3.28	3.52	0.24	Acceptable	
A17	3.28	18	1.94	9.29	0.0054	0.0054	0.05	1.10	0.00	0.00	0.00	0.0	0.0000	0.00	22	0.00	0.00	0.01	0.00	0.05	3.33	3.51	0.18	Acceptable	*
EX2	3.28	30	31.39	296.43	0.0099	0.0099	2.92	6.40	0.16	1.94	2.48	4.8	0.0951	0.03	72	0.06	0.25	0.33	0.13	3.09	6.36	9.00	2.64	Acceptable	
EX1	6.36	12	1.94	10.59	0.0104	0.0104	0.11	2.48	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.03	0.01	0.13	6.49	8.93	2.44	Acceptable	*
EX7	2.52	42	64.30	33.66	0.0051	0.0051	0.17	6.68	0.17	49.90	6.78	338.5	0.7146	0.25	28	0.11	0.54	0.70	0.27	0.52	3.04	3.50	0.46	Acceptable	
A13	3.04	18	1.94	4.62	0.0108	0.0108	0.05	1.10	0.00	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.00	0.01	0.00	0.05	3.09	3.55	0.46	Acceptable	*
EX6	3.04	36	47.95	67.14	0.0113	0.0113	0.76	6.78	0.18	44.21	9.01	398.1	1.2594	0.44	0	0.00	0.62	0.81	0.31	1.07	4.11	4.78	0.67	Acceptable	
EX5	4.11	30	44.21	215.87	0.0141	0.0141	3.04	9.01	0.31	1.66	4.49	7.4	0.3126	0.11	51	0.15	0.57	0.74	0.29	3.41	7.52	9.00	1.48	Acceptable	
EX4	7.52	12	1.66	26.91	0.0023	0.0104	0.06	4.49	0.08	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.08	0.10	0.04	0.11	7.64	9.47	1.83	Acceptable	*
A28	-0.77	42	62.57	85.88	0.0031	0.0061	0.27	9.03	0.32	58.46	5.95	347.8	0.5496	0.19	90	0.38	0.89	1.16	0.45	0.72	-0.05	3.28	3.33	Acceptable	
A7	-0.05	18	1.22	19.85	0.0004	0.0101	0.01	3.64	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	-0.01	3.28	3.29	Acceptable	*
A6	-0.05	42	57.24	27.88	0.0100	0.0100	0.28	5.95	0.14	35.86	4.21	150.8	0.2748	0.10	90	0.19	0.43	0.55	0.21	0.56	0.51	3.31	2.80	Acceptable	
A9	0.51	36	29.74	48.27	0.0155	0.0155	0.75	4.21	0.07	29.74	6.92	205.8	0.7439	0.26	90	0.52	0.85	1.10	0.42	1.18	1.68	3.12	1.44	Acceptable	
A10	1.68	18	7.99	15.84	0.0095	0.0095	0.15	4.52	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.10	0.04	0.20	1.88	3.08	1.20	Acceptable	*
D6	1.68	24	21.74	25.70	0.0101	0.0101	0.26	6.92	0.19	21.74	4.45	96.7	0.3070	0.11	90	0.21	0.51	0.66	0.25	0.51	2.20	4.42	2.22	Acceptable	
A11	2.20	24	13.97	11.12	0.0054	0.0054	0.06	4.45	0.08	13.97	4.45	62.1	0.3070	0.11	0	0.00	0.18	0.24	0.09	0.15	2.35	3.42	1.07	Acceptable	
A12	2.35	24	13.97	29.16	0.0050	0.0050	0.15	4.45	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.10	0.04	0.20	2.55	3.03	0.48	Acceptable	*
A8	0.51	15	1.58	18.30	0.0044	0.0044	0.08	1.29	0.01	0.00	0.00	0.0	0.0000	0.00	30	0.00	0.01	0.01	0.00	0.08	0.59	3.20	2.61	Acceptable	*

P4	0.51	36	25.92	152.77	0.0050	0.0050	0.76	3.67	0.05	12.31	1.74	21.4	0.0471	0.02	0	0.00	0.07	0.09	0.03	0.80	1.31	5.99	4.68	Acceptable	
A3	1.31	18	4.54	15.73	0.0017	0.0051	0.03	4.45	0.08	4.54	3.45	15.7	0.1852	0.06	0	0.00	0.14	0.18	0.07	0.10	1.41	6.07	4.66	Acceptable	
A5	1.41	18	2.02	43.53	0.0005	0.0049	0.02	3.45	0.05	1.66	3.39	5.6	0.1780	0.06	90	0.12	0.23	0.30	0.12	0.17	1.59	5.28	3.69	Acceptable	*
A4	1.59	15	1.66	23.16	0.0008	0.0050	0.02	3.39	0.04	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.04	0.06	0.02	0.05	1.63	5.78	4.15	Acceptable	*
A2	1.41	15	1.15	33.41	0.0005	0.0050	0.02	3.01	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.04	1.45	5.43	3.98	Acceptable	*
A1	1.41	15	1.37	24.14	0.0009	0.0154	0.02	4.63	0.08	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.08	0.11	0.04	0.08	1.49	5.87	4.38	Acceptable	*
P3	1.31	36	12.31	185.68	0.0050	0.0050	0.93	1.74	0.01	1.87	3.10	5.8	0.1497	0.05	90	0.10	0.17	0.22	0.08	1.04	2.35	7.86	5.51	Acceptable	
P2	2.35	24	1.87	15.00	0.0002	0.0050	0.00	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.04	0.05	0.02	0.03	2.38	7.60	5.22	Acceptable	*
P1	2.35	24	0.72	31.43	0.0000	0.0050	0.00	2.35	0.02	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.02	0.03	0.01	0.02	2.37	7.80	5.43	Acceptable	*
D5	2.20	24	7.78	191.66	0.0050	0.0050	0.96	2.48	0.02	7.78	2.48	19.2	0.0951	0.03	90	0.07	0.12	0.16	0.06	1.02	3.22	5.70	2.48	Acceptable	
D4	3.22	24	7.78	28.44	0.0049	0.0049	0.14	2.48	0.02	7.78	2.48	19.2	0.0951	0.03	25	0.02	0.07	0.09	0.04	0.18	3.40	5.40	2.00	Acceptable	
D3	3.40	24	7.78	161.07	0.0050	0.0050	0.81	2.48	0.02	7.78	2.48	19.2	0.0951	0.03	22	0.02	0.07	0.09	0.04	0.85	4.24	6.77	2.53	Acceptable	
D2	4.24	24	7.78	33.82	0.0050	0.0050	0.17	2.48	0.02	3.89	1.62	6.3	0.0406	0.01	45	0.02	0.05	0.07	0.03	0.20	4.45	7.00	2.55	Acceptable	
D1	4.45	21	3.89	66.51	0.0050	0.0050	0.33	1.62	0.01	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.01	0.01	0.01	0.34	4.78	4.80	0.02	Acceptable	*
EX12	4.45	21	3.89	27.89	0.0050	0.0050	0.14	1.62	0.01	0.00	0.00	0.0	0.0000	0.00	60	0.00	0.01	0.01	0.01	0.15	4.59	6.04	1.45	Acceptable	*
PUMP 2																									
B16	-4.80	48	132.48	4.28	0.0074	0.0187	0.03	16.72	1.08	132.48	6.78	898.2	0.7138	0.25	0	0.00	1.33	1.73	0.67	0.70	-4.10	6.00	10.10	Acceptable	Starting HGL assumed at normal depth of the pipe
B15	-4.10	18	8.86	34.33	0.0056	0.0102	0.19	6.78	0.18	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.18	0.23	0.09	0.31	-3.79	4.08	7.87	Acceptable	*
B14	-4.10	48	123.62	112.30	0.0058	0.0100	0.65	12.89	0.65	123.62	9.84	1216.2	1.5028	0.53	45	0.57	1.74	2.27	0.87	1.52	-2.58	5.50	8.08	Acceptable	
B13	-2.58	48	123.62	24.47	0.0074	0.0082	0.18	9.84	0.38	123.62	9.84	1216.2	1.5028	0.53	53	0.71	1.61	2.09	0.80	0.99	-1.59	6.00	7.59	Acceptable	
B12	-1.59	48	123.62	92.70	0.0074	0.0081	0.69	9.84	0.38	123.62	9.84	1216.2	1.5028	0.53	38	0.42	1.32	1.72	0.66	1.35	-0.24	4.50	4.74	Acceptable	
Q2	-0.24	48	123.62	109.46	0.0074	0.0080	0.81	9.84	0.38	119.30	8.37	998.0	1.0866	0.38	90	0.76	1.52	1.97	0.76	1.57	1.33	6.40	5.07	Acceptable	
EX8	1.33	18	13.46	68.55	0.0164	0.0101	1.13	7.62	0.23	2.45	4.39	10.7	0.2987	0.10	57	0.14	0.47	0.61	0.24	1.43	2.76	7.25	4.49	Acceptable	
EX10	2.76	15	1.22	50.59	0.0008	0.0150	0.04	4.39	0.07	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.07	0.10	0.04	0.09	2.85	6.58	3.73	Acceptable	*
EX9	2.76	12	1.22	6.91	0.0012	0.0043	0.01	3.02	0.04	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.04	0.05	0.02	0.03	2.79	6.79	4.00	Acceptable	*
Q1	1.33	48	105.84	45.00	0.0054	0.0051	0.24	8.42	0.28	105.12	8.37	879.3	1.0866	0.38	0	0.00	0.66	0.85	0.33	0.57	1.90	6.40	4.50	Acceptable	*
B11	1.90	48	105.12	17.53	0.0054	0.0051	0.09	8.37	0.27	105.12	5.66	595.2	0.4978	0.17	90	0.35	0.79	1.03	0.40	0.49	2.39	7.00	4.61	Acceptable	
EX11	2.39	30	27.79	28.16	0.0046	0.0103	0.13	5.66	0.12	27.79	5.66	157.4	0.4978	0.17	45	0.19	0.49	0.63	0.24	0.37	2.76	7.16	4.40	Acceptable	
B9	2.39	48	77.33	158.44	0.0029	0.0075	0.46	6.15	0.15	77.33	6.10	471.9	0.5782	0.20	0	0.00	0.35	0.45	0.17	0.63	3.02	5.33	2.31	Acceptable	
B10	3.02	18	0.65	18.66	0.0000	0.0102	0.00	0.37	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	3.02	4.88	1.86	Acceptable	*
B8	3.02	48	76.68	128.38	0.0029	0.0075	0.37	6.10	0.14	60.70	4.58	278.2	0.3262	0.11	0	0.00	0.26	0.34	0.13	0.53	3.56	4.75	1.19	Acceptable	
B7	3.56	18	2.02	16.43	0.0004	0.0103	0.01	1.14	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	3.57	4.54	0.97	Acceptable	*
B6	3.56	18	1.08	20.46	0.0001	0.0103	0.00	0.61	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	3.56	4.48	0.92	Acceptable	*
B3	3.56	48	57.60	86.54	0.0016	0.0060	0.14	4.58	0.08	6.62	2.20	14.6	0.0752	0.03	0	0.00	0.11	0.14	0.05	0.21	3.77	4.80	1.03	Acceptable	
B5	3.77	18	1.08	22.17	0.0001	0.0104	0.00	0.61	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	3.77	4.58	0.81	Acceptable	*
B4	3.77	18	3.89	36.88	0.0014	0.0095	0.05	2.20	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.02	0.01	0.06	3.83	4.64	0.81	Acceptable	*
B2A	3.77	48	52.63	42.94	0.0013	0.0051	0.06	4.19	0.07	52.63	10.38	546.6	1.6746	0.59	0	0.00	0.65	0.85	0.33	0.38	4.15	5.00	0.85	Acceptable	
EX C3	4.15	30	50.98	19.15	0.0155	0.0204	0.30	10.38	0.42	1.66	0.94	1.6	0.0136	0.00	90	0.01	0.43	0.56	0.22	0.58	4.73	5.10	0.37	Acceptable	
B2	4.15	18	1.66	12.42	0.0002	0.0048	0.00	0.94	0.00	1.66	0.94	1.6	0.0136	0.00	90	0.01	0.02	0.02	0.01	0.01	4.16	5.02	0.86	Acceptable	
B1	4.16	18	1.66	32.65	0.0002	0.0049	0.01	0.94	0.00	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.00	0.00	0.00	0.01	4.17	4.58	0.41	Acceptable	*
EX C4	4.73	30	44.28	281.77	0.0117	0.0122	3.28	9.02	0.32	2.16	2.75	5.9	0.1174	0.04	35	0.03	0.39	0.51	0.19	3.54	8.27	10.85	2.58	Acceptable	
EX C5	8.27	12	2.16	23.32	0.0037	0.0575	0.09	2.75	0.03	2.16	6.19	13.4	0.5946	0.21	35	0.17	0.40	0.53	0.20	0.29	8.55	11.29	2.74	Acceptable	
EX C6	8.55	8	2.16	29.72	0.0320	0.0300	0.95	6.19	0.15	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.15	0.19	0.07	1.05	9.60	12.04	2.44	Acceptable	*

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.
Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

STORM SEWER COST ESTIMATE - ALTERNATIVE 3

Item	Quantity	Unit	Unit Price	Total	
15" RCP CI IV	99.01	LF	\$ 59.53	\$ 5,894.07	
18" RCP CI IV	538.8	LF	\$ 73.14	\$ 39,407.83	
21" RCP CI IV	94.4	LF	\$ 92.03	\$ 8,687.63	
24" RCP CI IV	732.94	LF	\$ 105.62	\$ 77,413.12	
30" RCP CI IV	841.38	LF	\$ 129.95	\$ 109,337.33	
36" RCP CI IV	453.86	LF	\$ 180.45	\$ 81,899.04	
42" RCP CI IV	324.99	LF	\$ 227.72	\$ 74,006.72	
48" RCP CI IV	692.56	LF	\$ 259.24	\$ 179,539.25	
54" RCP CI IV	441.38	LF	\$ 312.08	\$ 137,745.87	
60" RCP CI IV	352.54	LF	\$ 366.83	\$ 129,322.25	
Manhole	26	EA	\$ 4,611.50	\$ 119,899.00	(MH-2 with watertight frame and cover
Inlet	31	EA	\$ 6,000.00	\$ 186,000.00	(DI-3B, 8' throat is \$5,984.01)
Outfall Valve 24"	1	EA	\$ 5,086.00	\$ 5,086.00	
Outfall Valve 30"	0	EA	\$ 9,449.00	\$ -	
Outfall Valve 36"	0	EA	\$ 9,449.00	\$ -	
Outfall Valve 42"	0	EA	\$ 14,088.00	\$ -	
Outfall Valve 48"	0	EA	\$ 21,859.00	\$ -	
Outfall Valve 60"	2	EA	\$ 43,782.00	\$ 87,564.00	
TOTAL				\$ 1,241,802.12	

Tideflex valve unit prices from sales rep

All other prices from Fairfax County 2017 Unit Price Schedule

100-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3																																
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS	
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT		
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN				FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
													C _f =	1.25																		
CAMERON ST BYPASS																																
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	13.80		9.11	9.11	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	5.15	0.87	6.72	2.38	7.15	8.22	-2.57	-4.95	outfall unknown	
DUKE ST																																
EX GRATE	MH	EX OUTFALL		0.21		0.21	0.80	0.17		0.17	5.00	13.80	2.90		2.90	15	CL. IV	RCP	0.0212	84.07	0.013	9.40	2.36	0.31	6.58	1.78	2.57	1.20	0.12	-1.66		
DUKE ST BYPASS																																
EX13	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	13.80		31.05	31.05	24	CL. IV	RCP	0.0100	187.55	0.013	22.64	9.88	1.37	8.29	1.88	8.44	4.99	1.45	-0.43		
PUMP STATION 1																																
EX12	EX DI	D2	MH	0.54		0.54	0.80	0.43		0.43	5.00	13.80	7.45		7.45	21	CL. IV	RCP	0.0050	27.89	0.013	11.22	3.10	0.66	4.99	0.14	6.46	3.55	1.16	1.02		
D1	GRATE	D2	MH	0.19	0.35	0.54	0.80	0.15	0.28	0.43	5.00	13.80	2.62	4.83	7.45	21	CL. IV	RCP	0.0050	66.51	0.013	11.16	3.10	0.67	4.96	0.33	4.80	1.72	1.33	1.00		
D2	MH	D3	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	33.82	0.013	16.03	4.74	0.93	5.87	0.17	7.00	4.00	1.00	0.83		
D3	MH	D4	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	161.07	0.013	16.04	4.74	0.93	5.87	0.81	6.77	3.94	0.83	0.02		
D4	MH	D5	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0049	28.44	0.013	15.87	4.74	0.94	5.81	0.14	5.40	3.38	0.02	-0.12		
D5	MH	D6	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	191.66	0.013	16.00	4.74	0.93	5.86	0.96	5.70	3.82	-0.12	-1.08		
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	13.80	1.38		1.38	24	CL. IV	RCP	0.0050	31.43	0.013	16.03	0.44	0.09	2.81	0.16	8.22	1.47	4.75	4.59		
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	13.80	2.21		3.59	24	CL. IV	RCP	0.0050	15.00	0.013	15.99	1.14	0.22	3.92	0.08	8.02	1.27	4.75	4.68		
P3	MH	P4	MH		1.45	1.71	0.80		1.16	1.37	5.00	13.80		20.01	23.60	36	CL. IV	RCP	0.0050	185.68	0.013	47.19	3.34	0.50	6.68	0.93	7.86	4.78	0.08	-0.85		
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	13.80	2.62		2.62	15	CL. IV	RCP	0.0154	24.14	0.013	8.00	2.14	0.33	5.74	0.37	6.29	1.75	3.29	2.92		
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	13.80	2.21		2.21	15	CL. IV	RCP	0.0050	33.41	0.013	4.57	1.80	0.48	3.68	0.17	5.85	2.00	2.60	2.43		
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	15	CL. IV	RCP	0.0050	23.16	0.013	4.57	2.59	0.70	4.02	0.12	6.20	2.00	2.95	2.83		
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	13.80	0.69		3.86	18	CL. IV	RCP	0.0049	43.53	0.013	7.35	2.19	0.53	4.20	0.21	5.70	1.37	2.83	2.62		
A3	MH	P4	MH			0.63				0.50	5.00	13.80			8.69	18	CL. IV	RCP	0.0051	15.73	0.013	7.49	4.92	1.16	4.87	0.08	6.07	1.95	2.62	2.54		
P4	MH	A6	MH		1.26	2.97	0.80		1.01	2.38	5.00	13.80		17.39	49.68	36	CL. IV	RCP	0.0050	152.77	0.013	47.03	7.03	1.06	7.65	0.76	5.99	3.84	-0.85	-1.61		
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	13.80	3.04		3.04	15	CL. IV	RCP	0.0044	18.30	0.013	4.27	2.47	0.71	3.79	0.08	3.62	2.00	0.37	0.29		
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	13.80	26.77		26.77	24	CL. IV	RCP	0.0050	29.16	0.013	16.06	8.52	1.67	5.88	0.15	3.45	2.00	-0.55	-0.70		
A11	MH	D6	DI			1.94				1.55	5.00	13.80			26.77	24	CL. IV	RCP	0.0054	11.12	0.013	16.61	8.52	1.61	6.08	0.06	3.42	2.12	-0.70	-0.76		
D6	MH	A9	MH			3.02				2.42	5.00	13.80			41.68	24	CL. IV	RCP	0.0101	25.70	0.013	22.75	13.27	1.83	8.33	0.26	4.42	4.25	-1.83	-2.09		
A10	DI	A9	MH	0.05	1.06	1.11	0.80	0.04	0.85	0.89	5.00	13.80	0.69	14.63	15.32	18	CL. IV	RCP	0.0095	15.84	0.013	10.22	8.67	1.50	6.65	0.15	3.50	3.45	-1.45	-1.60		
A9	MH	A6	MH			4.13				3.3																						

A15	DI	K4	MH	0.21		0.44	0.80	0.17		0.35	5.00	13.80	2.90		6.07	18	CL. IV	RCP	0.0054	35.24	0.013	7.71	3.44	0.79	4.84	0.19	3.90	2.44	-0.04	-0.23	
A18	DI	A19	DI	0.20		0.20	0.80	0.16		0.16	5.00	13.80	2.76		2.76	18	CL. IV	RCP	0.0052	36.49	0.013	7.58	1.56	0.36	3.90	0.19	3.72	1.65	0.57	0.38	
A19	DI	K4	MH	0.19		0.39	0.80	0.15		0.31	5.00	13.80	2.62		5.38	18	CL. IV	RCP	0.0053	22.76	0.013	7.62	3.05	0.71	4.66	0.12	3.90	2.02	0.38	0.26	
K4	DI	K5	MH			16.0	0.80			12.77	5.00	13.80			220.25	54	CL. IV	RCP	0.0051	21.61	0.013	140.25	13.85	1.57	10.14	0.11	3.50	0.24	-1.24	-1.35	
A21	DI	K5	MH	0.13		0.13	0.80	0.10		0.10	5.00	13.80	1.79		1.79	18	CL. IV	RCP	0.0051	23.33	0.013	7.53	1.02	0.24	3.37	0.12	3.30	1.75	0.05	-0.07	
A23	DI	K5	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	13.80	1.24	2.21	3.45	18	CL. IV	RCP	0.0059	5.09	0.013	8.06	1.95	0.43	4.33	0.03	3.26	1.75	0.01	-0.02	
K5	MH	K6	MH			16.34				13.07	5.00	13.80			225.49	54	CL. IV	RCP	0.0050	106.82	0.013	138.47	14.18	1.63	10.01	0.53	3.20	0.05	-1.35	-1.88	
K6	MH	A25	MH			16.34				13.07	5.00	13.80			225.49	54	CL. IV	RCP	0.0050	79.34	0.013	139.58	14.18	1.62	10.09	0.40	3.15	0.53	-1.88	-2.28	
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	13.80	6.35		6.35	18	CL. IV	RCP	0.0060	8.27	0.013	8.16	3.59	0.78	5.13	0.05	2.09	2.00	-1.41	-1.46	
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	13.80	28.29		28.29	24	CL. IV	RCP	0.0100	17.99	0.013	22.62	9.00	1.25	8.28	0.18	2.09	2.00	-1.91	-2.09	
A25	MH	A29	MH			18.85				15.08	5.00	13.80			260.13	54	CL. IV	RCP	0.0050	210.39	0.013	138.87	16.36	1.87	10.04	1.05	2.35	0.63	-2.78	-3.83	
A29	MH	PUMP 1				27.54				22.03	5.00	13.80			380.05	60	CL. IV	RCP	0.0061	32.65	0.013	203.77	19.36	1.87	11.93	0.20	3.45	4.25	-5.80	-6.00	
PUMP 1		OUTFALL				27.54	0.80			22.03	5.00	13.80			380.05	60	CL. IV	RCP	0.0065	271.27	0.013	209.11	19.36	1.82	12.25	1.75	5.00	4.25	-4.25	-6.00	
PUMP STATION 2																															
EX C6		EX C5		0.30		0.30	0.80	0.24		0.24	5.00	13.80	4.14		4.14	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	11.86	1.98	6.89	0.89	12.46	4.01	7.78	6.89	
EX C5		EX C4				0.30	0.80			0.24	5.00	13.80			4.14	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	5.27	0.48	10.76	1.34	11.29	4.30	5.99	4.65	
EX C4	MH	EX C3	MH		5.85	6.15	0.80		4.68	4.92	5.00	13.80		80.73	84.87	30	CL. IV	RCP	0.0122	281.77	0.013	45.37	17.29	1.87	10.63	3.45	10.85	3.90	4.45	1.00	
EX C3	MH	B2A	MH		0.93	7.08	0.80		0.74	5.66	5.00	13.80		12.83	97.70	30	CL. IV	RCP	0.0204	19.15	0.013	58.51	19.90	1.67	13.71	0.39	5.10	2.07	0.53	0.14	
B1	DI	B2	MH	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	18	CL. IV	RCP	0.0049	32.65	0.013	7.35	1.80	0.43	3.95	0.16	5.00	2.24	1.26	1.10	
B2	MH	B2A	MH			0.23	0.80			0.18	5.00	13.80			3.17	18	CL. IV	RCP	0.0048	12.42	0.013	7.30	1.80	0.43	3.92	0.06	5.02	2.42	1.10	1.04	
B2A	MH	B3	MH			7.31	0.80			5.85	5.00	13.80			100.88	48	CL. IV	RCP	0.0051	42.94	0.013	102.78	8.03	0.98	9.49	0.22	5.00	0.86	0.14	-0.08	
B4	DI	B3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	13.80	4.00	3.45	7.45	18	CL. IV	RCP	0.0095	36.88	0.013	10.23	4.22	0.73	6.31	0.35	5.06	2.25	1.31	0.96	
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0104	22.17	0.013	10.70	1.17	0.19	4.48	0.23	5.00	2.25	1.25	1.02	
B3	MH	B8	MH			8.00	0.80			6.40	5.00	13.80			110.40	48	CL. IV	RCP	0.0060	86.54	0.013	111.31	8.79	0.99	10.27	0.52	4.80	0.88	-0.08	-0.60	
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0103	20.46	0.013	10.64	1.17	0.19	4.45	0.21	4.90	2.25	1.15	0.94	
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	13.80	3.86		3.86	18	CL. IV	RCP	0.0103	16.43	0.013	10.68	2.19	0.36	5.50	0.17	4.96	2.25	1.21	1.04	
B8	MH	B9	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	13.80		30.64	146.97	48	CL. IV	RCP	0.0075	128.38	0.013	124.17	11.70	1.18	11.36	0.96	4.75	1.35	-0.60	-1.56	
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	13.80	1.24		1.24	18	CL. IV	RCP	0.0102	18.66	0.013	10.60	0.70	0.12	3.66	0.19	5.30	4.37	-0.57	-0.76	
B9	MH	B11	MH			10.74	0.80			8.59	5.00	13.80			148.21	48	CL. IV	RCP	0.0075	158.44	0.013	124.44	11.79	1.19	11.39	1.19	5.33	2.89	-1.56	-2.75	
EX11	DI	B11	MH		3.86	3.86	0.80		3.09	3.09	5.00	13.80		53.27	53.27	30	CL. IV	RCP	0.0103	28.16	0.013	41.61	10.85	1.28	9.75	0.29	7.16	4.20	0.46	0.17	
B11	DI	Q1	MH			14.60	0.80			11.68	5.00	13.80			201.48	48	CL. IV	RCP	0.0051	17.53	0.013	102.89	16.03	1.96	9.42	0.09	7.00	6.15	-3.15	-3.24	
Q1	DI	Q2	MH	0.10		14.70	0.80	0.08		11.76	5.00	13.80	1.38		202.86	48	CL. IV	RCP	0.0051	45.00	0.013	102.66	16.14	1.98	9.39	0.23	6.82	6.06	-3.24	-3.47	
EX9	EX DI	EX8	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	2.99	1.00	3.47	0.03	7.21	2.25	3.96	3.99	
EX10	EX DI	EX8	MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	1.91	0.30	5.48	0.76	7.00	4.09	1.66	0.90	
EX8	EX DI	Q2	MH		1.53	1.87	0.80		1.22	1.50	5.00	13.80		21.11	25.81	18	CL. IV	RCP	0.0101	68.55	0.013	10.54	14.60	2.45	6.86	0.69	7.25	5.80	-0.05	-0.74	
Q2	MH	B12	MH		0.60	17.17	0.80		0.48	13.74	5.00	13.80		8.28	236.95	48	CL. IV	RCP	0.0080	109.46	0.013	128.75	18.86	1.84	11.78	0.88	6.40	5.87	-3.47	-4.35	
B12	MH	B13	MH			17.17	0.80			13.74	5.00	13.80			236.95	48	CL. IV	RCP	0.0081	92.70	0.013	129.16	18.86	1.83	11.82	0.75	4.50	4.85	-4.35	-5.10	
B13	MH	B14	MH			17.17	0.80			13.74	5.00	13.80			236.95	48	CL. IV	RCP	0.0082	24.47	0.013	129.82	18.86	1.83	11.88	0.20	6.00	7.10	-5.10	-5.30	
B14	MH	B16	MH			17.17	0.80			13.74	5.00	13.80			236.95	48	CL. IV	RCP	0.0100	112.30	0.013	143.40	18.86	1.65	13.12	1.12	5.50	6.80	-5.30	-6.42	
B15	DI	B16	MH	0.52	0.71	1.23	0.80	0.42	0.57	0.98	5.00	13.80	7.18	9.80	16.97	18	CL. IV	RCP	0.0102	34.33	0.013	10.60	9.61	1.60	6.90	0.35	4.50	3.00	0.00	-0.35	
B16	MH	PUMP 2				18.40	0.80			14.72	5.00	13.80			253.92	48	CL. IV	RCP	0.0187	4.28	0.013	196.32	20.21	1.29	17.97	0.08	6.00	9.92	-7.92	-8.00	
PUMP 2		OUTFALL				18.40	0.80			14.72	5.00	13.80			253.92	60	CL. IV	RCP	0.0103	48.62	0.013	264.02	12.93	0.96	15.60	0.50	6.00	7.50	-6.50	-7.00	

100-YEAR HGL COMPUTATIONS - ALTERNATE 3																									
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev. (2)	D _o (3)	Q _o (4)	L _o (5)	S _{fo} ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance	Remarks
								V _o (8)	H _o (9)	Q _i (10)	V _i (11)	Q _i /V _i (12)	$\frac{V_i^2}{(2g)}$ (2g) (13)	H _i (13)	Angle (14)	H _Δ (15)	H _t (16)	1.3 H _t (17)	0.5 H _t (18)						
CAMERON ST																									
EX C1	10.20	18	9.11	237.53	0.0100	0.0100	2.38	5.15	0.10	9.11	5.15	46.9	0.4125	0.14	0	0.00	0.25	0.32	0.12	2.50	12.70	7.15	-5.55	Unacceptable	Outfall unknown; Starting HGL at 100-yr WSE of Ri
DUKE ST																									
EX GRATE	10.20	15	2.90	84.07	0.0212	0.0212	1.78	2.36	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.03	0.01	1.79	11.99	2.57	-9.42	Unacceptable	To be removed or upgraded during improvements
DUKE ST BYPASS																									
EX13	10.20	24	31.05	187.55	0.0100	0.0100	1.88	9.88	0.38	31.05	8.29	257.3	1.0666	0.37	0	0.00	0.75	0.98	0.38	2.26	12.46	8.44	-4.02	Unacceptable	Starting HGL at 100-yr WSE of River
PUMP 1																									
A29	-2.00	60	380.05	32.65	0.0161	0.0061	0.53	11.93	0.55	380.05	16.36	6216.1	4.1540	1.45	90	2.91	4.91	6.39	2.46	2.98	0.98	3.45	2.47	Acceptable	Starting HGL assumed at normal depth of the pipe
A25	0.98	54	260.13	210.39	0.0050	0.0050	1.05	16.36	1.04	260.13	14.18	3688.1	3.1214	1.09	0	0.00	2.13	2.77	1.07	2.12	3.10	2.35	-0.75	Unacceptable	
A27	3.10	24	28.29	17.99	0.0100	0.0100	0.18	9.00	0.31	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.31	0.41	0.16	0.38	3.48	1.67	-1.81	Unacceptable	*
A26	3.10	18	6.35	8.27	0.0060	0.0060	0.05	3.59	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.08	3.18	1.67	-1.51	Unacceptable	*
K6	3.10	54	225.49	79.34	0.0050	0.0050	0.40	14.18	0.78	225.49	10.01	2257.7	1.5566	0.54	0	0.00	1.33	1.72	0.66	1.06	4.16	3.15	-1.01	Unacceptable	
K5	4.16	54	225.49	106.82	0.0100	0.0050	1.06	10.01	0.39	225.49	13.85	3122.7	2.9779	1.04	0	0.00	1.43	1.86	0.72	1.78	5.94	3.20	-2.74	Unacceptable	
A23	5.94	18	3.45	5.09	0.0059	0.0059	0.03	1.95	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.04	5.98	2.84	-3.14	Unacceptable	*
A21	5.94	18	1.79	23.33	0.0051	0.0051	0.12	1.02	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.01	0.00	0.12	6.06	2.88	-3.18	Unacceptable	*
K4	5.94	54	220.25	21.61	0.0051	0.0051	0.11	13.85	0.74	220.25	13.13	2891.4	2.6762	0.94	0	0.00	1.68	2.19	0.84	0.95	6.89	3.50	-3.39	Unacceptable	
A19	6.89	18	5.38	22.76	0.0053	0.0053	0.12	3.05	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.14	7.03	3.48	-3.55	Unacceptable	*
A18	7.03	18	2.76	36.49	0.0052	0.0052	0.19	1.56	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.20	7.23	3.30	-3.93	Unacceptable	*
A15	6.89	18	6.07	35.24	0.0054	0.0054	0.19	3.44	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.22	7.11	3.48	-3.63	Unacceptable	*
A14	7.11	18	3.17	36.21	0.0050	0.0050	0.18	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.19	7.30	3.26	-4.04	Unacceptable	*
K3	6.89	54	208.79	23.22	0.0052	0.0052	0.12	13.13	0.67	208.79	8.89	1856.8	1.2280	0.43	0	0.00	1.10	1.43	0.55	0.67	7.56	3.70	-3.86	Unacceptable	
EX3	7.56	42	85.56	28.94	0.0152	0.0152	0.44	8.89	0.31	63.89	12.26	783.2	2.3330	0.82	30	0.65	1.78	2.31	0.89	1.60	9.16	3.52	-5.64	Unacceptable	
A17	9.16	18	3.73	9.29	0.0054	0.0054	0.05	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	22	0.00	0.02	0.02	0.01	0.06	9.22	3.51	-5.71	Unacceptable	*
EX2	9.16	30	60.17	296.43	0.0099	0.0099	2.92	12.26	0.58	3.73	4.74	17.7	0.3495	0.12	72	0.23	0.94	1.22	0.47	3.53	12.69	9.00	-3.69	Unacceptable	
EX1	12.69	12	3.73	10.59	0.0104	0.0104	0.11	4.74	0.09	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.09	0.11	0.04	0.17	12.85	8.93	-3.92	Unacceptable	*
EX7	7.56	42	123.23	33.66	0.0051	0.0051	0.17	12.81	0.64	95.63	13.00	1243.5	2.6252	0.92	28	0.42	1.98	2.57	0.99	1.45	9.02	3.50	-5.52	Unacceptable	
A13	9.02	18	3.73	4.62	0.0108	0.0108	0.05	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.02	0.02	0.01	0.06	9.08	3.55	-5.53	Unacceptable	*
EX6	9.02	36	91.91	67.14	0.0113	0.0113	0.76	13.00	0.66	84.73	17.26	1462.6	4.6267	1.62	0	0.00	2.28	2.96	1.14	1.90	10.91	4.78	-6.13	Unacceptable	
EX5	10.91	30	84.73	215.87	0.0141	0.0141	3.04	17.26	1.16	3.17	4.04	12.8	0.2536	0.09	51	0.12	1.36	1.77	0.68	3.93	14.84	9.00	-5.84	Unacceptable	
EX4	14.84	12	3.17	26.91	0.0104	0.0104	0.28	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.06	0.08	0.03	0.32	15.16	9.47	-5.69	Unacceptable	*
A28	0.98	42	119.92	85.88	0.0108	0.0061	0.92	9.35	0.34	112.06	11.40	1277.8	2.0191	0.71	90	1.41	2.46	3.20	1.23	2.15	3.14	3.28	0.14	Acceptable	
A7	3.14	18	2.35	19.85	0.0008	0.0101	0.02	4.59	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.11	0.04	0.07	3.21	3.28	0.07	Acceptable	*
A6	3.14	42	109.71	27.88	0.0100	0.0100	0.28	11.40	0.50	68.72	8.06	554.1	1.0095	0.35	90	0.71	1.56	2.03	0.78	1.30	4.43	3.31	-1.12	Unacceptable	
A9	4.43	36	56.99	48.27	0.0155	0.0155	0.75	8.06	0.25	56.99	13.27	756.1	2.7327	0.96	90	1.91	3.12	4.06	1.56	2.31	6.75	3.12	-3.63	Unacceptable	
A10	6.75	18	15.32	15.84	0.0095	0.0095	0.15	8.67	0.29	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.29	0.38	0.15	0.34	7.08	3.08	-4.00	Unacceptable	*
D6	6.75	24	41.68	25.70	0.0101	0.0101	0.26	13.27	0.68	41.68	8.52	355.2	1.1277	0.39	90	0.79	1.87	2.43	0.93	1.19	7.94	4.42	-3.52	Unacceptable	
A11	7.94	24	26.77	11.12	0.0054	0.0054	0.06	8.52	0.28	26.77	8.52	228.1	1.1277	0.39	0	0.00	0.68	0.88	0.34	0.40	8.34	3.42	-4.92	Unacceptable	
A12	8.34	24	26.77	29.16	0.0050	0.0050	0.15	8.52	0.28	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.28	0.37	0.14	0.33	8.67	3.03	-5.64	Unacceptable	*
A8	4.43	15	3.04	18.30	0.0044	0.0044	0.08	2.47	0.02	0.00	0.00	0.0	0.0000	0.00	30	0.00	0.02	0.03	0.01	0.10	4.53	3.20	-1.33	Unacceptable	*

P4	4.43	36	49.68	152.77	0.0050	0.0050	0.76	7.03	0.19	23.60	3.34	78.8	0.1731	0.06	0	0.00	0.25	0.33	0.13	0.92	5.36	5.99	0.63	Acceptable	
A3	5.36	18	8.69	15.73	0.0051	0.0051	0.08	4.92	0.09	8.69	2.19	19.0	0.0742	0.03	0	0.00	0.12	0.16	0.06	0.14	5.50	6.07	0.57	Acceptable	
A5	5.50	18	3.86	43.53	0.0049	0.0049	0.21	2.19	0.02	3.17	2.59	8.2	0.1039	0.04	90	0.07	0.13	0.17	0.06	0.30	5.79	5.28	-0.51	Unacceptable	*
A4	5.79	15	3.17	23.16	0.0050	0.0050	0.12	2.59	0.03	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.03	0.03	0.01	0.13	5.93	5.78	-0.15	Unacceptable	*
A2	5.50	15	2.21	33.41	0.0050	0.0050	0.17	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.18	5.67	5.43	-0.24	Unacceptable	*
A1	5.50	15	2.62	24.14	0.0154	0.0154	0.37	2.14	0.02	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.02	0.02	0.01	0.38	5.88	5.87	-0.01	Unacceptable	*
P3	5.36	36	23.60	185.68	0.0050	0.0050	0.93	3.34	0.04	3.59	3.92	14.1	0.2385	0.08	90	0.17	0.29	0.38	0.15	1.12	6.48	7.86	1.38	Acceptable	
P2	6.48	24	3.59	15.00	0.0004	0.0050	0.01	3.92	0.06	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.06	0.08	0.03	0.05	6.52	7.60	1.08	Acceptable	*
P1	6.48	24	1.38	31.43	0.0001	0.0050	0.00	2.81	0.03	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.03	0.04	0.02	0.02	6.50	7.80	1.30	Acceptable	*
D5	7.94	24	14.90	191.66	0.0050	0.0050	0.96	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	90	0.24	0.45	0.59	0.23	1.19	9.13	5.70	-3.43	Unacceptable	
D4	9.13	24	14.90	28.44	0.0049	0.0049	0.14	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	25	0.06	0.27	0.35	0.13	0.27	9.40	5.40	-4.00	Unacceptable	
D3	9.40	24	14.90	161.07	0.0050	0.0050	0.81	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	22	0.06	0.27	0.35	0.13	0.94	10.34	6.77	-3.57	Unacceptable	
D2	10.34	24	14.90	33.82	0.0050	0.0050	0.17	4.74	0.09	7.45	3.10	23.1	0.1490	0.05	45	0.06	0.20	0.26	0.10	0.30	10.64	7.00	-3.64	Unacceptable	
D1	10.64	21	7.45	66.51	0.0050	0.0050	0.33	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.04	0.05	0.02	0.35	10.99	4.80	-6.19	Unacceptable	*
EX12	10.64	21	7.45	27.89	0.0050	0.0050	0.14	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	60	0.00	0.04	0.05	0.02	0.16	10.80	6.04	-4.76	Unacceptable	*
PUMP 2																									
B16	-4.80	48	253.92	4.28	0.0237	0.0187	0.10	17.97	1.25	253.92	6.90	1752.0	0.7392	0.26	0	0.00	1.51	1.97	0.76	0.86	-3.94	6.00	9.94	Acceptable	Starting HGL assumed at normal depth of the pipe
B15	-3.94	18	16.97	34.33	0.0198	0.0102	0.68	6.90	0.18	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.18	0.24	0.09	0.80	-3.14	4.08	7.22	Acceptable	*
B14	-3.94	48	236.95	112.30	0.0100	0.0100	1.12	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	45	2.10	5.41	7.03	2.71	3.83	-0.12	5.50	5.62	Acceptable	
B13	-0.12	48	236.95	24.47	0.0272	0.0082	0.67	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	53	2.59	5.91	7.68	2.95	3.62	3.50	6.00	2.50	Acceptable	
B12	3.50	48	236.95	92.70	0.0272	0.0081	2.52	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	38	1.55	4.86	6.32	2.43	4.95	8.45	4.50	-3.95	Unacceptable	
Q2	8.45	48	236.95	109.46	0.0272	0.0080	2.98	18.86	1.38	228.67	16.03	3666.3	3.9917	1.40	90	2.79	5.57	7.24	2.79	5.77	14.22	6.40	-7.82	Unacceptable	
EX8	14.22	18	25.81	68.55	0.0604	0.0101	4.14	14.60	0.83	4.69	1.91	9.0	0.0567	0.02	57	0.03	0.87	1.14	0.44	4.71	18.93	7.25	-11.68	Unacceptable	
EX10	18.93	15	2.35	50.59	0.0150	0.0150	0.76	1.91	0.01	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.01	0.02	0.01	0.77	19.70	6.58	-13.12	Unacceptable	*
EX9	18.93	12	2.35	6.91	0.0043	0.0043	0.03	2.99	0.03	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.03	0.05	0.02	0.05	18.98	6.79	-12.19	Unacceptable	*
Q1	14.22	48	202.86	45.00	0.0200	0.0051	0.90	16.14	1.01	201.48	16.03	3230.4	3.9917	1.40	0	0.00	2.41	3.13	1.20	2.10	16.32	6.40	-9.92	Unacceptable	*
B11	16.32	48	201.48	17.53	0.0197	0.0051	0.34	16.03	1.00	201.48	10.85	2186.4	1.8286	0.64	90	1.28	2.92	3.79	1.46	1.80	18.13	7.00	-11.13	Unacceptable	
EX11	18.13	30	53.27	28.16	0.0169	0.0103	0.48	10.85	0.46	53.27	10.85	578.0	1.8286	0.64	45	0.69	1.79	2.33	0.90	1.37	19.50	7.16	-12.34	Unacceptable	
B9	18.13	48	148.21	158.44	0.0106	0.0075	1.69	11.79	0.54	148.21	11.70	1733.4	2.1240	0.74	0	0.00	1.28	1.67	0.64	2.33	20.45	5.33	-15.12	Unacceptable	
B10	20.45	18	1.24	18.66	0.0001	0.0102	0.00	0.70	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	20.46	4.88	-15.58	Unacceptable	*
B8	20.45	48	146.97	128.38	0.0105	0.0075	1.34	11.70	0.53	116.33	8.79	1022.0	1.1985	0.42	0	0.00	0.95	1.24	0.48	1.96	22.42	4.75	-17.67	Unacceptable	
B7	22.42	18	3.86	16.43	0.0014	0.0103	0.02	2.19	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.03	22.45	4.54	-17.91	Unacceptable	*
B6	22.42	18	2.07	20.46	0.0004	0.0103	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	22.43	4.48	-17.95	Unacceptable	*
B3	22.42	48	110.40	86.54	0.0059	0.0060	0.51	8.79	0.30	12.70	4.22	53.5	0.2761	0.10	0	0.00	0.40	0.52	0.20	0.77	23.19	4.80	-18.39	Unacceptable	
B5	23.19	18	2.07	22.17	0.0004	0.0104	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	23.20	4.58	-18.62	Unacceptable	*
B4	23.19	18	7.45	36.88	0.0050	0.0095	0.19	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.03	0.23	23.42	4.64	-18.78	Unacceptable	*
B2A	23.19	48	100.88	42.94	0.0049	0.0051	0.21	8.03	0.25	100.88	19.90	2007.9	6.1518	2.15	0	0.00	2.40	3.12	1.20	1.41	24.60	5.00	-19.60	Unacceptable	
EX C3	24.60	30	97.70	19.15	0.0568	0.0204	1.09	19.90	1.54	3.17	1.80	5.7	0.0501	0.02	90	0.04	1.59	2.07	0.80	2.12	26.72	5.10	-21.62	Unacceptable	
B2	24.60	18	3.17	12.42	0.0009	0.0048	0.01	1.80	0.01	3.17	1.80	5.7	0.0501	0.02	90	0.04	0.07	0.08	0.03	0.04	24.64	5.02	-19.62	Unacceptable	
B1	24.64	18	3.17	32.65	0.0009	0.0049	0.03	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.01	0.02	0.01	0.04	24.68	4.58	-20.10	Unacceptable	*
EX C4	26.72	30	84.87	281.77	0.0428	0.0122	12.07	17.29	1.16	4.14	5.27	21.8	0.4315	0.15	35	0.12	1.43	1.86	0.72	13.00	39.72	10.85	-28.87	Unacceptable	
EX C5	39.72	12	4.14	23.32	0.0135	0.0575	0.31	5.27	0.11	4.14	11.86	49.1	2.1842	0.76	35	0.61	1.48	1.93	0.74	1.06	40.78	11.29	-29.49	Unacceptable	
EX C6	40.78	8	4.14	29.72	0.1174	0.0300	3.49	11.86	0.55	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.55	0.71	0.27	3.84	44.62	12.04	-32.58	Unacceptable	*

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.
Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

100-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3 - UPSIZED PIPES																															
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT	
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN			FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
													C _f =	1.25																	
CAMERON ST BYPASS																															
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	13.80		9.11	9.11	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	5.15	0.87	6.72	2.38	7.15	8.22	-2.57	-4.95	outfall unknown
DUKE ST																															
EX GRATE	MH	EX OUTFALL		0.21		0.21	0.80	0.17		0.17	5.00	13.80	2.90		2.90	15	CL. IV	RCP	0.0212	84.07	0.013	9.40	2.36	0.31	6.58	1.78	2.57	1.20	0.12	-1.66	
DUKE ST BYPASS																															
EX13	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	13.80		31.05	31.05	30	CL. IV	RCP	0.0100	187.55	0.013	41.05	6.33	0.76	9.20	1.88	8.44	4.49	1.45	-0.43	
PUMP STATION 1																															
EX12	EX DI	D2	MH	0.54		0.54	0.80	0.43		0.43	5.00	13.80	7.45		7.45	24	CL. IV	RCP	0.0050	27.89	0.013	16.02	2.37	0.47	4.95	0.14	6.46	3.30	1.16	1.02	
D1	GRATE	D2	MH	0.19	0.35	0.54	0.80	0.15	0.28	0.43	5.00	13.80	2.62	4.83	7.45	24	CL. IV	RCP	0.0050	66.51	0.013	15.93	2.37	0.47	4.92	0.33	4.80	1.47	1.33	1.00	
D2	MH	D3	MH			1.08				0.86	5.00	13.80			14.90	30	CL. IV	RCP	0.0050	33.82	0.013	29.07	3.04	0.51	5.98	0.17	7.00	3.50	1.00	0.83	
D3	MH	D4	MH			1.08				0.86	5.00	13.80			14.90	30	CL. IV	RCP	0.0050	161.07	0.013	29.08	3.04	0.51	5.98	0.81	6.77	3.44	0.83	0.02	
D4	MH	D5	MH			1.08				0.86	5.00	13.80			14.90	30	CL. IV	RCP	0.0049	28.44	0.013	28.77	3.04	0.52	5.92	0.14	5.40	2.88	0.02	-0.12	
D5	MH	D6	MH			1.08				0.86	5.00	13.80			14.90	30	CL. IV	RCP	0.0050	191.66	0.013	29.02	3.04	0.51	5.97	0.96	5.70	3.32	-0.12	-1.08	
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	13.80	1.38		1.38	30	CL. IV	RCP	0.0050	31.43	0.013	29.07	0.28	0.05	2.72	0.16	8.22	0.97	4.75	4.59	
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	13.80	2.21		3.59	30	CL. IV	RCP	0.0050	15.00	0.013	28.99	0.73	0.12	3.72	0.08	8.02	0.77	4.75	4.68	
P3	MH	P4	MH		1.45	1.71	0.80		1.16	1.37	5.00	13.80		20.01	23.60	42	CL. IV	RCP	0.0050	185.68	0.013	71.18	2.45	0.33	6.51	0.93	7.86	4.28	0.08	-0.85	
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	13.80	2.62		2.62	18	CL. IV	RCP	0.0154	24.14	0.013	13.01	1.48	0.20	5.52	0.37	6.29	1.50	3.29	2.92	
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	13.80	2.21		2.21	18	CL. IV	RCP	0.0050	33.41	0.013	7.43	1.25	0.30	3.57	0.17	5.85	1.75	2.60	2.43	
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	18	CL. IV	RCP	0.0050	23.16	0.013	7.43	1.80	0.43	3.99	0.12	6.20	1.75	2.95	2.83	
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	13.80	0.69		3.86	21	CL. IV	RCP	0.0049	43.53	0.013	11.09	1.61	0.35	4.10	0.21	5.70	1.12	2.83	2.62	
A3	MH	P4	MH			0.63				0.50	5.00	13.80			8.69	21	CL. IV	RCP	0.0051	15.73	0.013	11.30	3.61	0.77	5.17	0.08	6.07	1.70	2.62	2.54	
P4	MH	A6	MH		1.26	2.97	0.80		1.01	2.38	5.00	13.80		17.39	49.68	42	CL. IV	RCP	0.0050	152.77	0.013	70.94	5.16	0.70	7.96	0.76	5.99	3.34	-0.85	-1.61	
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	13.80	3.04		3.04	18	CL. IV	RCP	0.0044	18.30	0.013	6.94	1.72	0.44	3.73	0.08	3.62	1.75	0.37	0.29	
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	13.80	26.77		26.77	30	CL. IV	RCP	0.0050	29.16	0.013	29.11	5.45	0.92	6.82	0.15	3.45	1.50	-0.55	-0.70	
A11	MH	D6	DI			1.94				1.55	5.00	13.80			26.77	30	CL. IV	RCP	0.0054	11.12	0.013	30.12	5.45	0.89	6.99	0.06	3.42	1.62	-0.70	-0.76	
D6	MH	A9	MH			3.02				2.42	5.00	13.80			41.68	30	CL. IV	RCP	0.0101	25.70	0.013	41.24	8.49	1.01	9.66	0.26	4.42	3.75	-1.83	-2.09	
A10	DI	A9	MH	0.05	1.06	1.11	0.80	0.04	0.85	0.89	5.00	13.80	0.69	14.63	15.32	21	CL. IV	RCP	0.0095	15.84	0.013	15.41	6.37	0.99	7.43	0.15	3.50	3.20	-1.45	-1.60	
A9	MH	A6	MH			4.13				3.30	5.00	13.80			56																

A15	DI	K4	MH	0.21		0.44	0.80	0.17		0.35	5.00	13.80	2.90		6.07	21	CL. IV	RCP	0.0054	35.24	0.013	11.63	2.52	0.52	4.88	0.19	3.90	2.19	-0.04	-0.23	
A18	DI	A19	DI	0.20		0.20	0.80	0.16		0.16	5.00	13.80	2.76		2.76	21	CL. IV	RCP	0.0052	36.49	0.013	11.43	1.15	0.24	3.80	0.19	3.72	1.40	0.57	0.38	
A19	DI	K4	MH	0.19		0.39	0.80	0.15		0.31	5.00	13.80	2.62		5.38	21	CL. IV	RCP	0.0053	22.76	0.013	11.50	2.24	0.47	4.64	0.12	3.90	1.77	0.38	0.26	
K4	DI	K5	MH			16.0	0.80			12.77	5.00	13.80			220.25	60	CL. IV	RCP	0.0051	21.61	0.013	185.75	11.22	1.19	10.88	0.11	3.50	-0.26	-1.24	-1.35	
A21	DI	K5	MH	0.13		0.13	0.80	0.10		0.10	5.00	13.80	1.79		1.79	21	CL. IV	RCP	0.0051	23.33	0.013	11.36	0.75	0.16	3.21	0.12	3.30	1.50	0.05	-0.07	
A23	DI	K5	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	13.80	1.24	2.21	3.45	21	CL. IV	RCP	0.0059	5.09	0.013	12.16	1.43	0.28	4.25	0.03	3.26	1.50	0.01	-0.02	
K5	MH	K6	MH			16.34				13.07	5.00	13.80			225.49	60	CL. IV	RCP	0.0050	106.82	0.013	183.39	11.48	1.23	10.74	0.53	3.20	-0.45	-1.35	-1.88	
K6	MH	A25	MH			16.34				13.07	5.00	13.80			225.49	60	CL. IV	RCP	0.0050	79.34	0.013	184.86	11.48	1.22	10.83	0.40	3.15	0.03	-1.88	-2.28	
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	13.80	6.35		6.35	21	CL. IV	RCP	0.0060	8.27	0.013	12.32	2.64	0.52	5.17	0.05	2.09	1.75	-1.41	-1.46	
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	13.80	28.29		28.29	30	CL. IV	RCP	0.0100	17.99	0.013	41.01	5.76	0.69	9.02	0.18	2.09	1.50	-1.91	-2.09	
A25	MH	A29	MH			18.85				15.08	5.00	13.80			260.13	60	CL. IV	RCP	0.0050	210.39	0.013	183.93	13.25	1.41	10.77	1.05	2.35	0.13	-2.78	-3.83	
A29	MH	PUMP 1				27.54				22.03	5.00	13.80			380.05	72	CL. IV	RCP	0.0061	32.65	0.013	331.35	13.44	1.15	13.48	0.20	3.45	3.25	-5.80	-6.00	
PUMP 1		OUTFALL				27.54	0.80			22.03	5.00	13.80			380.05	72	CL. IV	RCP	0.0065	271.27	0.013	340.04	13.44	1.12	13.83	1.75	5.00	3.25	-4.25	-6.00	
PUMP STATION 2																															
EX C6		EX C5		0.30		0.30	0.80	0.24		0.24	5.00	13.80	4.14		4.14	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	11.86	1.98	6.89	0.89	12.46	4.01	7.78	6.89	
EX C5		EX C4				0.30	0.80			0.24	5.00	13.80			4.14	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	5.27	0.48	10.76	1.34	11.29	4.30	5.99	4.65	
EX C4	MH	EX C3	MH		5.85	6.15	0.80		4.68	4.92	5.00	13.80		80.73	84.87	30	CL. IV	RCP	0.0122	281.77	0.013	45.37	17.29	1.87	10.63	3.45	10.85	3.90	4.45	1.00	
EX C3	MH	B2A	MH		0.93	7.08	0.80		0.74	5.66	5.00	13.80		12.83	97.70	30	CL. IV	RCP	0.0204	19.15	0.013	58.51	19.90	1.67	13.71	0.39	5.10	2.07	0.53	0.14	
B1	DI	B2	MH	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	21	CL. IV	RCP	0.0049	32.65	0.013	11.09	1.32	0.29	3.87	0.16	5.00	1.99	1.26	1.10	
B2	MH	B2A	MH			0.23	0.80			0.18	5.00	13.80			3.17	21	CL. IV	RCP	0.0048	12.42	0.013	11.01	1.32	0.29	3.84	0.06	5.02	2.17	1.10	1.04	
B2A	MH	B3	MH			7.31	0.80			5.85	5.00	13.80			100.88	54	CL. IV	RCP	0.0051	42.94	0.013	140.71	6.34	0.72	9.64	0.22	5.00	0.36	0.14	-0.08	
B4	DI	B3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	13.80	4.00	3.45	7.45	21	CL. IV	RCP	0.0095	36.88	0.013	15.43	3.10	0.48	6.35	0.35	5.06	2.00	1.31	0.96	
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	21	CL. IV	RCP	0.0104	22.17	0.013	16.13	0.86	0.13	4.23	0.23	5.00	2.00	1.25	1.02	
B3	MH	B8	MH			8.00	0.80			6.40	5.00	13.80			110.40	54	CL. IV	RCP	0.0060	86.54	0.013	152.38	6.94	0.72	10.44	0.52	4.80	0.38	-0.08	-0.60	
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	21	CL. IV	RCP	0.0103	20.46	0.013	16.05	0.86	0.13	4.20	0.21	4.90	2.00	1.15	0.94	
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	13.80	3.86		3.86	21	CL. IV	RCP	0.0103	16.43	0.013	16.11	1.61	0.24	5.29	0.17	4.96	2.00	1.21	1.04	
B8	MH	B9	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	13.80		30.64	146.97	54	CL. IV	RCP	0.0075	128.38	0.013	169.99	9.24	0.86	12.08	0.96	4.75	0.85	-0.60	-1.56	
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	13.80	1.24		1.24	21	CL. IV	RCP	0.0102	18.66	0.013	15.98	0.52	0.08	3.52	0.19	5.30	4.12	-0.57	-0.76	
B9	MH	B11	MH			10.74	0.80			8.59	5.00	13.80			148.21	54	CL. IV	RCP	0.0075	158.44	0.013	170.37	9.32	0.87	12.10	1.19	5.33	2.39	-1.56	-2.75	
EX11	DI	B11	MH		3.86	3.86	0.80		3.09	3.09	5.00	13.80		53.27	53.27	36	CL. IV	RCP	0.0103	28.16	0.013	67.66	7.54	0.79	10.63	0.29	7.16	3.70	0.46	0.17	
B11	DI	Q1	MH			14.60	0.80			11.68	5.00	13.80			201.48	54	CL. IV	RCP	0.0051	17.53	0.013	140.85	12.67	1.43	10.18	0.09	7.00	5.65	-3.15	-3.24	
Q1	DI	Q2	MH	0.10		14.70	0.80	0.08		11.76	5.00	13.80	1.38		202.86	54	CL. IV	RCP	0.0051	45.00	0.013	140.54	12.76	1.44	10.16	0.23	6.82	5.56	-3.24	-3.47	
EX9	EX DI	EX8	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	2.99	1.00	3.47	0.03	7.21	2.25	3.96	3.99	
EX10	EX DI	EX8	MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	1.91	0.30	5.48	0.76	7.00	4.09	1.66	0.90	
EX8	EX DI	Q2	MH		1.53	1.87	0.80		1.22	1.50	5.00	13.80		21.11	25.81	21	CL. IV	RCP	0.0101	68.55	0.013	15.89	10.73	1.62	7.60	0.69	7.25	5.55	-0.05	-0.74	
Q2	MH	B12	MH		0.60	17.17	0.80		0.48	13.74	5.00	13.80		8.28	236.95	54	CL. IV	RCP	0.0080	109.46	0.013	176.26	14.90	1.34	12.74	0.88	6.40	5.37	-3.47	-4.35	
B12	MH	B13	MH			17.17	0.80			13.74	5.00	13.80			236.95	54	CL. IV	RCP	0.0081	92.70	0.013	176.82	14.90	1.34	12.79	0.75	4.50	4.35	-4.35	-5.10	
B13	MH	B14	MH			17.17	0.80			13.74	5.00	13.80			236.95	54	CL. IV	RCP	0.0082	24.47	0.013	177.72	14.90	1.33	12.85	0.20	6.00	6.60	-5.10	-5.30	
B14	MH	B16	MH			17.17	0.80			13.74	5.00	13.80			236.95	54	CL. IV	RCP	0.0100	112.30	0.013	196.32	14.90	1.21	14.20	1.12	5.50	6.30	-5.30	-6.42	
B15	DI	B16	MH	0.52	0.71	1.23	0.80	0.42	0.57	0.98	5.00	13.80	7.18	9.80	16.97	21	CL. IV	RCP	0.0102	34.33	0.013	15.99	7.06	1.06	7.65	0.35	4.50	2.75	0.00	-0.35	
B16	MH	PUMP 2				18.40	0.80			14.72	5.00	13.80			253.92	54	CL. IV	RCP	0.0187	4.28	0.013	268.76	15.97	0.94	19.43	0.08	6.00	9.42	-7.92	-8.00	
PUMP 2		OUTFALL				18.40	0.80			14.72	5.00	13.80			253.92	72	CL. IV	RCP	0.0103	48.62	0.013	429.33	8.98	0.59	15.94	0.50	6.00	6.50	-6.50	-7.00	

P4	2.90	42	49.68	152.77	0.0050	0.0050	0.76	5.16	0.10	23.60	2.45	57.9	0.0934	0.03	0	0.00	0.14	0.18	0.07	0.85	3.75	5.99	2.24	Acceptable	
A3	3.75	21	8.69	15.73	0.0051	0.0051	0.08	3.61	0.05	8.69	1.61	14.0	0.0401	0.01	0	0.00	0.06	0.08	0.03	0.11	3.87	6.07	2.20	Acceptable	
A5	3.87	21	3.86	43.53	0.0049	0.0049	0.21	1.61	0.01	3.17	1.80	5.7	0.0501	0.02	90	0.04	0.06	0.08	0.03	0.25	4.12	5.28	1.16	Acceptable	*
A4	4.12	18	3.17	23.16	0.0050	0.0050	0.12	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.01	0.02	0.01	0.12	4.24	5.78	1.54	Acceptable	*
A2	3.87	18	2.21	33.41	0.0050	0.0050	0.17	1.25	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.17	4.04	5.43	1.39	Acceptable	*
A1	3.87	18	2.62	24.14	0.0154	0.0154	0.37	1.48	0.01	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.01	0.01	0.00	0.38	4.24	5.87	1.63	Acceptable	*
P3	3.75	42	23.60	185.68	0.0050	0.0050	0.93	2.45	0.02	3.59	3.72	13.4	0.2150	0.08	90	0.15	0.25	0.32	0.12	1.09	4.85	7.86	3.01	Acceptable	
P2	4.85	30	3.59	15.00	0.0002	0.0050	0.00	3.72	0.05	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.05	0.07	0.03	0.04	4.88	7.60	2.72	Acceptable	*
P1	4.85	30	1.38	31.43	0.0001	0.0050	0.00	2.72	0.03	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.03	0.04	0.01	0.02	4.87	7.80	2.93	Acceptable	*
D5	4.95	30	14.90	191.66	0.0050	0.0050	0.96	3.04	0.04	14.90	3.04	45.3	0.1431	0.05	90	0.10	0.19	0.24	0.09	1.05	6.01	5.70	-0.31	Unacceptable	
D4	6.01	30	14.90	28.44	0.0049	0.0049	0.14	3.04	0.04	14.90	3.04	45.3	0.1431	0.05	25	0.02	0.11	0.14	0.05	0.19	6.20	5.40	-0.80	Unacceptable	
D3	6.20	30	14.90	161.07	0.0050	0.0050	0.81	3.04	0.04	14.90	3.04	45.3	0.1431	0.05	22	0.02	0.11	0.14	0.05	0.86	7.06	6.77	-0.29	Unacceptable	
D2	7.06	30	14.90	33.82	0.0050	0.0050	0.17	3.04	0.04	7.45	2.37	17.7	0.0874	0.03	45	0.03	0.10	0.13	0.05	0.23	7.30	7.00	-0.30	Unacceptable	
D1	7.30	24	7.45	66.51	0.0050	0.0050	0.33	2.37	0.02	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.02	0.03	0.01	0.34	7.64	4.80	-2.84	Unacceptable	*
EX12	7.30	24	7.45	27.89	0.0050	0.0050	0.14	2.37	0.02	0.00	0.00	0.0	0.0000	0.00	60	0.00	0.02	0.03	0.01	0.15	7.45	6.04	-1.41	Unacceptable	*
PUMP 2																									
B16	-4.40	54	253.92	4.28	0.0126	0.0187	0.05	19.43	1.47	253.92	7.65	1941.6	0.9079	0.32	0	0.00	1.78	2.32	0.89	0.95	-3.45	6.00	9.45	Acceptable	Starting HGL assumed at normal depth of the pipe
B15	-3.45	21	16.97	34.33	0.0087	0.0102	0.30	7.65	0.23	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.23	0.30	0.11	0.45	-3.01	4.08	7.09	Acceptable	*
B14	-3.45	54	236.95	112.30	0.0100	0.0100	1.12	14.90	0.86	236.95	14.90	3530.1	3.4465	1.21	45	1.31	3.38	4.39	1.69	2.81	-0.64	5.50	6.14	Acceptable	
B13	-0.64	54	236.95	24.47	0.0145	0.0082	0.36	14.90	0.86	236.95	14.90	3530.1	3.4465	1.21	53	1.62	3.69	4.79	1.84	2.20	1.55	6.00	4.45	Acceptable	
B12	1.55	54	236.95	92.70	0.0145	0.0081	1.35	14.90	0.86	236.95	14.90	3530.1	3.4465	1.21	38	0.97	3.03	3.94	1.52	2.86	4.42	4.50	0.08	Acceptable	
Q2	4.42	54	236.95	109.46	0.0145	0.0080	1.59	14.90	0.86	228.67	12.67	2896.8	2.4920	0.87	90	1.74	3.48	4.52	1.74	3.33	7.75	6.40	-1.35	Unacceptable	
EX8	7.75	21	25.81	68.55	0.0265	0.0101	1.82	10.73	0.45	4.69	1.91	9.0	0.0567	0.02	57	0.03	0.49	0.64	0.25	2.14	9.89	7.25	-2.64	Unacceptable	
EX10	9.89	15	2.35	50.59	0.0150	0.0150	0.76	1.91	0.01	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.01	0.02	0.01	0.77	10.65	6.58	-4.07	Unacceptable	*
EX9	9.89	12	2.35	6.91	0.0043	0.0043	0.03	2.99	0.03	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.03	0.05	0.02	0.05	9.94	6.79	-3.15	Unacceptable	*
Q1	7.75	54	202.86	45.00	0.0106	0.0051	0.48	12.76	0.63	201.48	12.67	2552.4	2.4920	0.87	0	0.00	1.50	1.95	0.75	1.23	8.98	6.40	-2.58	Unacceptable	*
B11	8.98	54	201.48	17.53	0.0105	0.0051	0.18	12.67	0.62	201.48	7.54	1518.3	0.8818	0.31	90	0.62	1.55	2.01	0.77	0.96	9.94	7.00	-2.94	Unacceptable	
EX11	9.94	36	53.27	28.16	0.0064	0.0103	0.18	7.54	0.22	53.27	7.54	401.4	0.8818	0.31	45	0.34	0.86	1.12	0.43	0.61	10.55	7.16	-3.39	Unacceptable	
B9	9.94	54	148.21	158.44	0.0057	0.0075	0.90	9.32	0.34	148.21	9.24	1369.6	1.3260	0.46	0	0.00	0.80	1.04	0.40	1.30	11.24	5.33	-5.91	Unacceptable	
B10	11.24	21	1.24	18.66	0.0001	0.0102	0.00	0.52	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	11.24	4.88	-6.36	Unacceptable	*
B8	11.24	54	146.97	128.38	0.0056	0.0075	0.72	9.24	0.33	116.33	6.94	807.5	0.7482	0.26	0	0.00	0.59	0.77	0.30	1.10	12.34	4.75	-7.59	Unacceptable	
B7	12.34	21	3.86	16.43	0.0006	0.0103	0.01	1.61	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.01	0.02	12.36	4.54	-7.82	Unacceptable	*
B6	12.34	21	2.07	20.46	0.0002	0.0103	0.00	0.86	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.01	12.34	4.48	-7.86	Unacceptable	*
B3	12.34	54	110.40	86.54	0.0032	0.0060	0.27	6.94	0.19	12.70	3.10	39.3	0.1490	0.05	0	0.00	0.24	0.31	0.12	0.43	12.77	4.80	-7.97	Unacceptable	
B5	12.77	21	2.07	22.17	0.0002	0.0104	0.00	0.86	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.01	12.77	4.58	-8.19	Unacceptable	*
B4	12.77	21	7.45	36.88	0.0022	0.0095	0.08	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.04	0.05	0.02	0.11	12.87	4.64	-8.23	Unacceptable	*
B2A	12.77	54	100.88	42.94	0.0026	0.0051	0.11	6.34	0.16	100.88	19.90	2007.9	6.1518	2.15	0	0.00	2.31	3.00	1.15	1.27	14.04	5.00	-9.04	Unacceptable	
EX C3	14.04	30	97.70	19.15	0.0568	0.0204	1.09	19.90	1.54	3.17	1.32	4.2	0.0270	0.01	90	0.02	1.57	2.04	0.78	2.11	16.14	5.10	-11.04	Unacceptable	
B2	14.04	21	3.17	12.42	0.0004	0.0048	0.00	1.32	0.01	3.17	1.32	4.2	0.0270	0.01	90	0.02	0.04	0.05	0.02	0.02	14.06	5.02	-9.04	Unacceptable	
B1	14.06	21	3.17	32.65	0.0004	0.0049	0.01	1.32	0.01	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.01	0.01	0.00	0.02	14.08	4.58	-9.50	Unacceptable	*
EX C4	16.14	30	84.87	281.77	0.0428	0.0122	12.07	17.29	1.16	4.14	5.27	21.8	0.4315	0.15	35	0.12	1.43	1.86	0.72	13.00	29.14	10.85	-18.29	Unacceptable	
EX C5	29.14	12	4.14	23.32	0.0135	0.0575	0.31	5.27	0.11	4.14	11.86	49.1	2.1842	0.76	35	0.61	1.48	1.93	0.74	1.06	30.20	11.29	-18.91	Unacceptable	
EX C6	30.20	8	4.14	29.72	0.1174	0.0300	3.49	11.86	0.55	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.55	0.71	0.27	3.84	34.04	12.04	-22.00	Unacceptable	*
																					10.58				

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.
Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

100-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3 - SPLIT PS1 INFLOWS																																
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS	
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT		
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN				FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
													C _i =	1.25																		
CAMERON ST BYPASS																																
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	13.80		9.11	9.11	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	5.15	0.87	6.72	2.38	7.15	8.22	-2.57	-4.95	outfall unknown	
DUKE ST																																
EX GRATE	MH	EX OUTFALL		0.21		0.21	0.80	0.17		0.17	5.00	13.80	2.90		2.90	15	CL. IV	RCP	0.0212	84.07	0.013	9.40	2.36	0.31	6.58	1.78	2.57	1.20	0.12	-1.66		
DUKE ST BYPASS																																
EX13	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	13.80		31.05	31.05	24	CL. IV	RCP	0.0100	187.55	0.013	22.64	9.88	1.37	8.29	1.88	8.44	4.99	1.45	-0.43		
PUMP STATION 1																																
EX12	EX DI	D2	MH	0.54		0.54	0.80	0.43		0.43	5.00	13.80	7.45		7.45	21	CL. IV	RCP	0.0050	27.89	0.013	11.22	3.10	0.66	4.99	0.14	6.46	3.55	1.16	1.02		
D1	GRATE	D2	MH	0.19	0.35	0.54	0.80	0.15	0.28	0.43	5.00	13.80	2.62	4.83	7.45	21	CL. IV	RCP	0.0050	66.51	0.013	11.16	3.10	0.67	4.96	0.33	4.80	1.72	1.33	1.00		
D2	MH	D3	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	33.82	0.013	16.03	4.74	0.93	5.87	0.17	7.00	4.00	1.00	0.83		
D3	MH	D4	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	161.07	0.013	16.04	4.74	0.93	5.87	0.81	6.77	3.94	0.83	0.02		
D4	MH	D5	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0049	28.44	0.013	15.87	4.74	0.94	5.81	0.14	5.40	3.38	0.02	-0.12		
D5	MH	D6	MH			1.08				0.86	5.00	13.80			14.90	24	CL. IV	RCP	0.0050	191.66	0.013	16.00	4.74	0.93	5.86	0.96	5.70	3.82	-0.12	-1.08		
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	13.80	1.38		1.38	24	CL. IV	RCP	0.0050	31.43	0.013	16.03	0.44	0.09	2.81	0.16	8.22	1.47	4.75	4.59		
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	13.80	2.21		3.59	24	CL. IV	RCP	0.0050	15.00	0.013	15.99	1.14	0.22	3.92	0.08	8.02	1.27	4.75	4.68		
P3	MH	P4	MH		1.45	1.71	0.80		1.16	1.37	5.00	13.80		20.01	23.60	36	CL. IV	RCP	0.0050	185.68	0.013	47.19	3.34	0.50	6.68	0.93	7.86	4.78	0.08	-0.85		
A1	DI	A3	MH	0.19		0.19	0.80	0.15		0.15	5.00	13.80	2.62		2.62	15	CL. IV	RCP	0.0154	24.14	0.013	8.00	2.14	0.33	5.74	0.37	6.29	1.75	3.29	2.92		
A2	DI	A3	MH	0.16		0.16	0.80	0.13		0.13	5.00	13.80	2.21		2.21	15	CL. IV	RCP	0.0050	33.41	0.013	4.57	1.80	0.48	3.68	0.17	5.85	2.00	2.60	2.43		
A4	DI	A5	DI	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	15	CL. IV	RCP	0.0050	23.16	0.013	4.57	2.59	0.70	4.02	0.12	6.20	2.00	2.95	2.83		
A5	DI	A3	MH	0.05		0.28	0.80	0.04		0.22	5.00	13.80	0.69		3.86	18	CL. IV	RCP	0.0049	43.53	0.013	7.35	2.19	0.53	4.20	0.21	5.70	1.37	2.83	2.62		
A3	MH	P4	MH			0.63				0.50	5.00	13.80			8.69	18	CL. IV	RCP	0.0051	15.73	0.013	7.49	4.92	1.16	4.87	0.08	6.07	1.95	2.62	2.54		
P4	MH	A6	MH		1.26	2.97	0.80		1.01	2.38	5.00	13.80		17.39	49.68	36	CL. IV	RCP	0.0050	152.77	0.013	47.03	7.03	1.06	7.65	0.76	5.99	3.84	-0.85	-1.61		
A8	DI	A6	MH	0.22		0.22	0.80	0.18		0.18	5.00	13.80	3.04		3.04	15	CL. IV	RCP	0.0044	18.30	0.013	4.27	2.47	0.71	3.79	0.08	3.62	2.00	0.37	0.29		
A12	DI	A11	MH	1.94		1.94	0.80	1.55		1.55	5.00	13.80	26.77		26.77	24	CL. IV	RCP	0.0050	29.16	0.013	16.06	8.52	1.67	5.88	0.15	3.45	2.00	-0.55	-0.70		
A11	MH	D6	DI			1.94				1.55	5.00	13.80			26.77	24	CL. IV	RCP	0.0054	11.12	0.013	16.61	8.52	1.61	6.08	0.06	3.42	2.12	-0.70	-0.76		
D6	MH	A9	MH			3.02				2.42	5.00	13.80			41.68	24	CL. IV	RCP	0.0101	25.70	0.013	22.75	13.27	1.83	8.33	0.26	4.42	4.25	-1.83	-2.09		
A10	DI	A9	MH	0.05	1.06	1.11	0.80	0.04	0.85	0.89	5.00	13.80	0.69	14.63	15.32	18	CL. IV	RCP	0.0095	15.84	0.013	10.22	8.67	1.50	6.65	0.15	3.50	3.45	-1.45	-1.60		
A9	MH	A6	MH			4.13																										

A15	DI	K4	MH	0.21		0.44	0.80	0.17		0.35	5.00	13.80	2.90		6.07	18	CL. IV	RCP	0.0054	35.24	0.013	7.71	3.44	0.79	4.84	0.19	3.90	2.44	-0.04	-0.23	
A18	DI	A19	DI	0.20		0.20	0.80	0.16		0.16	5.00	13.80	2.76		2.76	18	CL. IV	RCP	0.0052	36.49	0.013	7.58	1.56	0.36	3.90	0.19	3.72	1.65	0.57	0.38	
A19	DI	K4	MH	0.19		0.39	0.80	0.15		0.31	5.00	13.80	2.62		5.38	18	CL. IV	RCP	0.0053	22.76	0.013	7.62	3.05	0.71	4.66	0.12	3.90	2.02	0.38	0.26	
K4	DI	K5	MH			16.0	0.80			12.77	5.00	13.80			220.25	54	CL. IV	RCP	0.0051	21.61	0.013	140.25	13.85	1.57	10.14	0.11	3.50	0.24	-1.24	-1.35	
A21	DI	K5	MH	0.13		0.13	0.80	0.10		0.10	5.00	13.80	1.79		1.79	18	CL. IV	RCP	0.0051	23.33	0.013	7.53	1.02	0.24	3.37	0.12	3.30	1.75	0.05	-0.07	
A23	DI	K5	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	13.80	1.24	2.21	3.45	18	CL. IV	RCP	0.0059	5.09	0.013	8.06	1.95	0.43	4.33	0.03	3.26	1.75	0.01	-0.02	
K5	MH	K6	MH			16.34				13.07	5.00	13.80			225.49	54	CL. IV	RCP	0.0050	106.82	0.013	138.47	14.18	1.63	10.01	0.53	3.20	0.05	-1.35	-1.88	
K6	MH	A25	MH			16.34				13.07	5.00	13.80			225.49	54	CL. IV	RCP	0.0050	79.34	0.013	139.58	14.18	1.62	10.09	0.40	3.15	0.53	-1.88	-2.28	
A26	DI	A25	MH	0.46		0.46	0.80	0.37		0.37	5.00	13.80	6.35		6.35	18	CL. IV	RCP	0.0060	8.27	0.013	8.16	3.59	0.78	5.13	0.05	2.09	2.00	-1.41	-1.46	
A27	DI	A25	MH	2.05		2.05	0.80	1.64		1.64	5.00	13.80	28.29		28.29	24	CL. IV	RCP	0.0100	17.99	0.013	22.62	9.00	1.25	8.28	0.18	2.09	2.00	-1.91	-2.09	
A25	MH	A29-King	MH			18.85				15.08	5.00	13.80			260.13	54	CL. IV	RCP	0.0050	210.39	0.013	138.87	16.36	1.87	10.04	1.05	2.35	0.63	-2.78	-3.83	
A29-Prince	MH	PUMP 1				8.69	0.80			6.95	5.00	13.80			119.92	42	CL. IV	RCP	0.0077	32.65	0.013	88.01	12.46	1.36	10.52	0.25	3.45	4.45	-4.50	-4.75	
A29-King	MH	PUMP 1				18.85	0.80			15.08	5.00	13.80			260.13	54	CL. IV	RCP	0.0061	32.65	0.013	153.86	16.36	1.69	11.12	0.20	3.45	4.75	-5.80	-6.00	
PUMP 1		OUTFALL				27.54	0.80			22.03	5.00	13.80			380.05	60	CL. IV	RCP	0.0065	271.27	0.013	209.11	19.36	1.82	12.25	1.75	5.00	4.25	-4.25	-6.00	
PUMP STATION 2																															
EX C6		EX C5		0.30		0.30	0.80	0.24		0.24	5.00	13.80	4.14		4.14	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	11.86	1.98	6.89	0.89	12.46	4.01	7.78	6.89	
EX C5		EX C4				0.30	0.80			0.24	5.00	13.80			4.14	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	5.27	0.48	10.76	1.34	11.29	4.30	5.99	4.65	
EX C4	MH	EX C3	MH		5.85	6.15	0.80		4.68	4.92	5.00	13.80		80.73	84.87	30	CL. IV	RCP	0.0122	281.77	0.013	45.37	17.29	1.87	10.63	3.45	10.85	3.90	4.45	1.00	
EX C3	MH	B2A	MH		0.93	7.08	0.80		0.74	5.66	5.00	13.80		12.83	97.70	30	CL. IV	RCP	0.0204	19.15	0.013	58.51	19.90	1.67	13.71	0.39	5.10	2.07	0.53	0.14	
B1	DI	B2	MH	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	18	CL. IV	RCP	0.0049	32.65	0.013	7.35	1.80	0.43	3.95	0.16	5.00	2.24	1.26	1.10	
B2	MH	B2A	MH			0.23	0.80			0.18	5.00	13.80			3.17	18	CL. IV	RCP	0.0048	12.42	0.013	7.30	1.80	0.43	3.92	0.06	5.02	2.42	1.10	1.04	
B2A	MH	B3	MH			7.31	0.80			5.85	5.00	13.80			100.88	48	CL. IV	RCP	0.0051	42.94	0.013	102.78	8.03	0.98	9.49	0.22	5.00	0.86	0.14	-0.08	
B4	DI	B3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	13.80	4.00	3.45	7.45	18	CL. IV	RCP	0.0095	36.88	0.013	10.23	4.22	0.73	6.31	0.35	5.06	2.25	1.31	0.96	
B5	DI	B3	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0104	22.17	0.013	10.70	1.17	0.19	4.48	0.23	5.00	2.25	1.25	1.02	
B3	MH	B8	MH			8.00	0.80			6.40	5.00	13.80			110.40	48	CL. IV	RCP	0.0060	86.54	0.013	111.31	8.79	0.99	10.27	0.52	4.80	0.88	-0.08	-0.60	
B6	DI	B8	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0103	20.46	0.013	10.64	1.17	0.19	4.45	0.21	4.90	2.25	1.15	0.94	
B7	DI	B8	MH	0.28		0.28	0.80	0.22		0.22	5.00	13.80	3.86		3.86	18	CL. IV	RCP	0.0103	16.43	0.013	10.68	2.19	0.36	5.50	0.17	4.96	2.25	1.21	1.04	
B8	MH	B9	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	13.80		30.64	146.97	48	CL. IV	RCP	0.0075	128.38	0.013	124.17	11.70	1.18	11.36	0.96	4.75	1.35	-0.60	-1.56	
B10	DI	B9	MH	0.09		0.09	0.80	0.07		0.07	5.00	13.80	1.24		1.24	18	CL. IV	RCP	0.0102	18.66	0.013	10.60	0.70	0.12	3.66	0.19	5.30	4.37	-0.57	-0.76	
B9	MH	B11	MH			10.74	0.80			8.59	5.00	13.80			148.21	48	CL. IV	RCP	0.0075	158.44	0.013	124.44	11.79	1.19	11.39	1.19	5.33	2.89	-1.56	-2.75	
EX11	DI	B11	MH																												

100-YEAR HGL COMPUTATIONS - ALTERNATE 3 - SPLIT PS1 INFLOWS																									
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev. (2)	D _o (3)	Q _o (4)	L _o (5)	S _o ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance	Remarks
								V _o (8)	H _o (9)	Q _i (10)	V _i (11)	Q _i V _i (12)	$\frac{V_i^2}{(2g)}$ (2g) (13)	H _i (13)	Angle (14)	H _Δ (15)	H _t (16)	1.3 H _t (17)	0.5 H _t (18)						
CAMERON ST																									
EX C1	10.20	18	9.11	237.53	0.0100	0.0100	2.38	5.15	0.10	9.11	5.15	46.9	0.4125	0.14	0	0.00	0.25	0.32	0.12	2.50	12.70	7.15	-5.55	Unacceptable	Outfall unknown; Starting HGL at 100-yr WSE of River
DUKE ST																									
EX GRATE	10.20	15	2.90	84.07	0.0212	0.0212	1.78	2.36	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.03	0.01	1.79	11.99	2.57	-9.42	Unacceptable	To be removed or upgraded during improvements to Point Lumley Park; Starting HGL at 100-yr WSE of River
DUKE ST BYPASS																									
EX13	10.20	24	31.05	187.55	0.0100	0.0100	1.88	9.88	0.38	31.05	8.29	257.3	1.0666	0.37	0	0.00	0.75	0.98	0.38	2.26	12.46	8.44	-4.02	Unacceptable	Starting HGL at 100-yr WSE of River
PUMP 1																									
A29-King	-2.40	54	260.13	32.65	0.0132	0.0061	0.43	11.12	0.48	380.05	16.36	6216.1	4.1540	1.45	90	2.91	4.84	6.29	2.42	2.85	0.45	3.45	3.00	Acceptable	Starting HGL assumed at normal depth of the pipe
A25	0.45	54	260.13	210.39	0.0050	0.0050	1.05	16.36	1.04	260.13	14.18	3688.1	3.1214	1.09	0	0.00	2.13	2.77	1.07	2.12	2.57	2.35	-0.22	Unacceptable	
A27	2.57	24	28.29	17.99	0.0100	0.0100	0.18	9.00	0.31	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.31	0.41	0.16	0.38	2.95	1.67	-1.28	Unacceptable	*
A26	2.57	18	6.35	8.27	0.0060	0.0060	0.05	3.59	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.08	2.65	1.67	-0.98	Unacceptable	*
K6	2.57	54	225.49	79.34	0.0050	0.0050	0.40	14.18	0.78	225.49	10.01	2257.7	1.5566	0.54	0	0.00	1.33	1.72	0.66	1.06	3.63	3.15	-0.48	Unacceptable	
K5	3.63	54	225.49	106.82	0.0100	0.0050	1.06	10.01	0.39	225.49	13.85	3122.7	2.9779	1.04	0	0.00	1.43	1.86	0.72	1.78	5.41	3.20	-2.21	Unacceptable	
A23	5.41	18	3.45	5.09	0.0059	0.0059	0.03	1.95	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.04	5.45	2.84	-2.61	Unacceptable	*
A21	5.41	18	1.79	23.33	0.0051	0.0051	0.12	1.02	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.01	0.00	0.12	5.53	2.88	-2.65	Unacceptable	*
K4	5.41	54	220.25	21.61	0.0051	0.0051	0.11	13.85	0.74	220.25	13.13	2891.4	2.6762	0.94	0	0.00	1.68	2.19	0.84	0.95	6.36	3.50	-2.86	Unacceptable	
A19	6.36	18	5.38	22.76	0.0053	0.0053	0.12	3.05	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.14	6.50	3.48	-3.02	Unacceptable	*
A18	6.50	18	2.76	36.49	0.0052	0.0052	0.19	1.56	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.20	6.70	3.30	-3.40	Unacceptable	*
A15	6.36	18	6.07	35.24	0.0054	0.0054	0.19	3.44	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.22	6.58	3.48	-3.10	Unacceptable	*
A14	6.58	18	3.17	36.21	0.0050	0.0050	0.18	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.19	6.77	3.26	-3.51	Unacceptable	*
K3	6.36	54	208.79	23.22	0.0052	0.0052	0.12	13.13	0.67	208.79	8.89	1856.8	1.2280	0.43	0	0.00	1.10	1.43	0.55	0.67	7.03	3.70	-3.33	Unacceptable	
EX3	7.03	42	85.56	28.94	0.0152	0.0152	0.44	8.89	0.31	63.89	12.26	783.2	2.3330	0.82	30	0.65	1.78	2.31	0.89	1.60	8.63	3.52	-5.11	Unacceptable	
A17	8.63	18	3.73	9.29	0.0054	0.0054	0.05	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	22	0.00	0.02	0.02	0.01	0.06	8.69	3.51	-5.18	Unacceptable	*
EX2	8.63	30	60.17	296.43	0.0099	0.0099	2.92	12.26	0.58	3.73	4.74	17.7	0.3495	0.12	72	0.23	0.94	1.22	0.47	3.53	12.16	9.00	-3.16	Unacceptable	
EX1	12.16	12	3.73	10.59	0.0104	0.0104	0.11	4.74	0.09	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.09	0.11	0.04	0.17	12.32	8.93	-3.39	Unacceptable	*
EX7	7.03	42	123.23	33.66	0.0051	0.0051	0.17	12.81	0.64	95.63	13.00	1243.5	2.6252	0.92	28	0.42	1.98	2.57	0.99	1.45	8.49	3.50	-4.99	Unacceptable	
A13	8.49	18	3.73	4.62	0.0108	0.0108	0.05	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.02	0.02	0.01	0.06	8.55	3.55	-5.00	Unacceptable	*
EX6	8.49	36	91.91	67.14	0.0113	0.0113	0.76	13.00	0.66	84.73	17.26	1462.6	4.6267	1.62	0	0.00	2.28	2.96	1.14	1.90	10.38	4.78	-5.60	Unacceptable	
EX5	10.38	30	84.73	215.87	0.0141	0.0141	3.04	17.26	1.16	3.17	4.04	12.8	0.2536	0.09	51	0.12	1.36	1.77	0.68	3.93	14.31	9.00	-5.31	Unacceptable	
EX4	14.31	12	3.17	26.91	0.0104	0.0104	0.28	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.06	0.08	0.03	0.32	14.63	9.47	-5.16	Unacceptable	*
A29-Prince	-1.95	42	119.92	32.65	0.0108	0.0077	0.35	10.52	0.43	122.27	4.59	561.5	0.3275	0.11	90	0.23	0.77	1.01	0.39	0.74	-1.21	3.45	4.66	Acceptable	
A28	-1.21	42	119.92	85.88	0.0061	0.0061	0.52	12.46	0.60	112.06	11.40	1277.8	2.0191	0.71	90	1.41	2.72	3.54	1.36	1.88	0.67	3.28	2.61	Acceptable	
A7	0.67	18	2.35	19.85	0.0008	0.0101	0.02	4.59	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.11	0.04	0.07	0.74	3.28	2.54	Acceptable	*
A6	0.67	42	109.71	27.88	0.0100	0.0100	0.28	11.40	0.50	68.72	8.06	554.1	1.0095	0.35	90	0.71	1.56	2.03	0.78	1.30	1.97	3.31	1.34	Acceptable	
A9	1.97	36	56.99	48.27	0.0155	0.0155	0.75	8.06	0.25	56.99	13.27	756.1	2.7327	0.96	90	1.91	3.12	4.06	1.56	2.31	4.28	3.12	-1.16	Unacceptable	
A10	4.28	18	15.32	15.84	0.0095	0.0095	0.15	8.67	0.29	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.29	0.38	0.15	0.34	4.62	3.08	-1.54	Unacceptable	*
D6	4.28	24	41.68	25.70	0.0101	0.0101	0.26	13.27	0.68	41.68	8.52	355.2	1.1277	0.39	90	0.79	1.87	2.43	0.93	1.19	5.47	4.42	-1.05	Unacceptable	
A11	5.47	24	26.77	11.12	0.0054	0.0054	0.06	8.52	0.28	26.77	8.52	228.1	1.1277	0.39	0	0.00	0.68	0.88	0.34	0.40	5.87	3.42	-2.45	Unacceptable	
A12	5.87	24	26.77	29.16	0.0050	0.0050	0.15	8.52	0.28	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.28	0.37	0.14	0.33	6.20	3.03	-3.17	Unacceptable	*
A8	1.97	15	3.04	18.30	0.0044	0.0044	0.08	2.47	0.02	0.00	0.00	0.0	0.0000	0.00	30	0.00	0.02	0.03	0.01	0.10	2.06	3.20	1.14	Acceptable	*

P4	1.97	36	49.68	152.77	0.0050	0.0050	0.76	7.03	0.19	23.60	3.34	78.8	0.1731	0.06	0	0.00	0.25	0.33	0.13	0.92	2.89	5.99	3.10	Acceptable	
A3	2.89	18	8.69	15.73	0.0052	0.0051	0.08	4.87	0.09	8.69	4.20	36.5	0.2743	0.10	0	0.00	0.19	0.24	0.09	0.18	3.07	6.07	3.00	Acceptable	
A5	3.07	18	3.86	43.53	0.0013	0.0049	0.06	4.20	0.07	3.17	4.02	12.8	0.2508	0.09	90	0.18	0.33	0.43	0.17	0.27	3.34	5.28	1.94	Acceptable	*
A4	3.34	15	3.17	23.16	0.0021	0.0050	0.05	4.02	0.06	0.00	0.00	0.0	0.0000	0.00	40	0.00	0.06	0.08	0.03	0.09	3.43	5.78	2.35	Acceptable	*
A2	3.07	15	2.21	33.41	0.0012	0.0050	0.04	3.68	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.07	3.14	5.43	2.29	Acceptable	*
A1	3.07	15	2.62	24.14	0.0021	0.0154	0.05	5.74	0.13	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.13	0.17	0.06	0.13	3.20	5.87	2.67	Acceptable	*
P3	2.89	36	23.60	185.68	0.0050	0.0050	0.93	3.34	0.04	3.59	3.92	14.1	0.2385	0.08	90	0.17	0.29	0.38	0.15	1.12	4.01	7.86	3.85	Acceptable	
P2	4.01	24	3.59	15.00	0.0004	0.0050	0.01	3.92	0.06	0.00	0.00	0.0	0.0000	0.00	87	0.00	0.06	0.08	0.03	0.05	4.06	7.60	3.54	Acceptable	*
P1	4.01	24	1.38	31.43	0.0001	0.0050	0.00	2.81	0.03	0.00	0.00	0.0	0.0000	0.00	48	0.00	0.03	0.04	0.02	0.02	4.04	7.80	3.76	Acceptable	*
D5	5.47	24	14.90	191.66	0.0050	0.0050	0.96	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	90	0.24	0.45	0.59	0.23	1.19	6.66	5.70	-0.96	Unacceptable	
D4	6.66	24	14.90	28.44	0.0049	0.0049	0.14	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	25	0.06	0.27	0.35	0.13	0.27	6.93	5.40	-1.53	Unacceptable	
D3	6.93	24	14.90	161.07	0.0050	0.0050	0.81	4.74	0.09	14.90	4.74	70.7	0.3495	0.12	22	0.06	0.27	0.35	0.13	0.94	7.87	6.77	-1.10	Unacceptable	
D2	7.87	24	14.90	33.82	0.0050	0.0050	0.17	4.74	0.09	7.45	3.10	23.1	0.1490	0.05	45	0.06	0.20	0.26	0.10	0.30	8.17	7.00	-1.17	Unacceptable	
D1	8.17	21	7.45	66.51	0.0050	0.0050	0.33	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.04	0.05	0.02	0.35	8.53	4.80	-3.73	Unacceptable	*
EX12	8.17	21	7.45	27.89	0.0050	0.0050	0.14	3.10	0.04	0.00	0.00	0.0	0.0000	0.00	60	0.00	0.04	0.05	0.02	0.16	8.34	6.04	-2.30	Unacceptable	*
PUMP 2																									
B16	-4.80	48	253.92	4.28	0.0237	0.0187	0.10	17.97	1.25	253.92	6.90	1752.0	0.7392	0.26	0	0.00	1.51	1.97	0.76	0.86	-3.94	6.00	9.94	Acceptable	Starting HGL assumed at normal depth of the pipe
B15	-3.94	18	16.97	34.33	0.0198	0.0102	0.68	6.90	0.18	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.18	0.24	0.09	0.80	-3.14	4.08	7.22	Acceptable	*
B14	-3.94	48	236.95	112.30	0.0100	0.0100	1.12	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	45	2.10	5.41	7.03	2.71	3.83	-0.12	5.50	5.62	Acceptable	
B13	-0.12	48	236.95	24.47	0.0272	0.0082	0.67	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	53	2.59	5.91	7.68	2.95	3.62	3.50	6.00	2.50	Acceptable	
B12	3.50	48	236.95	92.70	0.0272	0.0081	2.52	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	38	1.55	4.86	6.32	2.43	4.95	8.45	4.50	-3.95	Unacceptable	
Q2	8.45	48	236.95	109.46	0.0272	0.0080	2.98	18.86	1.38	228.67	16.03	3666.3	3.9917	1.40	90	2.79	5.57	7.24	2.79	5.77	14.22	6.40	-7.82	Unacceptable	
EX8	14.22	18	25.81	68.55	0.0604	0.0101	4.14	14.60	0.83	4.69	1.91	9.0	0.0567	0.02	57	0.03	0.87	1.14	0.44	4.71	18.93	7.25	-11.68	Unacceptable	
EX10	18.93	15	2.35	50.59	0.0150	0.0150	0.76	1.91	0.01	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.01	0.02	0.01	0.77	19.70	6.58	-13.12	Unacceptable	*
EX9	18.93	12	2.35	6.91	0.0043	0.0043	0.03	2.99	0.03	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.03	0.05	0.02	0.05	18.98	6.79	-12.19	Unacceptable	*
Q1	14.22	48	202.86	45.00	0.0200	0.0051	0.90	16.14	1.01	201.48	16.03	3230.4	3.9917	1.40	0	0.00	2.41	3.13	1.20	2.10	16.32	6.40	-9.92	Unacceptable	*
B11	16.32	48	201.48	17.53	0.0197	0.0051	0.34	16.03	1.00	201.48	10.85	2186.4	1.8286	0.64	90	1.28	2.92	3.79	1.46	1.80	18.13	7.00	-11.13	Unacceptable	
EX11	18.13	30	53.27	28.16	0.0169	0.0103	0.48	10.85	0.46	53.27	10.85	578.0	1.8286	0.64	45	0.69	1.79	2.33	0.90	1.37	19.50	7.16	-12.34	Unacceptable	
B9	18.13	48	148.21	158.44	0.0106	0.0075	1.69	11.79	0.54	148.21	11.70	1733.4	2.1240	0.74	0	0.00	1.28	1.67	0.64	2.33	20.45	5.33	-15.12	Unacceptable	
B10	20.45	18	1.24	18.66	0.0001	0.0102	0.00	0.70	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	20.46	4.88	-15.58	Unacceptable	*
B8	20.45	48	146.97	128.38	0.0105	0.0075	1.34	11.70	0.53	116.33	8.79	1022.0	1.1985	0.42	0	0.00	0.95	1.24	0.48	1.96	22.42	4.75	-17.67	Unacceptable	
B7	22.42	18	3.86	16.43	0.0014	0.0103	0.02	2.19	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.03	22.45	4.54	-17.91	Unacceptable	*
B6	22.42	18	2.07	20.46	0.0004	0.0103	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	22.43	4.48	-17.95	Unacceptable	*
B3	22.42	48	110.40	86.54	0.0059	0.0060	0.51	8.79	0.30	12.70	4.22	53.5	0.2761	0.10	0	0.00	0.40	0.52	0.20	0.77	23.19	4.80	-18.39	Unacceptable	
B5	23.19	18	2.07	22.17	0.0004	0.0104	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	23.20	4.58	-18.62	Unacceptable	*
B4	23.19	18	7.45	36.88	0.0050	0.0095	0.19	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.03	0.23	23.42	4.64	-18.78	Unacceptable	*
B2A	23.19	48	100.88	42.94	0.0049	0.0051	0.21	8.03	0.25	100.88	19.90	2007.9	6.1518	2.15	0	0.00	2.40	3.12	1.20	1.41	24.60	5.00	-19.60	Unacceptable	
EX C3	24.60	30	97.70	19.15	0.0568	0.0204	1.09	19.90	1.54	3.17	1.80	5.7	0.0501	0.02	90	0.04	1.59	2.07	0.80	2.12	26.72	5.10	-21.62	Unacceptable	
B2	24.60	18	3.17	12.42	0.0009	0.0048	0.01	1.80	0.01	3.17	1.80	5.7	0.0501	0.02	90	0.04	0.07	0.08	0.03	0.04	24.64	5.02	-19.62	Unacceptable	
B1	24.64	18	3.17	32.65	0.0009	0.0049	0.03	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.01	0.02	0.01	0.04	24.68	4.58	-20.10	Unacceptable	*
EX C4	26.72	30	84.87	281.77	0.0428	0.0122	12.07	17.29	1.16	4.14	5.27	21.8	0.4315	0.15	35	0.12	1.43	1.86	0.72	13.00	39.72	10.85	-28.87	Unacceptable	
EX C5	39.72	12	4.14	23.32	0.0135	0.0575	0.31	5.27	0.11	4.14	11.86	49.1	2.1842	0.76	35	0.61	1.48	1.93	0.74	1.06	40.78	11.29	-29.49	Unacceptable	
EX C6	40.78	8	4.14	29.72	0.1174	0.0300	3.49	11.86	0.55	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.55	0.71	0.27	3.84	44.62	12.04	-32.58	Unacceptable	*

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.
Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

10-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3B																															
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT	
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN				FT/FT	FT	n	C.F.S.	FPS		FPS	FT				
CAMERON ST BYPASS																															
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	9.00		4.75	4.75	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	2.69	0.45	5.77	2.38	7.15	8.22	-2.57	-4.95	all unknown
DUKE ST BYPASS																															
DE1	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	9.00		16.20	16.20	24	CL. IV	RCP	0.0100	187.55	0.013	22.64	5.16	0.72	7.86	1.88	8.44	4.99	1.45	-0.43	
PUMP STATION 1																															
D1	DI	D3	MH	0.12		0.12	0.80	0.10		0.10	5.00	9.00	0.86		0.86	12	CL. IV	RCP	0.0100	18.69	0.013	3.56	1.10	0.24	3.63	0.19	6.50	4.06	1.44	1.26	
D2	DI	D3	MH	0.39		0.39	0.80	0.31		0.31	5.00	9.00	2.81		2.81	12	CL. IV	RCP	0.0200	7.65	0.013	5.04	3.58	0.56	6.61	0.15	6.50	4.09	1.41	1.26	
D3	MH	D6	MH		1.26	1.77	0.80		1.01	1.42	5.00	9.00		9.07	12.74	24	CL. IV	RCP	0.0050	209.42	0.013	15.99	4.06	0.80	5.65	1.05	6.60	3.44	1.16	0.11	
D4	DI	D6	MH	0.09		0.09	0.80	0.07		0.07	5.00	9.00	0.65		0.65	12	CL. IV	RCP	0.0200	18.70	0.013	5.04	0.83	0.13	4.04	0.37	5.30	3.72	0.58	0.21	
D5	DI	D6	MH	0.06		0.06	0.80	0.05		0.05	5.00	9.00	0.43		0.43	12	CL. IV	RCP	0.0200	7.64	0.013	5.04	0.55	0.09	3.53	0.15	5.30	3.94	0.36	0.21	
D6	MH	D9	MH			1.92	0.80			1.54	5.00	9.00			13.82	24	CL. IV	RCP	0.0150	127.86	0.013	27.70	4.40	0.50	8.73	1.92	5.40	3.29	0.11	-1.81	
D7	DI	D9	MH	0.07		0.07	0.80	0.06		0.06	5.00	9.00	0.50		0.50	12	CL. IV	RCP	0.0100	18.69	0.013	3.56	0.64	0.14	3.04	0.19	3.30	3.42	-1.12	-1.31	
D8	DI	D9	MH	0.04		0.04	0.80	0.03		0.03	5.00	9.00	0.29		0.29	12	CL. IV	RCP	0.0100	7.65	0.013	3.56	0.37	0.08	2.49	0.08	3.30	3.53	-1.23	-1.31	
D9	MH	P11	MH		1.37	3.40	0.80		1.10	2.72	5.00	9.00		9.86	24.48	36	CL. IV	RCP	0.0200	44.86	0.013	94.29	3.46	0.26	10.81	0.90	3.50	2.31	-1.81	-2.70	
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	12	CL. IV	RCP	0.0100	28.05	0.013	3.56	0.92	0.20	3.40	0.28	8.22	3.28	3.95	3.66	
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	9.00	1.15		1.87	12	CL. IV	RCP	0.0100	18.96	0.013	3.56	2.38	0.53	4.58	0.19	8.02	3.17	3.85	3.66	
P3	MH	P6	MH		1.45	1.71	0.80		1.16	1.37	5.00	9.00		10.44	12.31	24	CL. IV	RCP	0.0100	159.88	0.013	22.61	3.92	0.54	7.34	1.60	7.86	3.20	2.66	1.07	
P4	DI	P6	MH	0.16		0.16	0.80	0.13		0.13	5.00	9.00	1.15		1.15	12	CL. IV	RCP	0.0200	18.28	0.013	5.04	1.47	0.23	4.94	0.37	5.85	2.67	2.18	1.82	
P5	DI	P6	MH	0.10		0.10	0.80	0.08		0.08	5.00	9.00	0.72		0.72	12	CL. IV	RCP	0.0200	17.83	0.013	5.04	0.92	0.14	4.30	0.36	5.85	2.68	2.17	1.82	
P6	MH	P7	MH			1.97	0.80			1.58	5.00	9.00			14.18	24	CL. IV	RCP	0.0200	39.00	0.013	31.98	4.51	0.44	9.77	0.78	5.95	3.13	0.82	0.04	
PE1	EX DI	PE2	EX MH	0.19		0.19	0.80	0.15		0.15	5.00	9.00	1.37		1.37	8	CL. IV	RCP	0.0197	14.20	0.013	1.70	3.92	0.81	5.44	0.28	6.30	1.58	4.05	3.77	
PE2	EX MH	PE5	EX MH			0.19	0.80	0.00		0.15	5.00	9.00	0.00		1.37	12	CL. IV	RCP	0.0708	21.62	0.013	9.47	1.74	0.14	8.08	1.53	6.27	1.50	3.77	2.24	
PE3	EX DI	PE4	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	15	CL. IV	RCP	0.0410	21.70	0.013	13.08	1.35	0.13	6.71	0.89	6.20	0.95	4.00	3.11	
PE4	EX DI	PE5	EX MH	0.05		0.28	0.80	0.04		0.22	5.00	9.00	0.36		2.02	18	CL. IV	RCP	0.0203	41.77	0.013	14.98	1.14	0.13	5.51	0.85	5.70	0.76	3.44	2.59	
PE5	EX MH	P7	MH		1.26	1.73	0.80		1.01	1.38	5.00	9.00		9.07	12.46	18	CL. IV	RCP	0.1136	20.54	0.013	35.40	7.05	0.35	18.03	2.33	6.07	1.95	2.62	0.29	
P7	MH	P10	MH			3.70	0.80			2.96	5.00	9.00			26.64	36	CL. IV	RCP	0.0100	107.81	0.013	66.67	3.77	0.40	8.77	1.08	6.00	3.21	-0.21	-1.29	
P8	DI	P10	MH	0.12		0.12	0.80	0.10		0.10	5.00	9.00	0.86		0.86	18	CL. IV	RCP	0.0100	22.32	0.013	10.50	0.49	0.08	3.27	0.22	3.60	3.02	-0.92	-1.14	
P9	DI	P10	MH	0.18		0.18	0.80	0.14		0.14	5.00	9.00	1.30		1.30	18	CL. IV	RCP	0.0100	21.99	0.013	10.50	0.73	0.12	3.74	0.22	3.50	2.92	-0.92	-1.14	
P10	MH	P11	MH			4.00	0.80			3.20	5.00	9.00			28.80	36	CL. IV	RCP	0.0100	121.18	0.013	66.67	4.07	0.43	8.96	1.21	3.91	2.30	-1.39	-2.60	
P11	MH	P12	DI			7.40	0.80			5.92	5.00	9.00			53.28	36	CL. IV	RCP	0.0200	23.44	0.013	94.29	7.54	0.57	13.74	0.47	4.25	3.95	-2.70	-3.17	
P12	DI	P13	MH	0.68		8.08	0.80	0.54		6.46	5.00	9.00	4.90		58.18	42	CL. IV	RCP	0.0200	11.04	0.013	142.23	6.05	0.41	13.75	0.22	4.00	3.77	-3.27	-3.49	
P13	MH	PUMP 1				8.08	0.80			6.46	5.00	9.00			58.18	42	CL. IV	RCP	0.0200	20.31	0.013	142.23	6.05	0.41	13.75	0.41	4.25	4.34	-3.59	-4.00	

KE1	EX MH	KE2	EX MH		0.27	0.27	0.80		0.22	0.22	5.00	9.00		1.94	1.94	12	CL. IV	RCP	0.0104	10.59	0.013	3.63	2.48	0.54	4.67	0.11	9.35	3.60	4.75	4.64	
KE2	EX MH	K2	MH		4.09	4.36	0.80		3.27	3.49	5.00	9.00		29.45	31.39	30	CL. IV	RCP	0.0100	296.43	0.013	41.00	6.40	0.77	9.19	2.96	9.00	3.69	2.81	-0.15	
K1	DI	K2	MH	0.27		0.27	0.80	0.22		0.22	5.00	9.00	1.94		1.94	12	CL. IV	RCP	0.0200	9.29	0.013	5.04	2.48	0.39	5.96	0.19	3.93	2.73	0.20	0.01	
K2	MH	K3	MH		1.57	6.20	0.80		1.26	4.96	5.00	9.00		11.30	44.64	36	CL. IV	RCP	0.0100	28.94	0.013	66.67	6.32	0.67	10.09	0.29	3.52	9.03	-8.51	-8.80	
KE3	EX DI	KE4	EX MH	0.24		0.24	0.80	0.19		0.19	5.00	9.00	1.73		1.73	12	CL. IV	RCP	0.0104	26.91	0.013	3.63	2.20	0.48	4.53	0.28	9.89	3.79	5.10	4.82	
KE4	EX MH	K4	MH		5.91	6.15	0.80		4.73	4.92	5.00	9.00		42.55	44.28	30	CL. IV	RCP	0.0200	215.87	0.013	57.99	9.02	0.76	12.99	4.32	9.00	2.57	3.93	-0.39	
K4	MH	K6	MH		0.52	6.67	0.80		0.42	5.34	5.00	9.00		3.74	48.02	36	CL. IV	RCP	0.0100	67.14	0.013	66.67	6.79	0.72	10.28	0.67	4.78	2.17	-0.39	-1.06	
K5	DI	K6	MH	0.27		0.27	0.80	0.22		0.22	5.00	9.00	1.94		1.94	12	CL. IV	RCP	0.0100	4.62	0.013	3.56	2.48	0.55	4.63	0.05	3.97	4.03	-1.06	-1.11	
K6	MH	K3	MH		2.00	8.94	0.80		1.60	7.15	5.00	9.00		14.40	64.37	36	CL. IV	RCP	0.0100	33.66	0.013	66.67	9.11	0.97	10.94	0.34	3.50	9.31	-8.81	-9.14	
K3	MH	K11	MH			15.14	0.80			12.11	5.00	9.00			109.01	54	CL. IV	RCP	0.0050	23.22	0.013	139.00	6.85	0.78	9.70	0.12	3.65	9.79	-10.64	-10.76	
K7	DI	K8	DI	0.20		0.20	0.80	0.16		0.16	5.00	9.00	1.44		1.44	12	CL. IV	RCP	0.0100	36.49	0.013	3.56	1.83	0.40	4.22	0.36	3.50	11.01	-8.51	-8.88	
K8	DI	K11	MH	0.19		0.39	0.80	0.15		0.31	5.00	9.00	1.37		2.81	12	CL. IV	RCP	0.0100	38.41	0.013	3.56	3.58	0.79	5.03	0.38	3.20	11.08	-8.88	-9.26	
K9	DI	K10	DI	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	12	CL. IV	RCP	0.0100	36.21	0.013	3.56	2.11	0.46	4.40	0.36	3.20	10.75	-8.55	-8.91	
K10	DI	K11	MH	0.21		0.44	0.80	0.17		0.35	5.00	9.00	1.51		3.17	15	CL. IV	RCP	0.0100	35.24	0.013	6.46	2.58	0.49	5.21	0.35	3.64	11.30	-8.91	-9.26	
K11	MH	K14	MH			15.97	0.80			12.78	5.00	9.00			114.98	54	CL. IV	RCP	0.0050	79.75	0.013	139.00	7.23	0.83	9.79	0.40	3.40	9.66	-10.76	-11.16	
K12	DI	K14	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	12	CL. IV	RCP	0.0200	11.96	0.013	5.04	1.38	0.21	4.87	0.24	3.43	11.35	-8.92	-9.16	
K13	DI	K14	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	9.00	0.65	1.15	1.80	12	CL. IV	RCP	0.0200	6.94	0.013	5.04	2.29	0.36	5.77	0.14	3.43	11.45	-9.02	-9.16	
K14	MH	K15	MH			16.37	0.80			13.10	5.00	9.00			117.86	54	CL. IV	RCP	0.0050	71.97	0.013	139.00	7.41	0.85	9.88	0.36	3.65	10.31	-11.16	-11.52	
K15	MH	K17	DI/JB			16.37	0.80			13.10	5.00	9.00			117.86	54	CL. IV	RCP	0.0050	66.94	0.013	139.00	7.41	0.85	9.88	0.33	4.10	11.12	-11.52	-11.85	
K16	DI	K17	DI/JB	0.18		0.18	0.80	0.14		0.14	5.00	9.00	1.30		1.30	12	CL. IV	RCP	0.0200	25.18	0.013	5.04	1.65	0.26	5.19	0.50	3.56	11.41	-8.85	-9.35	
K17	DI/JB	K19	DI/JB	0.04	1.21	17.80	0.80	0.03	0.97	14.24	5.00	9.00	0.29	8.71	128.16	54	CL. IV	RCP	0.0050	89.20	0.013	139.00	8.06	0.92	10.05	0.45	3.56	10.91	-11.85	-12.30	
K18	DI	K19	DI/JB	0.03	0.20	0.23	0.80	0.02	0.16	0.18	5.00	9.00	0.22	1.44	1.66	12	CL. IV	RCP	0.0200	26.65	0.013	5.04	2.11	0.33	5.64	0.53	3.91	11.68	-8.77	-9.30	
K19	DI/JB	K21	DI/JB	0.03		18.06	0.80	0.02		14.45	5.00	9.00	0.22		130.03	54	CL. IV	RCP	0.0050	107.83	0.013	139.00	8.18	0.94	10.05	0.54	3.91	11.71	-12.30	-12.84	
K20	DI	K21	DI/JB	0.04	0.22	0.26	0.80	0.03	0.18	0.21	5.00	9.00	0.29	1.58	1.87	12	CL. IV	RCP	0.0200	26.65	0.013	5.04	2.38	0.37	5.90	0.53	3.41	11.72	-9.31	-9.84	
K21	DI/JB	K24	MH	0.03		18.35	0.80	0.02		14.68	5.00	9.00	0.22		132.12	54	CL. IV	RCP	0.0050	52.40	0.013	139.00	8.31	0.95	10.05	0.26	3.41	11.75	-12.84	-13.10	
K22	DI	K23	DI	0.04	0.17	0.21	0.80	0.03	0.14	0.17	5.00	9.00	0.29	1.22	1.51	12	CL. IV	RCP	0.0200	26.33	0.013	5.04	1.93	0.30	5.52	0.53	3.40	11.50	-9.10	-9.63	
K23	DI	K24	MH	0.04		0.25	0.80	0.03		0.20	5.00	9.00	0.29		1.80	12	CL. IV	RCP	0.0200	48.76	0.013	5.04	2.29	0.36	5.77	0.98	3.40	12.53	-10.13	-11.10	
K24	MH	K25	MH			18.60	0.80			14.88	5.00	9.00			133.92	54	CL. IV	RCP	0.0100	32.13	0.013	196.58	8.42	0.68	13.35	0.32	4.10	12.70	-13.10	-13.42	
K25	MH	PUMP 1			1.10	19.70	0.80		0.88	15.76	5.00	9.00		7.92	141.84	54	CL. IV	RCP	0.0100	57.80	0.013	196.58	8.92	0.72	13.47	0.58	4.40	13.32	-13.42	-14.00	
PUMP 1 - COMBINED						27.78	0.80			22.22	5.00	9.00			200.02																
PUMP 1		OUTFALL NORTH				13.89	0.80			11.11	5.00	9.00			100.01	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	5.09	0.38	12.33	0.53	5.00	5.47	-5.47	-6.00	
PUMP 1		OUTFALL SOUTH				13.89	0.80			11.11	5.00	9.00			100.01	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	5.09	0.38	12.33	0.53	5.00	5.47	-5.47	-6.00	

PUMP STATION 2																															
TE3	EX DI	TE2	EX MH	0.30		0.30	0.80	0.24		0.24	5.00	9.00	2.16		2.16	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	6.19	1.03	6.89	0.89	12.46	4.01	7.78	6.89	
TE2	EX MH	TE1	EX MH			0.30	0.80			0.24	5.00	9.00			2.16	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	2.75	0.25	8.80	1.34	11.29	4.30	5.99	4.65	
TE1	EX MH	T3	MH		5.85	6.15	0.80		4.68	4.92	5.00	9.00		42.12	44.28	30	CL. IV	RCP	0.0130	265.80	0.013	46.71	9.02	0.95	10.94	3.45	10.85	3.90	4.45	1.00	
T1	DI	T3	MH	0.23		0.23	0.80	0.18		0.18	5.00	9.00	1.66		1.66	18	CL. IV	RCP	0.0100	13.74	0.013	10.50	0.94	0.16	4.04	0.14	5.00	10.19	-6.69	-6.83	
T2	DI	T3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	9.00	2.09	1.80	3.89	18	CL. IV	RCP	0.0100	26.61	0.013	10.50	2.20	0.37	5.47	0.27	5.06	10.12	-6.56	-6.83	
T3	MH	T4	MH		0.93	7.85	0.80		0.74	6.28	5.00	9.00		6.70	56.52	36	CL. IV	RCP	0.0100	37.40	0.013	66.67	8.00	0.85	10.66	0.37	5.10	8.93	-6.83	-7.20	
T4	MH	T6	MH			7.85	0.80			6.28	5.00	9.00			56.52	48	CL. IV	RCP	0.0050	42.94	0.013	101.54	4.50	0.56	8.32	0.21	5.00	8.20	-7.20	-7.42	
T5	DI	T6	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	18	CL. IV	RCP	0.0200	18.37	0.013	14.85	0.61	0.07	4.45	0.37	4.50	10.05	-7.05	-7.42	
T6	MH	T9	MH			8.00	0.80			6.40	5.00	9.00			57.60	48	CL. IV	RCP	0.0050	86.54	0.013	101.54	4.58	0.57	8.32	0.43	4.80	8.22	-7.42	-7.85	
T7	DI	T9	MH	0.15		0.15	0.80	0.12		0.12	5.00	9.00	1.08		1.08	18	CL. IV	RCP	0.0200	18.44	0.013	14.85	0.61	0.07	4.45	0.37	4.90	10.38	-6.98	-7.35	
T8	DI	T9	MH	0.28		0.28	0.80	0.22		0.22	5.00	9.00	2.02		2.02	18	CL. IV	RCP	0.0200	18.67	0.013	14.85	1.14	0.14	5.46	0.37	4.96	10.44	-6.98	-7.35	
T9	MH	T11	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	9.00		15.98	76.68	48	CL. IV	RCP	0.0050	128.37	0.013	101.54	6.10	0.76	8.89	0.64	4.75	8.60	-7.85	-8.49	
T10	DI	T11	MH	0.09		0.09	0.80	0.07		0.07	5.00	9.00	0.65		0.65	18	CL. IV	RCP	0.0200	18.66	0.013	14.85	0.37	0.04	3.87	0.37	5.30	11.42	-7.62	-7.99	
T11	MH	T12	MH			10.74	0.80			8.59	5.00	9.00			77.33	48	CL. IV	RCP	0.0050	166.60	0.013	101.54	6.15	0.76	8.89	0.83	5.33	9.82	-8.49	-9.33	
TE4	DI	T12	MH		3.86	3.86	0.80		3.09	3.09	5.00	9.00		27.79	27.79	30	CL. IV	RCP	0.0200	25.56	0.013	57.99	5.66	0.48	11.58	0.51	7.16	4.20	0.46	-0.05	
T12	DI	T13	MH			14.60	0.80			11.68	5.00	9.00			105.12	48	CL. IV	RCP	0.0100	20.15	0.013	143.59	8.37	0.73	12.46	0.20	7.00	12.33	-9.33	-9.53	
T13	DI	T14	MH	0.10		14.70	0.80	0.08		11.76	5.00	9.00	0.72		105.84	48	CL. IV	RCP	0.0100	45.00	0.013	143.59	8.42	0.74	12.46	0.45	6.82	12.40	-9.58	-10.03	
TE6	EX DI	TE5	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	9.00	1.22		1.22	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	1.56	0.52	3.02	0.03	7.21	2.25	3.96	3.99	
TE7	EX DI	TE5	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	9.00	1.22		1.22	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	1.00	0.15	4.39	0.76	7.00	4.09	1.66	0.90	
TE5	EX MH	T14	MH		1.53	1.87	0.80		1.22	1.50	5.00	9.00		11.02	13.46	18	CL. IV	RCP	0.0200	68.55	0.013	14.85	7.62	0.91	9.66	1.37	7.25	5.80	-0.05	-1.42	
T14	MH	T15	MH		0.60	17.17	0.80		0.48	13.74	5.00	9.00		4.32	123.62	48	CL. IV	RCP	0.0100	180.90	0.013	143.59	9.84	0.86	12.91	1.81	7.21	13.69	-10.48	-12.29	
T15	MH	T16	MH			17.17	0.80			13.74	5.00	9.00			123.62	48	CL. IV	RCP	0.0100	79.31	0.013	143.59	9.84	0.86	12.91	0.79	7.00	15.29	-12.29	-13.08	
T16	MH	PUMP 2				17.17	0.80			13.74	5.00	9.00			123.62	48	CL. IV	RCP	0.0100	39.60	0.013	143.59	9.84	0.86	12.91	0.40	7.25	16.38	-13.13	-13.52	
T17	DI	T20	MH	0.24		0.24	0.80	0.19		0.19	5.00	9.00	1.73		1.73	12	CL. IV	RCP	0.0200	50.21	0.013	5.04	2.20	0.34	5.71	1.00	6.40	5.03	0.37	-0.63	
T18	DI	T19	MH	0.14		0.14	0.80	0.11		0.11	5.00	9.00	1.01		1.01	18	CL. IV	RCP	0.0200	28.63	0.013	14.85	0.57	0.07	4.29	0.57	4.50	2.86	0.14	-0.43	
T19	DI	T20	MH	0.22		0.36	0.80	0.18		0.29	5.00	9.00	1.58		2.59	18	CL. IV	RCP	0.0200	32.26	0.013	14.85	1.47	0.17	5.97	0.65	6.00	4.98	-0.48	-1.13	
T20	MH	PUMP 2				0.60	1.80			0.48	5.00	9.00			4.32	24	CL. IV	RCP	0.0200	18.53	0.013	31.98	1.38	0.14	6.62	0.37	5.50	5.13	-1.63	-2.00	
PUMP 2 - COMBINED						17.77	0.80			14.22	5.00	9.00			127.94																
PUMP 2		OUTFALL NORTH				8.89	0.80			7.11	5.00	9.00			63.97	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	3.26	0.25	10.61	0.53	5.00	5.47	-5.47	-6.00	
PUMP 2		OUTFALL SOUTH				8.89	0.80			7.11	5.00	9.00			63.97	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	3.26	0.25	10.61	0.53	5.00	5.47	-5.47	-6.00	

10-YEAR HGL COMPUTATIONS - ALTERNATE 3B																									
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water Surface Elev. (2)	D _o (3)	Q _o (4)	L _o (5)	S _{f_o} ft/ft (6)	Slope ft/ft (6)	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance	Remarks
								V _o (8)	H _o (9)	Q _i (10)	V _i (11)	Q _i V _i (12)	$\frac{V_i^2}{2g}$ (2g) (13)	H _i (13)	Angle (14)	H _Δ (15)	H _L (16)	1.3 H _L (17)	0.5 H _L (18)						
CAMERON ST																									
EX C1	6.00	18	4.75	237.53	0.0022	0.0100	0.52	5.77	0.13	4.75	5.77	27.4	0.5169	0.18	0	0.00	0.31	0.40	0.16	0.67	6.67	7.15	0.48	Acceptable	Outfall unknown; Starting HGL at 10-yr WSE of River
DUKE ST BYPASS																									
DE1	6.00	24	16.20	187.55	0.0043	0.0100	0.81	7.86	0.24	16.20	7.86	127.3	0.9582	0.34	0	0.00	0.57	0.75	0.29	1.10	7.10	8.44	1.34	Acceptable	Starting HGL at 10-yr WSE of River
PUMP 1																									
K25	-6.00	54	141.84	57.80	0.0100	0.0100	0.58	8.92	0.31	133.92	8.42	1127.7	1.1010	0.39	45	0.42	1.11	1.45	0.56	1.13	-4.87	4.40	9.27	Acceptable	Starting HGL at max. water level of pump station
K24	-4.87	54	133.92	32.13	0.0100	0.0100	0.32	8.42	0.28	133.92	8.31	1112.5	1.0716	0.38	90	0.75	1.40	1.82	0.70	1.02	-3.84	4.10	7.94	Acceptable	
K23	-3.84	12	1.80	48.76	0.0200	0.0200	0.98	2.29	0.02	1.51	1.93	2.9	0.0575	0.02	90	0.04	0.08	0.11	0.04	1.02	-2.83	2.98	5.81	Acceptable	*
K22	-2.83	12	1.51	26.33	0.0200	0.0200	0.53	1.93	0.01	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.01	0.02	0.01	0.54	-2.29	2.98	5.27	Acceptable	*
K21	-3.84	54	132.12	52.40	0.0050	0.0050	0.26	8.31	0.27	131.90	8.18	1078.4	1.0380	0.36	0	0.00	0.63	0.82	0.32	0.58	-3.27	2.99	6.26	Acceptable	*
K20	-3.27	12	1.87	26.65	0.0200	0.0200	0.53	2.38	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.03	0.01	0.55	-2.72	2.99	5.71	Acceptable	*
K19	-2.72	54	130.03	107.83	0.0050	0.0050	0.54	8.18	0.26	129.82	8.06	1046.1	1.0083	0.35	0	0.00	0.61	0.80	0.31	0.85	-1.87	3.49	5.36	Acceptable	*
K18	-1.87	12	1.66	26.65	0.0200	0.0200	0.53	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.54	-1.33	3.49	4.82	Acceptable	*
K17	-1.87	54	128.16	89.20	0.0050	0.0050	0.45	8.06	0.25	119.16	7.41	883.1	0.8528	0.30	0	0.00	0.55	0.72	0.28	0.72	-1.15	3.14	4.29	Acceptable	*
K16	-1.15	12	1.30	25.18	0.0200	0.0200	0.50	1.65	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.01	0.51	-0.64	2.72	3.36	Acceptable	*
K15	-1.15	54	117.86	66.94	0.0050	0.0050	0.33	7.41	0.21	117.86	7.41	873.5	0.8528	0.30	90	0.60	1.11	1.44	0.55	0.89	-0.26	4.10	4.36	Acceptable	
K14	-0.26	54	117.86	71.97	0.0050	0.0050	0.36	7.41	0.21	117.86	7.23	852.1	0.8116	0.28	0	0.00	0.50	0.65	0.25	0.61	0.35	3.65	3.30	Acceptable	
K13	0.35	12	1.80	6.94	0.0200	0.0200	0.14	2.29	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.03	0.01	0.15	0.50	3.01	2.51	Acceptable	*
K12	0.35	12	1.08	11.96	0.0200	0.0200	0.24	1.38	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.24	0.59	3.01	2.42	Acceptable	*
K11	0.35	54	114.98	79.75	0.0050	0.0050	0.40	7.23	0.20	114.98	6.85	788.1	0.7295	0.26	0	0.00	0.46	0.60	0.23	0.63	0.97	3.40	2.43	Acceptable	*
K10	0.97	15	3.17	35.24	0.0100	0.0100	0.35	2.58	0.03	1.66	2.11	3.5	0.0690	0.02	90	0.05	0.10	0.13	0.05	0.42	1.39	3.22	1.83	Acceptable	*
K9	1.39	12	1.66	36.21	0.0100	0.0100	0.36	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.37	1.76	2.78	1.02	Acceptable	*
K8	0.97	12	2.81	38.41	0.0100	0.0100	0.38	3.58	0.05	1.44	1.83	2.6	0.0522	0.02	90	0.04	0.10	0.14	0.05	0.45	1.43	2.78	1.35	Acceptable	*
K7	1.43	12	1.44	36.49	0.0100	0.0100	0.37	1.83	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.02	0.01	0.37	1.80	3.08	1.28	Acceptable	*
K3	0.97	54	109.01	23.22	0.0050	0.0050	0.12	6.85	0.18	109.01	9.11	992.6	1.2876	0.45	0	0.00	0.63	0.82	0.32	0.43	1.41	3.65	2.24	Acceptable	
K6	1.41	36	64.37	33.66	0.0100	0.0100	0.34	9.11	0.32	49.97	6.79	339.5	0.7167	0.25	30	0.20	0.77	1.01	0.39	0.84	2.25	3.50	1.25	Acceptable	
K5	2.25	12	1.94	4.62	0.0100	0.0100	0.05	2.48	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.03	0.01	0.06	2.31	3.55	1.24	Acceptable	*
K4	2.25	36	48.02	67.14	0.0100	0.0100	0.67	6.79	0.18	44.28	9.02	399.4	1.2635	0.44	0	0.00	0.62	0.81	0.31	0.98	3.23	4.78	1.55	Acceptable	
KE4	3.23	30	44.28	215.87	0.0200	0.0200	4.32	9.02	0.32	1.73	2.20	3.8	0.0752	0.03	50	0.04	0.38	0.49	0.19	4.56	7.79	9.00	1.21	Acceptable	
KE3	7.79	12	1.73	26.91	0.0104	0.0104	0.28	2.20	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.02	0.01	0.29	8.08	9.47	1.39	Acceptable	*
K2	1.41	36	44.64	28.94	0.0100	0.0100	0.29	6.32	0.15	33.34	9.19	306.3	1.3109	0.46	30	0.37	0.98	1.27	0.49	0.93	2.33	3.52	1.19	Acceptable	
K1	2.33	12	1.94	9.29	0.0200	0.0200	0.19	2.48	0.02	0.00	0.00	0.0	0.0000	0.00	25	0.00	0.02	0.03	0.01	0.20	2.53	3.51	0.98	Acceptable	*
KE2	2.33	30	31.39	296.43	0.0048	0.0100	1.44	9.19	0.33	1.94	4.67	9.1	0.3383	0.12	75	0.22	0.67	0.87	0.33	1.87	4.21	9.00	4.79	Acceptable	
KE1	4.21	12	1.94	10.59	0.0029	0.0104	0.03	4.67	0.08	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.08	0.11	0.04	0.09	4.29	8.93	4.64	Acceptable	*
P13	-6.00	42	58.18	20.31	0.0039	0.0200	0.08	13.75	0.73	58.18	13.75	799.8	2.9352	1.03	45	1.12	2.88	3.74	1.44	1.52	-4.48	3.83	8.31	Acceptable	Starting HGL at max. water level of pump station
P12	-4.48	42	58.18	11.04	0.0039	0.0200	0.04	13.75	0.73	53.28	13.74	732.1	2.9314	1.03	0	0.00	1.76	2.29	0.88	0.92	-3.56	4.00	7.56	Acceptable	*
P11	-3.56	36	53.28	23.44	0.0060	0.0200	0.14	13.74	0.73	28.80	8.96	258.1	1.2469	0.44	0	0.00	1.17	1.52	0.58	0.90	-2.66	4.25	6.91	Acceptable	
P10	-2.66	36	28.80	121.18	0.0021	0.0100	0.25	8.96	0.31	28.80	8.77	252.6	1.1949	0.42	0	0.00	0.73	0.95	0.36	0.62	-2.04	3.49	5.53	Acceptable	
P9	-2.04	18	1.30	21.99	0.0004	0.0100	0.01	3.74	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.04	-2.00	3.08	5.08	Acceptable	*
P8	-2.04	18	0.86	22.32	0.0002	0.0100	0.00	3.27	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.03	-2.01	3.18	5.19	Acceptable	*
P7	-2.04	36	26.64	107.81	0.0018	0.0100	0.20	8.77	0.30	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.30	0.39	0.15	0.39	-1.65	6.00	7.65	Acceptable	

PE5	-1.65	18	12.46	20.54	0.0174	0.1136	0.36	18.03	1.26	3.38	5.51	18.6	0.4714	0.16	30	0.13	1.56	2.03	0.78	1.37	-0.28	6.07	6.35	Acceptable	
PE4	-0.28	18	2.02	41.77	0.0009	0.0203	0.04	5.51	0.12	1.66	6.71	11.1	0.6999	0.24	45	0.27	0.63	0.82	0.31	0.45	0.16	5.28	5.12	Acceptable	*
PE3	0.16	15	1.66	21.70	0.0017	0.0410	0.04	6.71	0.17	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.17	0.23	0.09	0.15	0.31	5.78	5.47	Acceptable	*
PE2	0.31	12	1.37	21.62	0.0071	0.0708	0.15	5.51	0.12	1.37	5.44	7.4	0.4600	0.16	45	0.17	0.45	0.59	0.23	0.38	0.69	6.27	5.58	Acceptable	
PE1	0.69	8	1.37	14.20	0.0102	0.0197	0.15	5.44	0.11	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.11	0.15	0.06	0.22	0.91	5.88	4.97	Acceptable	*
P6	-1.65	24	14.18	39.00	0.0043	0.0200	0.17	9.77	0.37	14.18	7.34	104.1	0.8371	0.29	90	0.59	1.25	1.62	0.62	0.79	-0.86	5.53	6.39	Acceptable	
P5	-0.86	12	0.72	17.83	0.0009	0.0200	0.02	4.30	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.09	0.04	0.06	-0.80	5.43	6.23	Acceptable	*
P4	-0.86	12	1.15	18.28	0.0018	0.0200	0.03	4.94	0.09	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.09	0.12	0.05	0.09	-0.77	5.43	6.20	Acceptable	*
P3	-0.86	24	12.31	159.88	0.0028	0.0100	0.46	7.34	0.21	2.59	4.58	11.9	0.3257	0.11	0	0.00	0.32	0.42	0.16	0.67	-0.19	7.86	8.05	Acceptable	
P2	-0.19	12	1.87	18.96	0.0027	0.0100	0.05	4.58	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.11	0.04	0.10	-0.09	7.60	7.69	Acceptable	*
P1	-0.19	12	0.72	28.05	0.0007	0.0100	0.02	3.40	0.04	0.00	0.00	0.0	0.0000	0.00	43	0.00	0.04	0.06	0.02	0.05	-0.14	7.80	7.94	Acceptable	*
D9	-2.66	36	24.48	44.86	0.0021	0.0200	0.09	10.81	0.45	14.62	8.73	127.6	1.1829	0.41	0	0.00	0.87	1.13	0.43	0.66	-2.00	3.50	5.50	Acceptable	
D8	-2.00	12	0.29	7.65	0.0002	0.0100	0.00	2.49	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.03	0.01	0.02	-1.99	2.88	4.87	Acceptable	*
D7	-2.00	12	0.50	18.69	0.0004	0.0100	0.01	3.04	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.03	-1.97	2.88	4.85	Acceptable	*
D6	-2.00	24	13.82	127.86	0.0038	0.0150	0.49	8.73	0.30	13.82	5.65	78.1	0.4957	0.17	0	0.00	0.47	0.61	0.23	0.72	-1.28	5.40	6.68	Acceptable	
D5	-1.28	12	0.43	7.64	0.0005	0.0200	0.00	3.53	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.04	-1.25	4.88	6.13	Acceptable	*
D4	-1.28	12	0.65	18.70	0.0008	0.0200	0.02	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.06	-1.22	4.88	6.10	Acceptable	*
D3	-1.28	24	12.74	209.42	0.0026	0.0050	0.54	5.65	0.12	3.67	6.61	24.3	0.6775	0.24	0	0.00	0.36	0.47	0.18	0.77	-0.51	6.60	7.11	Acceptable	
D2	-0.51	12	2.81	7.65	0.0059	0.0200	0.04	6.61	0.17	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.17	0.22	0.08	0.15	-0.35	6.08	6.43	Acceptable	*
D1	-0.51	12	0.86	18.69	0.0009	0.0100	0.02	3.63	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.07	0.03	0.05	-0.46	6.08	6.54	Acceptable	*
PUMP 2																									
T20	-8.00	24	4.32	18.53	0.0009	0.0200	0.02	6.62	0.17	4.32	5.97	25.8	0.5528	0.19	90	0.39	0.75	0.98	0.38	0.39	-7.61	5.50	13.11	Acceptable	Starting HGL at max. water level of pump station
T19	-7.61	18	2.59	32.26	0.0012	0.0200	0.04	5.97	0.14	2.74	4.29	11.7	0.2852	0.10	25	0.05	0.28	0.37	0.14	0.18	-7.43	5.58	13.01	Acceptable	*
T18	-7.43	18	1.01	28.63	0.0004	0.0200	0.01	4.29	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.04	0.06	-7.37	4.08	11.45	Acceptable	*
T17	-7.43	12	1.73	50.21	0.0030	0.0200	0.15	5.71	0.13	123.62	9.84	1216.2	1.5028	0.53	0	0.00	0.65	0.85	0.33	0.48	-6.95	5.98	12.93	Acceptable	*
T16	-8.00	48	123.62	39.60	0.0074	0.0100	0.29	9.84	0.38	123.62	9.84	1216.2	1.5028	0.53	53	0.71	1.61	2.09	0.80	1.10	-6.90	7.25	14.15	Acceptable	Starting HGL at max. water level of pump station
T15	-6.90	48	123.62	79.31	0.0074	0.0100	0.59	9.84	0.38	123.62	9.84	1216.2	1.5028	0.53	38	0.42	1.32	1.72	0.66	1.25	-5.65	7.00	12.65	Acceptable	
T14	-5.65	48	123.62	180.90	0.0074	0.0100	1.34	9.84	0.38	119.30	3.02	360.0	0.1414	0.05	90	0.10	0.52	0.68	0.26	1.60	-4.05	7.21	11.26	Acceptable	
TE5	-4.05	18	13.46	68.55	0.0164	0.0200	1.13	9.66	0.36	2.45	3.02	7.4	0.1414	0.05	57	0.07	0.48	0.62	0.24	1.44	-2.61	7.25	9.86	Acceptable	
TE7	-2.61	15	1.22	50.59	0.0004	0.0150	0.02	4.39	0.07	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.07	0.10	0.04	0.07	-2.55	6.58	9.13	Acceptable	*
TE6	-2.61	12	1.22	6.91	0.0012	0.0043	0.01	3.02	0.04	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.04	0.05	0.02	0.03	-2.58	6.79	9.37	Acceptable	*
T13	-4.05	48	105.84	45.00	0.0054	0.0100	0.24	8.42	0.28	105.12	8.37	879.3	1.0866	0.38	0	0.00	0.66	0.85	0.33	0.57	-3.48	6.40	9.88	Acceptable	*
T12	-3.48	48	105.12	20.15	0.0054	0.0100	0.11	8.37	0.27	105.12	6.15	646.9	0.5880	0.21	90	0.41	0.89	1.16	0.44	0.55	-2.93	7.00	9.93	Acceptable	
TE4	-2.93	30	27.79	25.56	0.0046	0.0200	0.12	11.58	0.52	27.79	5.66	157.4	0.4978	0.17	45	0.19	0.88	1.15	0.44	0.56	-2.37	7.16	9.53	Acceptable	
T11	-2.93	48	77.33	166.60	0.0029	0.0050	0.48	6.15	0.15	77.33	6.10	471.9	0.5782	0.20	0	0.00	0.35	0.45	0.17	0.66	-2.27	5.33	7.60	Acceptable	
T10	-2.27	18	0.65	18.66	0.0000	0.0200	0.00	0.37	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	-2.27	4.88	7.15	Acceptable	*
T9	-2.27	48	76.68	128.37	0.0029	0.0050	0.37	6.10	0.14	60.70	4.58	278.2	0.3262	0.11	0	0.00	0.26	0.34	0.13	0.53	-1.73	4.75	6.48	Acceptable	
T8	-1.73	18	2.02	18.67	0.0004	0.0200	0.01	1.14	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	-1.72	4.54	6.26	Acceptable	*
T7	-1.73	18	1.08	18.44	0.0001	0.0200	0.00	0.61	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	-1.73	4.48	6.21	Acceptable	*
T6	-1.73	48	57.60	86.54	0.0016	0.0050	0.14	4.58	0.08	57.60	4.50	259.1	0.3141	0.11	0	0.00	0.19	0.25	0.10	0.23	-1.50	4.80	6.30	Acceptable	
T5	-1.50	18	1.08	18.37	0.0001	0.0200	0.00	0.61	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	-1.50	4.08	5.58	Acceptable	*
T4	-1.50	48	56.52	42.94	0.0015	0.0050	0.07	4.50	0.08	56.52	8.00	451.9	0.9928	0.35	0	0.00	0.43	0.55	0.21	0.28	-1.22	5.00	6.22	Acceptable	
T3	-1.22	36	56.52	37.40	0.0072	0.0100	0.27	8.00	0.25	49.82	10.94	545.3	1.8598	0.65	90	1.30	2.20	2.86	1.10	1.37	0.15	5.10	4.95	Acceptable	
T2	0.15	18	3.89	26.61	0.0014	0.0100	0.04	2.20	0.02	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.02	0.02	0.01	0.05	0.20	4.64	4.44	Acceptable	*
T1	0.15	18	1.66	13.74	0.0002	0.0100	0.00	0.94	0.00	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.00	0.00	0.00	0.01	0.15	4.58	4.43	Acceptable	*
TE1	0.15	30	44.28	265.80	0.0117	0.0130	3.10	10.94	0.46	2.16	8.80	19.0	1.2038	0.42	35	0.34	1.22	1.59	0.61	3.89	4.04	10.85	6.81	Acceptable	
TE2	4.04	12	2.16	23.32	0.0037	0.0575	0.09	8.80	0.30	2.16	6.89	14.9	0.7381	0.26	35	0.21	0.77	1.00	0.38	0.47	4.51	11.29	6.78	Acceptable	
TE3	4.51	8	2.16	29.72	0.0320	0.0300	0.95	6.89	0.18	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.18	0.24	0.09	1.07	5.58	12.04	6.46	Acceptable	*

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)

HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.

Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

100-YEAR STORM SEWER COMPUTATIONS - ALTERNATE 3B																															
FROM POINT	STR TYPE	TO POINT	STR TYPE	INCR. AREA "A"	ADD AREA "A"	ACCUM AREA "A"	RUN-FF COEF.	CA			INLET TIME	RAIN FALL	RUNOFF Q			DIA.	PIPE CLASS	PIPE MATERIAL	SLOPE	LENGTH		CAPACITY	FULL FLOW VEL	q/Q	VEL	vertical drop	TOP	cover	INVERT ELEV		REMARKS
													INC.	ADD	TOTAL														UPPER INVERT	LOWER INVERT	
				AC	AC	AC	C	INC.	ADD.	ACCUM.	MIN	IN/HR	CFS	CFS	CFS	IN			FT/FT	FT	n	C.F.S.	FPS		FPS	FT					
													C _r (100) =	1.25																	
CAMERON ST BYPASS																															
EX C1		EX OUTFALL			0.66	0.66	0.80		0.53	0.53	5.00	13.80		9.11	9.11	18	CL. IV	RCP	0.0100	237.53	0.013	10.51	5.15	0.87	6.72	2.38	7.15	8.22	-2.57	-4.95	all unknown
DUKE ST BYPASS																															
DE1	MH	OUTFALL			2.25	2.25	0.80		1.80	1.80	5.00	13.80		31.05	31.05	24	CL. IV	RCP	0.0100	187.55	0.013	22.64	9.88	1.37	8.29	1.88	8.44	4.99	1.45	-0.43	
PUMP STATION 1																															
D1	DI	D3	MH	0.12		0.12	0.80	0.10		0.10	5.00	13.80	1.66		1.66	12	CL. IV	RCP	0.0100	18.69	0.013	3.56	2.11	0.46	4.40	0.19	6.50	4.06	1.44	1.26	
D2	DI	D3	MH	0.39		0.39	0.80	0.31		0.31	5.00	13.80	5.38		5.38	12	CL. IV	RCP	0.0200	7.65	0.013	5.04	6.85	1.07	7.37	0.15	6.50	4.09	1.41	1.26	
D3	MH	D6	MH		1.26	1.77	0.80		1.01	1.42	5.00	13.80		17.39	24.43	24	CL. IV	RCP	0.0050	209.42	0.013	15.99	7.78	1.53	5.85	1.05	6.60	3.44	1.16	0.11	
D4	DI	D6	MH	0.09		0.09	0.80	0.07		0.07	5.00	13.80	1.24		1.24	12	CL. IV	RCP	0.0200	18.70	0.013	5.04	1.58	0.25	5.13	0.37	5.30	3.72	0.58	0.21	
D5	DI	D6	MH	0.06		0.06	0.80	0.05		0.05	5.00	13.80	0.83		0.83	12	CL. IV	RCP	0.0200	7.64	0.013	5.04	1.05	0.16	4.49	0.15	5.30	3.94	0.36	0.21	
D6	MH	D9	MH			1.92	0.80			1.54	5.00	13.80			26.50	24	CL. IV	RCP	0.0150	127.86	0.013	27.70	8.43	0.96	10.14	1.92	5.40	3.29	0.11	-1.81	
D7	DI	D9	MH	0.07		0.07	0.80	0.06		0.06	5.00	13.80	0.97		0.97	12	CL. IV	RCP	0.0100	18.69	0.013	3.56	1.23	0.27	3.76	0.19	3.30	3.42	-1.12	-1.31	
D8	DI	D9	MH	0.04		0.04	0.80	0.03		0.03	5.00	13.80	0.55		0.55	12	CL. IV	RCP	0.0100	7.65	0.013	3.56	0.70	0.15	3.08	0.08	3.30	3.53	-1.23	-1.31	
D9	MH	P11	MH		1.37	3.40	0.80		1.10	2.72	5.00	13.80		18.91	46.92	36	CL. IV	RCP	0.0200	44.86	0.013	94.29	6.64	0.50	13.21	0.90	3.50	2.31	-1.81	-2.70	
P1	DI	P3	MH	0.10		0.10	0.80	0.08		0.08	5.00	13.80	1.38		1.38	12	CL. IV	RCP	0.0100	28.05	0.013	3.56	1.76	0.39	4.22	0.28	8.22	3.28	3.95	3.66	
P2	DI	P3	MH	0.16		0.26	0.80	0.13		0.21	5.00	13.80	2.21		3.59	12	CL. IV	RCP	0.0100	18.96	0.013	3.56	4.57	1.01	5.21	0.19	8.02	3.17	3.85	3.66	
P3	MH	P6	MH		1.45	1.71	0.80		1.16	1.37	5.00	13.80		20.01	23.60	24	CL. IV	RCP	0.0100	159.88	0.013	22.61	7.51	1.04	8.28	1.60	7.86	3.20	2.66	1.07	
P4	DI	P6	MH	0.16		0.16	0.80	0.13		0.13	5.00	13.80	2.21		2.21	12	CL. IV	RCP	0.0200	18.28	0.013	5.04	2.81	0.44	6.09	0.37	5.85	2.67	2.18	1.82	
P5	DI	P6	MH	0.10		0.10	0.80	0.08		0.08	5.00	13.80	1.38		1.38	12	CL. IV	RCP	0.0200	17.83	0.013	5.04	1.76	0.27	5.32	0.36	5.85	2.68	2.17	1.82	
P6	MH	P7	MH			1.97	0.80			1.58	5.00	13.80			27.19	24	CL. IV	RCP	0.0200	39.00	0.013	31.98	8.65	0.85	11.50	0.78	5.95	3.13	0.82	0.04	
PE1	EX DI	PE2	EX MH	0.19		0.19	0.80	0.15		0.15	5.00	13.80	2.62		2.62	8	CL. IV	RCP	0.0197	14.20	0.013	1.70	7.51	1.55	5.59	0.28	6.30	1.58	4.05	3.77	
PE2	EX MH	PE5	EX MH			0.19	0.80			0.15	5.00	13.80			2.62	12	CL. IV	RCP	0.0708	21.62	0.013	9.47	3.34	0.28	10.01	1.53	6.27	1.50	3.77	2.24	
PE3	EX DI	PE4	DI	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	15	CL. IV	RCP	0.0410	21.70	0.013	13.08	2.59	0.24	8.53	0.89	6.20	0.95	4.00	3.11	
PE4	EX DI	PE5	EX MH	0.05		0.28	0.80	0.04		0.22	5.00	13.80	0.69		3.86	18	CL. IV	RCP	0.0203	41.77	0.013	14.98	2.19	0.26	6.87	0.85	5.70	0.76	3.44	2.59	
PE5	EX MH	P7	MH		1.26	1.73	0.80		1.01	1.38	5.00	13.80		17.39	23.87	18	CL. IV	RCP	0.1136	20.54	0.013	35.40	13.51	0.67	21.43	2.33	6.07	1.95	2.62	0.29	
P7	MH	P10	MH			3.70	0.80			2.96	5.00	13.80			51.06	36	CL. IV	RCP	0.0100	107.81	0.013	66.67	7.22	0.77	10.38	1.08	6.00	3.21	-0.21	-1.29	
P8	DI	P10	MH	0.12		0.12	0.80	0.10		0.10	5.00	13.80	1.66		1.66	18	CL. IV	RCP	0.0100	22.32	0.013	10.50	0.94	0.16	4.04	0.22	3.60	3.02	-0.92	-1.14	
P9	DI	P10	MH	0.18		0.18	0.80	0.14		0.14	5.00	13.80	2.48		2.48	18	CL. IV	RCP	0.0100	21.99	0.013	10.50	1.41	0.24	4.69	0.22	3.50	2.92	-0.92	-1.14	
P10	MH	P11	MH			4.00	0.80			3.20	5.00	13.80			55.20	36	CL. IV	RCP	0.0100	121.18	0.013	66.67	7.81	0.83	10.56	1.21	3.91	2.30	-1.39	-2.60	
P11	MH	P12	DI			7.40	0.80			5.92	5.00	13.80			102.12	36	CL. IV	RCP	0.0200	23.44	0.013	94.29	14.45	1.08	15.34	0.47	4.25	3.95	-2.70	-3.17	
P12	DI	P13	MH	0.68		8.08	0.80	0.54		6.46	5.00	13.80	9.38		111.50	42	CL. IV	RCP	0.0200	11.04	0.013	142.23	11.59	0.78	16.41	0.22	4.00	3.77	-3.27	-3.49	
P13	MH	PUMP 1				8.08	0.80			6.46	5.00	13.80			111.50	42	CL. IV	RCP	0.0200	20.31	0.013	142.23	11.59	0.78	16.41	0.41	4.25	4.34	-3.59	-4.00	

KE1	EX MH	KE2	EX MH		0.27	0.27	0.80		0.22	0.22	5.00	13.80		3.73	3.73	12	CL. IV	RCP	0.0104	10.59	0.013	3.63	4.74	1.03	5.31	0.11	9.35	3.60	4.75	4.64	
KE2	EX MH	K2	MH		4.09	4.36	0.80		3.27	3.49	5.00	13.80		56.44	60.17	30	CL. IV	RCP	0.0100	296.43	0.013	41.00	12.26	1.47	9.61	2.96	9.00	3.69	2.81	-0.15	
K1	DI	K2	MH	0.27		0.27	0.80	0.22		0.22	5.00	13.80	3.73		3.73	12	CL. IV	RCP	0.0200	9.29	0.013	5.04	4.74	0.74	6.99	0.19	3.93	2.73	0.20	0.01	
K2	MH	K3	MH		1.57	6.20	0.80		1.26	4.96	5.00	13.80		21.67	85.56	36	CL. IV	RCP	0.0100	28.94	0.013	66.67	12.10	1.28	10.85	0.29	3.52	9.03	-8.51	-8.80	
KE3	EX DI	KE4	EX MH	0.24		0.24	0.80	0.19		0.19	5.00	13.80	3.31		3.31	12	CL. IV	RCP	0.0104	26.91	0.013	3.63	4.22	0.91	5.32	0.28	9.89	3.79	5.10	4.82	
KE4	EX MH	K4	MH		5.91	6.15	0.80		4.73	4.92	5.00	13.80		81.56	84.87	30	CL. IV	RCP	0.0200	215.87	0.013	57.99	17.29	1.46	13.58	4.32	9.00	2.57	3.93	-0.39	
K4	MH	K6	MH		0.52	6.67	0.80		0.42	5.34	5.00	13.80		7.18	92.05	36	CL. IV	RCP	0.0100	67.14	0.013	66.67	13.02	1.38	10.85	0.67	4.78	2.17	-0.39	-1.06	
K5	DI	K6	MH	0.27		0.27	0.80	0.22		0.22	5.00	13.80	3.73		3.73	12	CL. IV	RCP	0.0100	4.62	0.013	3.56	4.74	1.05	5.21	0.05	3.97	4.03	-1.06	-1.11	
K6	MH	K3	MH		2.00	8.94	0.80		1.60	7.15	5.00	13.80		27.60	123.37	36	CL. IV	RCP	0.0100	33.66	0.013	66.67	17.45	1.85	10.85	0.34	3.50	9.31	-8.81	-9.14	
K3	MH	K11	MH			15.14	0.80			12.11	5.00	13.80			208.93	54	CL. IV	RCP	0.0050	23.22	0.013	139.00	13.14	1.50	10.05	0.12	3.65	9.79	-10.64	-10.76	
K7	DI	K8	DI	0.20		0.20	0.80	0.16		0.16	5.00	13.80	2.76		2.76	12	CL. IV	RCP	0.0100	36.49	0.013	3.56	3.51	0.77	5.03	0.36	3.50	11.01	-8.51	-8.88	
K8	DI	K11	MH	0.19		0.39	0.80	0.15		0.31	5.00	13.80	2.62		5.38	12	CL. IV	RCP	0.0100	38.41	0.013	3.56	6.85	1.51	5.21	0.38	3.20	11.08	-8.88	-9.26	
K9	DI	K10	DI	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	12	CL. IV	RCP	0.0100	36.21	0.013	3.56	4.04	0.89	5.17	0.36	3.20	10.75	-8.55	-8.91	
K10	DI	K11	MH	0.21		0.44	0.80	0.17		0.35	5.00	13.80	2.90		6.07	15	CL. IV	RCP	0.0100	35.24	0.013	6.46	4.95	0.94	6.05	0.35	3.64	11.30	-8.91	-9.26	
K11	MH	K14	MH			15.97	0.80			12.78	5.00	13.80			220.39	54	CL. IV	RCP	0.0050	79.75	0.013	139.00	13.86	1.59	10.05	0.40	3.40	9.66	-10.76	-11.16	
K12	DI	K14	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	12	CL. IV	RCP	0.0200	11.96	0.013	5.04	2.64	0.41	6.03	0.24	3.43	11.35	-8.92	-9.16	
K13	DI	K14	MH	0.09	0.16	0.25	0.80	0.07	0.13	0.20	5.00	13.80	1.24	2.21	3.45	12	CL. IV	RCP	0.0200	6.94	0.013	5.04	4.39	0.68	6.93	0.14	3.43	11.45	-9.02	-9.16	
K14	MH	K15	MH			16.37	0.80			13.10	5.00	13.80			225.91	54	CL. IV	RCP	0.0050	71.97	0.013	139.00	14.20	1.63	10.05	0.36	3.65	10.31	-11.16	-11.52	
K15	MH	K17	DI/JB			16.37	0.80			13.10	5.00	13.80			225.91	54	CL. IV	RCP	0.0050	66.94	0.013	139.00	14.20	1.63	10.05	0.33	4.10	11.12	-11.52	-11.85	
K16	DI	K17	DI/JB	0.18		0.18	0.80	0.14		0.14	5.00	13.80	2.48		2.48	12	CL. IV	RCP	0.0200	25.18	0.013	5.04	3.16	0.49	6.35	0.50	3.56	11.41	-8.85	-9.35	
K17	DI/JB	K19	DI/JB	0.04	1.21	17.80	0.80	0.03	0.97	14.24	5.00	13.80	0.55	16.70	245.64	54	CL. IV	RCP	0.0050	89.20	0.013	139.00	15.44	1.77	10.05	0.45	3.56	10.91	-11.85	-12.30	
K18	DI	K19	DI/JB	0.03	0.20	0.23	0.80	0.02	0.16	0.18	5.00	13.80	0.41	2.76	3.17	12	CL. IV	RCP	0.0200	26.65	0.013	5.04	4.04	0.63	6.80	0.53	3.91	11.68	-8.77	-9.30	
K19	DI/JB	K21	DI/JB	0.03		18.06	0.80	0.02		14.45	5.00	13.80	0.41		249.23	54	CL. IV	RCP	0.0050	107.83	0.013	139.00	15.67	1.79	10.05	0.54	3.91	11.71	-12.30	-12.84	
K20	DI	K21	DI/JB	0.04	0.22	0.26	0.80	0.03	0.18	0.21	5.00	13.80	0.55	3.04	3.59	12	CL. IV	RCP	0.0200	26.65	0.013	5.04	4.57	0.71	6.99	0.53	3.41	11.72	-9.31	-9.84	
K21	DI/JB	K24	MH	0.03		18.35	0.80	0.02		14.68	5.00	13.80	0.41		253.23	54	CL. IV	RCP	0.0050	52.40	0.013	139.00	15.92	1.82	10.05	0.26	3.41	11.75	-12.84	-13.10	
K22	DI	K23	DI	0.04	0.17	0.21	0.80	0.03	0.14	0.17	5.00	13.80	0.55	2.35	2.90	12	CL. IV	RCP	0.0200	26.33	0.013	5.04	3.69	0.58	6.67	0.53	3.40	11.50	-9.10	-9.63	
K23	DI	K24	MH	0.04		0.25	0.80	0.03		0.20	5.00	13.80	0.55		3.45	12	CL. IV	RCP	0.0200	48.76	0.013	5.04	4.39	0.68	6.93	0.98	3.40	12.53	-10.13	-11.10	
K24	MH	K25	MH			18.60	0.80			14.88	5.00	13.80			256.68	54	CL. IV	RCP	0.0100	32.13	0.013	196.58	16.14	1.31	14.21	0.32	4.10	12.70	-13.10	-13.42	
K25	MH	PUMP 1			1.10	19.70	0.80		0.88	15.76	5.00	13.80		15.18	271.86	54	CL. IV	RCP	0.0100	57.80	0.013	196.58	17.09	1.38	14.21	0.58	4.40	13.32	-13.42	-14.00	
PUMP 1 - COMBINED						27.78	0.80			22.22	5.00	13.80			383.36																
PUMP 1		OUTFALL NORTH				13.89	0.80			11.11	5.00	13.80			191.68	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	9.76	0.74	14.45	0.53	5.00	5.47	-5.47	-6.00	
PUMP 1		OUTFALL SOUTH				13.89	0.80			11.11	5.00	13.80			191.68	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	9.76	0.74	14.45	0.53	5.00	5.47	-5.47	-6.00	

PUMP STATION 2																														
TE3	EX DI	TE2	EX MH	0.30		0.30	0.80	0.24		0.24	5.00	13.80	4.14		4.14	8	CL. IV	RCP	0.0300	29.72	0.013	2.09	11.86	1.98	6.89	0.89	12.46	4.01	7.78	6.89
TE2	EX MH	TE1	EX MH			0.30	0.80			0.24	5.00	13.80			4.14	12	CL. IV	RCP	0.0575	23.32	0.013	8.54	5.27	0.48	10.76	1.34	11.29	4.30	5.99	4.65
TE1	EX MH	T3	MH		5.85	6.15	0.80		4.68	4.92	5.00	13.80		80.73	84.87	30	CL. IV	RCP	0.0130	265.80	0.013	46.71	17.29	1.82	10.94	3.45	10.85	3.90	4.45	1.00
T1	DI	T3	MH	0.23		0.23	0.80	0.18		0.18	5.00	13.80	3.17		3.17	18	CL. IV	RCP	0.0100	13.74	0.013	10.50	1.80	0.30	5.11	0.14	5.00	10.19	-6.69	-6.83
T2	DI	T3	MH	0.29	0.25	0.54	0.80	0.23	0.20	0.43	5.00	13.80	4.00	3.45	7.45	18	CL. IV	RCP	0.0100	26.61	0.013	10.50	4.22	0.71	6.42	0.27	5.06	10.12	-6.56	-6.83
T3	MH	T4	MH		0.93	7.85	0.80		0.74	6.28	5.00	13.80		12.83	108.33	36	CL. IV	RCP	0.0100	37.40	0.013	66.67	15.33	1.62	10.85	0.37	5.10	8.93	-6.83	-7.20
T4	MH	T6	MH			7.85	0.80			6.28	5.00	13.80			108.33	48	CL. IV	RCP	0.0050	42.94	0.013	101.54	8.62	1.07	9.29	0.21	5.00	8.20	-7.20	-7.42
T5	DI	T6	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0200	18.37	0.013	14.85	1.17	0.14	5.46	0.37	4.50	10.05	-7.05	-7.42
T6	MH	T9	MH			8.00	0.80			6.40	5.00	13.80			110.40	48	CL. IV	RCP	0.0050	86.54	0.013	101.54	8.79	1.09	9.29	0.43	4.80	8.22	-7.42	-7.85
T7	DI	T9	MH	0.15		0.15	0.80	0.12		0.12	5.00	13.80	2.07		2.07	18	CL. IV	RCP	0.0200	18.44	0.013	14.85	1.17	0.14	5.46	0.37	4.90	10.38	-6.98	-7.35
T8	DI	T9	MH	0.28		0.28	0.80	0.22		0.22	5.00	13.80	3.86		3.86	18	CL. IV	RCP	0.0200	18.67	0.013	14.85	2.19	0.26	6.89	0.37	4.96	10.44	-6.98	-7.35
T9	MH	T11	MH		2.22	10.65	0.80	0.00	1.78	8.52	5.00	13.80		30.64	146.97	48	CL. IV	RCP	0.0050	128.37	0.013	101.54	11.70	1.45	9.29	0.64	4.75	8.60	-7.85	-8.49
T10	DI	T11	MH	0.09		0.09	0.80	0.07		0.07	5.00	13.80	1.24		1.24	18	CL. IV	RCP	0.0200	18.66	0.013	14.85	0.70	0.08	4.62	0.37	5.30	11.42	-7.62	-7.99
T11	MH	T12	MH			10.74	0.80			8.59	5.00	13.80			148.21	48	CL. IV	RCP	0.0050	166.60	0.013	101.54	11.79	1.46	9.29	0.83	5.33	9.82	-8.49	-9.33
TE4	DI	T12	MH		3.86	3.86	0.80		3.09	3.09	5.00	13.80		53.27	53.27	30	CL. IV	RCP	0.0200	25.56	0.013	57.99	10.85	0.92	13.58	0.51	7.16	4.20	0.46	-0.05
T12	DI	T13	MH			14.60	0.80			11.68	5.00	13.80			201.48	48	CL. IV	RCP	0.0100	20.15	0.013	143.59	16.03	1.40	13.14	0.20	7.00	12.33	-9.33	-9.53
T13	DI	T14	MH	0.10		14.70	0.80	0.08		11.76	5.00	13.80	1.38		202.86	48	CL. IV	RCP	0.0100	45.00	0.013	143.59	16.14	1.41	13.14	0.45	6.82	12.40	-9.58	-10.03
TE6	EX DI	TE5	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	12	CL. IV	RCP	0.0043	6.91	0.013	2.35	2.99	1.00	3.47	0.03	7.21	2.25	3.96	3.99
TE7	EX DI	TE5	EX MH	0.17		0.17	0.80	0.14		0.14	5.00	13.80	2.35		2.35	15	CL. IV	RCP	0.0150	50.59	0.013	7.91	1.91	0.30	5.48	0.76	7.00	4.09	1.66	0.90
TE5	EX MH	T14	MH		1.53	1.87	0.80		1.22	1.50	5.00	13.80		21.11	25.81	18	CL. IV	RCP	0.0200	68.55	0.013	14.85	14.60	1.74	9.66	1.37	7.25	5.80	-0.05	-1.42
T14	MH	T15	MH		0.60	17.17	0.80		0.48	13.74	5.00	13.80		8.28	236.95	48	CL. IV	RCP	0.0100	180.90	0.013	143.59	18.86	1.65	13.14	1.81	7.21	13.69	-10.48	-12.29
T15	MH	T16	MH			17.17	0.80			13.74	5.00	13.80			236.95	48	CL. IV	RCP	0.0100	79.31	0.013	143.59	18.86	1.65	13.14	0.79	7.00	15.29	-12.29	-13.08
T16	MH	PUMP 2				17.17	0.80			13.74	5.00	13.80			236.95	48	CL. IV	RCP	0.0100	39.60	0.013	143.59	18.86	1.65	13.14	0.40	7.25	16.38	-13.13	-13.52
T17	DI	T20	MH	0.24		0.24	0.80	0.19		0.19	5.00	13.80	3.31		3.31	12	CL. IV	RCP	0.0200	50.21	0.013	5.04	4.22	0.66	6.86	1.00	6.40	5.03	0.37	-0.63
T18	DI	T19	MH	0.14		0.14	0.80	0.11		0.11	5.00	13.80	1.93		1.93	18	CL. IV	RCP	0.0200	28.63	0.013	14.85	1.09	0.13	5.46	0.57	4.50	2.86	0.14	-0.43
T19	DI	T20	MH	0.22		0.36	0.80	0.18		0.29	5.00	13.80	3.04		4.97	18	CL. IV	RCP	0.0200	32.26	0.013	14.85	2.81	0.33	7.40	0.65	6.00	4.98	-0.48	-1.13
T20	MH	PUMP 2				0.60	1.80			0.48	5.00	13.80			8.28	24	CL. IV	RCP	0.0200	18.53	0.013	31.98	2.64	0.26	8.25	0.37	5.50	5.13	-1.63	-2.00
PUMP 2 - COMBINED						17.77	0.80			14.22	5.00	13.80			245.23															
PUMP 2		OUTFALL NORTH				8.89	0.80			7.11	5.00	13.80			122.61	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	6.24	0.47	12.99	0.53	5.00	5.47	-5.47	-6.00
PUMP 2		OUTFALL SOUTH				8.89	0.80			7.11	5.00	13.80			122.61	60	CL. IV	RCP	0.0100	53.15	0.013	260.35	6.24	0.47	12.99	0.53	5.00	5.47	-5.47	-6.00

100-YEAR HGL COMPUTATIONS - ALTERNATE 3B																											
UPSTREAM STRUCTURE NUMBER (1)	Outlet Water	D _o (3)	Q _o (4)	L _o (5)	S _{io}	Slope	H _f (7)	JUNCTION LOSS												Final H (19)	Inlet Water Surface Elev. (20)	Rim Elev.* (21)	WSE Distance to Rim	Clearance	Remarks		
	Surface Elev. (2)											V _o (8)	H _o (9)	Q _i (10)	V _i (11)	Q _i V _i (12)	$\frac{V_i^2}{2g}$ (2g) (13)	H _i (13)	Angle (14)							H _Δ (15)	H _i (16)
CAMERON ST																											
EX C1	6.00	18	9.11	237.53	0.0059	0.0100	1.40	6.72	0.18	9.11	6.72	61.2	0.7015	0.25	0	0.00	0.42	0.55	0.21	1.61	7.61	7.15	-0.46	Unacceptable	Outfall unknown; Starting HGL at 10-yr WSE of River		
DUKE ST BYPASS																											
DE1	6.00	24	31.05	187.55	0.0143	0.0100	2.67	8.29	0.27	31.05	8.29	257.3	1.0666	0.37	0	0.00	0.64	0.83	0.32	2.99	8.99	8.44	-0.55	Unacceptable	Starting HGL at 10-yr WSE of River		
PUMP 1																											
K25	-6.00	54	271.86	57.80	0.0100	0.0100	0.58	17.09	1.13	256.68	16.14	4142.6	4.0445	1.42	45	1.54	4.09	5.31	2.04	2.62	-3.38	4.40	7.78	Acceptable	Starting HGL at max. water level of pump station		
K24	-3.38	54	256.68	32.13	0.0100	0.0100	0.32	16.14	1.01	256.68	15.92	4086.9	3.9365	1.38	90	2.76	5.14	6.69	2.57	2.89	-0.48	4.10	4.58	Acceptable			
K23	-0.48	12	3.45	48.76	0.0200	0.0200	0.98	4.39	0.07	2.90	3.69	10.7	0.2114	0.07	90	0.15	0.30	0.39	0.15	1.12	0.64	2.98	2.34	Acceptable	*		
K22	0.64	12	2.90	26.33	0.0200	0.0200	0.53	3.69	0.05	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.05	0.07	0.03	0.56	1.20	2.98	1.78	Acceptable	*		
K21	-0.48	54	253.23	52.40	0.0050	0.0050	0.26	15.92	0.98	252.82	15.67	3961.7	3.8131	1.33	0	0.00	2.32	3.01	1.16	1.42	0.94	2.99	2.05	Acceptable	*		
K20	0.94	12	3.59	26.65	0.0200	0.0200	0.53	4.57	0.08	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.08	0.11	0.04	0.59	1.52	2.99	1.47	Acceptable	*		
K19	1.52	54	249.23	107.83	0.0050	0.0050	0.54	15.67	0.95	248.81	15.44	3842.9	3.7041	1.30	0	0.00	2.25	2.92	1.12	1.66	3.19	3.49	0.30	Acceptable	*		
K18	3.19	12	3.17	26.65	0.0200	0.0200	0.53	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.57	3.76	3.49	-0.27	Unacceptable	*		
K17	3.19	54	245.64	89.20	0.0050	0.0050	0.45	15.44	0.93	228.39	14.20	3244.1	3.1329	1.10	0	0.00	2.02	2.63	1.01	1.46	4.64	3.14	-1.50	Unacceptable	*		
K16	4.64	12	2.48	25.18	0.0200	0.0200	0.50	3.16	0.04	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.04	0.05	0.02	0.53	5.17	2.72	-2.45	Unacceptable	*		
K15	4.64	54	225.91	66.94	0.0050	0.0050	0.33	14.20	0.78	225.91	14.20	3208.8	3.1329	1.10	90	2.19	4.07	5.29	2.04	2.37	7.02	4.10	-2.92	Unacceptable			
K14	7.02	54	225.91	71.97	0.0050	0.0050	0.36	14.20	0.78	225.91	13.86	3130.4	2.9816	1.04	0	0.00	1.83	2.37	0.91	1.27	8.29	3.65	-4.64	Unacceptable			
K13	8.29	12	3.45	6.94	0.0200	0.0200	0.14	4.39	0.07	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.07	0.10	0.04	0.19	8.48	3.01	-5.47	Unacceptable	*		
K12	8.29	12	2.07	11.96	0.0200	0.0200	0.24	2.64	0.03	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.03	0.04	0.01	0.26	8.55	3.01	-5.54	Unacceptable	*		
K11	8.29	54	220.39	79.75	0.0050	0.0050	0.40	13.86	0.75	220.39	13.14	2895.2	2.6797	0.94	0	0.00	1.68	2.19	0.84	1.24	9.53	3.40	-6.13	Unacceptable			
K10	9.53	15	6.07	35.24	0.0100	0.0100	0.35	4.95	0.10	3.17	4.04	12.8	0.2536	0.09	90	0.18	0.36	0.47	0.18	0.59	10.12	3.22	-6.90	Unacceptable	*		
K9	10.12	12	3.17	36.21	0.0100	0.0100	0.36	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.40	10.52	2.78	-7.74	Unacceptable	*		
K8	9.53	12	5.38	38.41	0.0100	0.0100	0.38	6.85	0.18	2.76	3.51	9.7	0.1918	0.07	90	0.13	0.38	0.50	0.19	0.63	10.16	2.78	-7.38	Unacceptable	*		
K7	10.16	12	2.76	36.49	0.0100	0.0100	0.37	3.51	0.05	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.05	0.06	0.02	0.40	10.56	3.08	-7.48	Unacceptable	*		
K3	9.53	54	208.93	23.22	0.0050	0.0050	0.12	13.14	0.67	208.93	17.45	3646.6	4.7302	1.66	0	0.00	2.33	3.02	1.16	1.28	10.81	3.65	-7.16	Unacceptable			
K6	10.81	36	123.37	33.66	0.0100	0.0100	0.34	17.45	1.18	95.77	13.02	1247.1	2.6331	0.92	30	0.74	2.84	3.69	1.42	2.18	12.99	3.50	-9.49	Unacceptable			
K5	12.99	12	3.73	4.62	0.0100	0.0100	0.05	4.74	0.09	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.09	0.11	0.04	0.10	13.09	3.55	-9.54	Unacceptable	*		
K4	12.99	36	92.05	67.14	0.0100	0.0100	0.67	13.02	0.66	84.87	17.29	1467.4	4.6418	1.62	0	0.00	2.28	2.97	1.14	1.81	14.80	4.78	-10.02	Unacceptable			
KE4	14.80	30	84.87	215.87	0.0200	0.0200	4.32	17.29	1.16	3.31	4.22	14.0	0.2761	0.10	50	0.13	1.39	1.80	0.69	5.22	20.02	9.00	-11.02	Unacceptable			
KE3	20.02	12	3.31	26.91	0.0104	0.0104	0.28	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.03	0.32	20.35	9.47	-10.88	Unacceptable	*		
K2	10.81	36	85.56	28.94	0.0100	0.0100	0.29	12.10	0.57	63.89	12.26	783.2	2.3330	0.82	30	0.65	2.04	2.65	1.02	1.61	12.42	3.52	-8.90	Unacceptable			
K1	12.42	12	3.73	9.29	0.0200	0.0200	0.19	4.74	0.09	0.00	0.00	0.0	0.0000	0.00	25	0.00	0.09	0.11	0.04	0.24	12.67	3.51	-9.16	Unacceptable	*		
KE2	12.42	30	60.17	296.43	0.0100	0.0100	2.97	12.26	0.58	3.73	4.74	17.7	0.3495	0.12	75	0.23	0.94	1.22	0.47	3.57	16.00	9.00	-7.00	Unacceptable			
KE1	16.00	12	3.73	10.59	0.0104	0.0104	0.11	4.74	0.09	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.09	0.11	0.04	0.17	16.16	8.93	-7.23	Unacceptable	*		
P13	-6.00	42	111.50	20.31	0.0100	0.0200	0.20	16.41	1.05	111.50	16.41	1829.7	4.1813	1.46	45	1.59	4.10	5.33	2.05	2.25	-3.75	3.83	7.58	Acceptable	Starting HGL at max. water level of pump station		
P12	-3.75	42	111.50	11.04	0.0100	0.0200	0.11	16.41	1.05	102.12	15.34	1566.6	3.6543	1.28	0	0.00	2.32	3.02	1.16	1.27	-2.48	4.00	6.48	Acceptable	*		
P11	-2.48	36	102.12	23.44	0.0177	0.0200	0.42	15.34	0.91	55.20	10.56	583.2	1.7330	0.61	0	0.00	1.52	1.98	0.76	1.40	-1.07	4.25	5.32	Acceptable			
P10	-1.07	36	55.20	121.18	0.0055	0.0100	0.66	10.56	0.43	55.20	10.38	572.7	1.6717	0.59	0	0.00	1.02	1.32	0.51	1.17	0.10	3.49	3.39	Acceptable			
P9	0.10	18	2.48	21.99	0.0009	0.0100	0.02	4.69	0.09	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.09	0.11	0.04	0.08	0.17	3.08	2.91	Acceptable	*		
P8	0.10	18	1.66	22.32	0.0005	0.0100	0.01	4.04	0.06	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.06	0.08	0.03	0.05	0.15	3.18	3.03	Acceptable	*		
P7	0.10	36	51.06	107.81	0.0048	0.0100	0.52	10.38	0.42	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.42	0.54	0.21	0.79	0.89	6.00	5.11	Acceptable			

PE5	0.89	18	23.87	20.54	0.0452	0.1136	0.93	21.43	1.78	6.49	6.87	44.5	0.7320	0.26	30	0.20	2.24	2.92	1.12	2.39	3.28	6.07	2.79	Acceptable	
PE4	3.28	18	3.86	41.77	0.0021	0.0203	0.09	6.87	0.18	3.17	8.53	27.1	1.1286	0.40	45	0.43	1.01	1.31	0.50	0.74	4.02	5.28	1.26	Acceptable	*
PE3	4.02	15	3.17	21.70	0.0038	0.0410	0.08	8.53	0.28	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.28	0.37	0.14	0.27	4.29	5.78	1.49	Acceptable	*
PE2	4.29	12	2.62	21.62	0.1650	0.0708	3.57	2.19	0.02	2.62	7.51	19.7	0.8761	0.31	45	0.33	0.66	0.86	0.33	3.90	8.18	6.27	-1.91	Unacceptable	
PE1	8.18	8	2.62	14.20	0.0197	0.0197	0.28	7.51	0.22	0.00	0.00	0.0	0.0000	0.00	45	0.00	0.22	0.28	0.11	0.42	8.61	5.88	-2.73	Unacceptable	*
P6	0.89	24	27.19	39.00	0.0113	0.0200	0.44	11.50	0.51	27.19	8.28	225.0	1.0641	0.37	90	0.74	1.63	2.12	0.82	1.26	2.15	5.53	3.38	Acceptable	
P5	2.15	12	1.38	17.83	0.0022	0.0200	0.04	5.32	0.11	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.11	0.14	0.05	0.11	2.26	5.43	3.17	Acceptable	*
P4	2.15	12	2.21	18.28	0.0043	0.0200	0.08	6.09	0.14	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.14	0.19	0.07	0.17	2.32	5.43	3.11	Acceptable	*
P3	2.15	24	23.60	159.88	0.0082	0.0100	1.32	8.28	0.27	4.97	5.21	25.9	0.4223	0.15	0	0.00	0.41	0.54	0.21	1.59	3.74	7.86	4.12	Acceptable	
P2	3.74	12	3.59	18.96	0.0077	0.0100	0.15	5.21	0.11	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.11	0.14	0.05	0.21	3.95	7.60	3.65	Acceptable	*
P1	3.74	12	1.38	28.05	0.0017	0.0100	0.05	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	43	0.00	0.07	0.09	0.03	0.09	3.83	7.80	3.97	Acceptable	*
D9	-1.07	36	46.92	44.86	0.0051	0.0200	0.23	13.21	0.68	28.01	10.14	284.0	1.5961	0.56	0	0.00	1.24	1.61	0.62	1.03	-0.04	3.50	3.54	Acceptable	
D8	-0.04	12	0.55	7.65	0.0100	0.0100	0.08	0.70	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.08	0.04	2.88	2.84	Acceptable	*
D7	-0.04	12	0.97	18.69	0.0100	0.0100	0.19	1.23	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.19	0.15	2.88	2.73	Acceptable	*
D6	-0.04	24	26.50	127.86	0.0104	0.0150	1.33	10.14	0.40	26.50	5.85	155.1	0.5320	0.19	0	0.00	0.59	0.76	0.29	1.62	1.58	5.40	3.82	Acceptable	
D5	1.58	12	0.83	7.64	0.0200	0.0200	0.15	1.05	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.01	0.00	0.16	1.73	4.88	3.15	Acceptable	*
D4	1.58	12	1.24	18.70	0.0200	0.0200	0.37	1.58	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.38	1.96	4.88	2.92	Acceptable	*
D3	1.58	24	24.43	209.42	0.0088	0.0050	1.85	5.85	0.13	7.04	6.85	48.2	0.7292	0.26	0	0.00	0.39	0.50	0.19	2.10	3.68	6.60	2.92	Acceptable	
D2	3.68	12	5.38	7.65	0.0200	0.0200	0.15	6.85	0.18	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.18	0.24	0.09	0.27	3.95	6.08	2.13	Acceptable	*
D1	3.68	12	1.66	18.69	0.0100	0.0100	0.19	2.11	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.20	3.88	6.08	2.20	Acceptable	*
PUMP 2																									
T20	-8.00	24	8.28	18.53	0.0020	0.0200	0.04	8.25	0.26	8.28	7.40	61.2	0.8492	0.30	90	0.59	1.16	1.50	0.58	0.62	-7.38	5.50	12.88	Acceptable	Starting HGL at max. water level of pump station
T19	-7.38	18	4.97	32.26	0.0029	0.0200	0.09	7.40	0.21	5.24	5.46	28.6	0.4633	0.16	25	0.07	0.45	0.58	0.22	0.32	-7.07	5.58	12.65	Acceptable	*
T18	-7.07	18	1.93	28.63	0.0008	0.0200	0.02	5.46	0.12	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.12	0.15	0.06	0.10	-6.97	4.08	11.05	Acceptable	*
T17	-7.07	12	3.31	50.21	0.0076	0.0200	0.38	6.86	0.18	236.95	18.86	4467.8	5.5207	1.93	0	0.00	2.12	2.75	1.06	1.44	-5.63	5.98	11.61	Acceptable	*
T16	-8.00	48	236.95	39.60	0.0272	0.0100	1.08	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	53	2.59	5.91	7.68	2.95	4.03	-3.97	7.25	11.22	Acceptable	Starting HGL at max. water level of pump station
T15	-3.97	48	236.95	79.31	0.0272	0.0100	2.16	18.86	1.38	236.95	18.86	4467.8	5.5207	1.93	38	1.55	4.86	6.32	2.43	4.59	0.62	7.00	6.38	Acceptable	
T14	0.62	48	236.95	180.90	0.0272	0.0100	4.92	18.86	1.38	228.67	2.99	683.0	0.1385	0.05	90	0.10	1.53	1.98	0.76	5.69	6.31	7.21	0.90	Acceptable	
TE5	6.31	18	25.81	68.55	0.0604	0.0200	4.14	14.60	0.83	4.69	2.99	14.0	0.1385	0.05	57	0.07	0.94	1.22	0.47	4.75	11.06	7.25	-3.81	Unacceptable	
TE7	11.06	15	2.35	50.59	0.0013	0.0150	0.07	1.91	0.01	0.00	0.00	0.0	0.0000	0.00	57	0.00	0.01	0.02	0.01	0.08	11.13	6.58	-4.55	Unacceptable	*
TE6	11.06	12	2.35	6.91	0.0043	0.0043	0.03	2.99	0.03	0.00	0.00	0.0	0.0000	0.00	13	0.00	0.03	0.05	0.02	0.05	11.11	6.79	-4.32	Unacceptable	*
T13	6.31	48	202.86	45.00	0.0200	0.0100	0.90	16.14	1.01	201.48	16.03	3230.4	3.9917	1.40	0	0.00	2.41	3.13	1.20	2.10	8.41	6.40	-2.01	Unacceptable	*
T12	8.41	48	201.48	20.15	0.0197	0.0100	0.40	16.03	1.00	201.48	11.79	2376.3	2.1600	0.76	90	1.51	3.27	4.25	1.63	2.03	10.44	7.00	-3.44	Unacceptable	
TE4	10.44	30	53.27	25.56	0.0169	0.0200	0.43	10.85	0.46	53.27	10.85	578.0	1.8286	0.64	45	0.69	1.79	2.33	0.90	1.33	11.76	7.16	-4.60	Unacceptable	
T11	10.44	48	148.21	166.60	0.0106	0.0050	1.77	11.79	0.54	148.21	11.70	1733.4	2.1240	0.74	0	0.00	1.28	1.67	0.64	2.42	12.85	5.33	-7.52	Unacceptable	
T10	12.85	18	1.24	18.66	0.0001	0.0200	0.00	0.70	0.00	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.00	0.00	0.00	0.00	12.86	4.88	-7.98	Unacceptable	*
T9	12.85	48	146.97	128.37	0.0105	0.0050	1.34	11.70	0.53	116.33	8.79	1022.0	1.1985	0.42	0	0.00	0.95	1.24	0.48	1.96	14.82	4.75	-10.07	Unacceptable	
T8	14.82	18	3.86	18.67	0.0014	0.0200	0.03	2.19	0.02	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.02	0.02	0.01	0.04	14.85	4.54	-10.31	Unacceptable	*
T7	14.82	18	2.07	18.44	0.0004	0.0200	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	14.83	4.48	-10.35	Unacceptable	*
T6	14.82	48	110.40	86.54	0.0059	0.0050	0.51	8.79	0.30	110.40	8.62	951.7	1.1540	0.40	0	0.00	0.70	0.91	0.35	0.86	15.68	4.80	-10.88	Unacceptable	
T5	15.68	18	2.07	18.37	0.0004	0.0200	0.01	1.17	0.01	0.00	0.00	0.0	0.0000	0.00	90	0.00	0.01	0.01	0.00	0.01	15.69	4.08	-11.61	Unacceptable	*
T4	15.68	48	108.33	42.94	0.0057	0.0050	0.24	8.62	0.29	108.33	15.33	1660.2	3.6471	1.28	0	0.00	1.56	2.03	0.78	1.03	16.71	5.00	-11.71	Unacceptable	
T3	16.71	36	108.33	37.40	0.0264	0.0100	0.99	15.33	0.91	95.50	17.29	1651.1	4.6418	1.62	90	3.25	5.79	7.52	2.89	3.88	20.59	5.10	-15.49	Unacceptable	
T2	20.59	18	7.45	26.61	0.0050	0.0100	0.13	4.22	0.07	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.07	0.09	0.03	0.18	20.76	4.64	-16.12	Unacceptable	*
T1	20.59	18	3.17	13.74	0.0009	0.0100	0.01	1.80	0.01	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.01	0.02	0.01	0.02	20.61	4.58	-16.03	Unacceptable	*
TE1	20.59	30	84.87	265.80	0.0428	0.0130	11.38	17.29	1.16	4.14	5.27	21.8	0.4315	0.15	35	0.12	1.43	1.86	0.72	12.31	32.90	10.85	-22.05	Unacceptable	
TE2	32.90	12	4.14	23.32	0.0135	0.0575	0.31	5.27	0.11	4.14	11.86	49.1	2.1842	0.76	35	0.61	1.48	1.93	0.74	1.06	33.96	11.29	-22.67	Unacceptable	
TE3	33.96	8	4.14	29.72	0.1174	0.0300	3.49	11.86	0.55	0.00	0.00	0.0	0.0000	0.00	0	0.00	0.55	0.71	0.27	3.84	37.80	12.04	-25.76	Unacceptable	*

*Lesser of the Rim Elevation or the Rim Elevation minus 0.42' (Throat Opening is 5" for CSDI-1A)

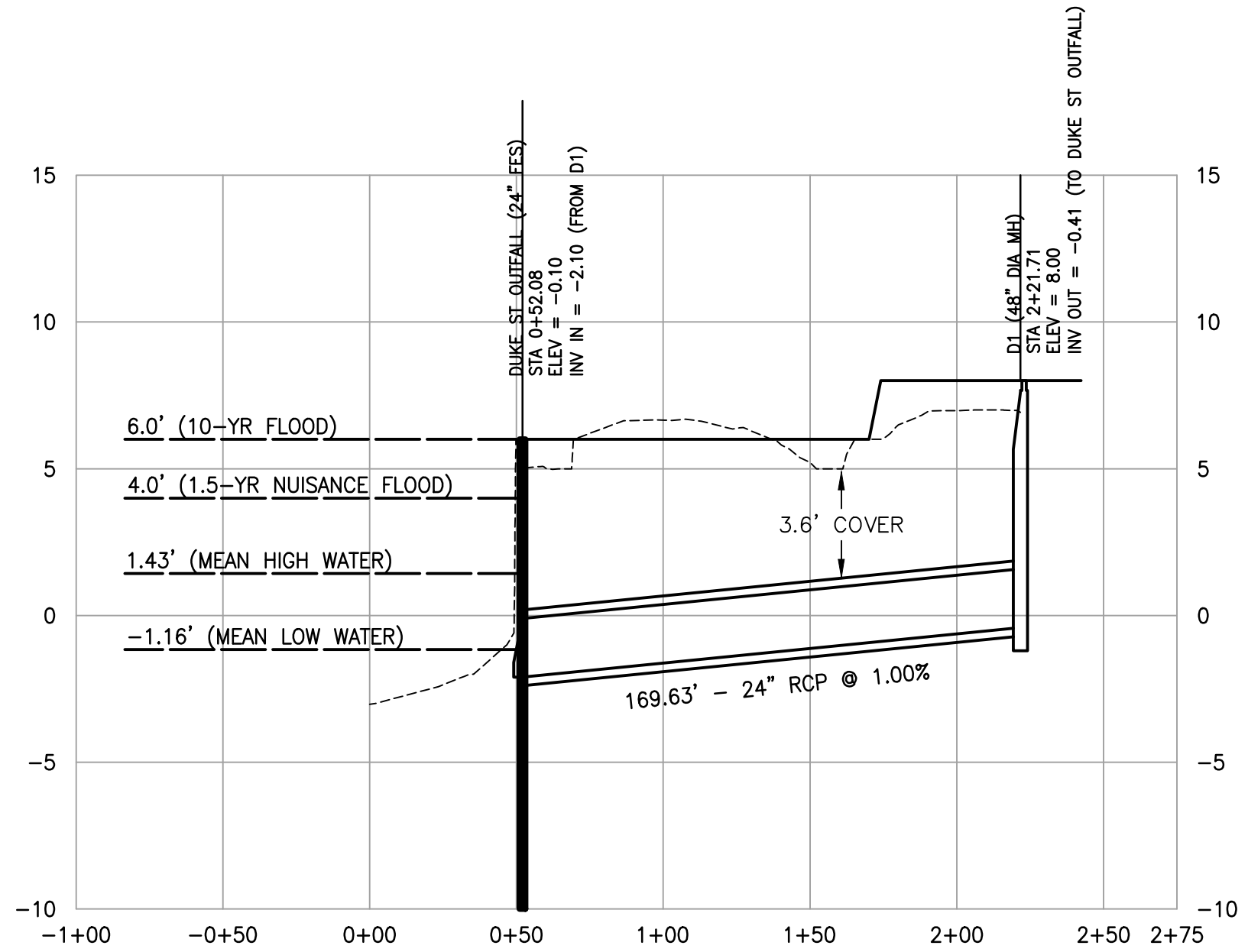
HGL considered "Acceptable" when Inlet Water Surface Elevation is less than the throat of the inlet.

Per City of Alexandria HGL considered "Acceptable" when Inlet Water Surface Elevation is less than 2' from the throat of the inlet (waiver will be requested).

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix E PRELIMINARY STORM SEWER PROFILES

Appendix E PRELIMINARY STORM SEWER PROFILES



Duke St Bypass
Horizontal Scale: 1" = 20'
Vertical Scale: 1" = 2'

**Stantec**
Tel. 703.263.1220
Fax. 703.263.1221
www.stantec.com

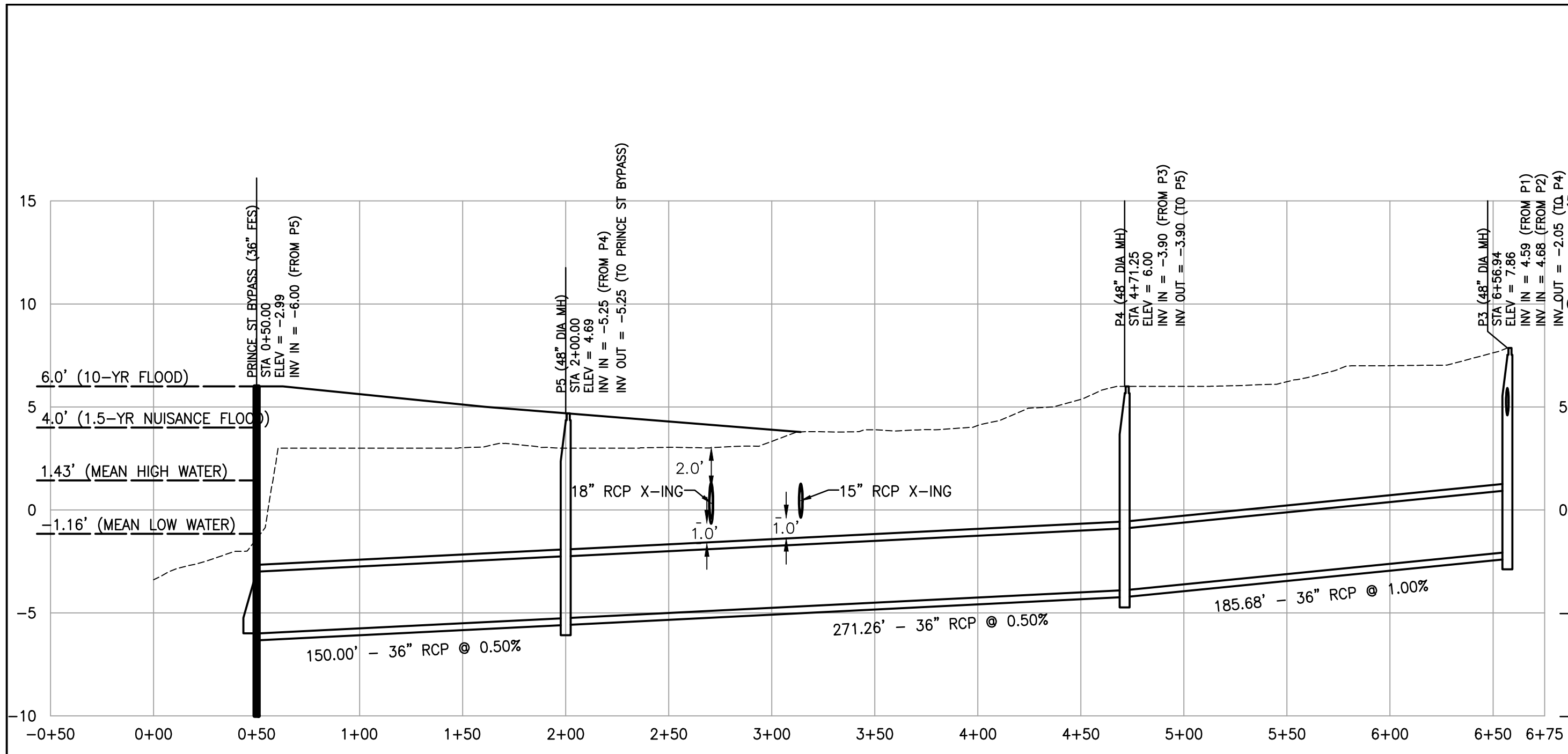
STANTEC
4500 DALY DRIVE, SUITE 100
CHANTILLY, VA 20151

BYPASS STORM SYSTEM
PROFILES - ALT 1
WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION



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Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313

Date: AUGUST 2017
Scale: H:1" = 50' V:1" = 5'
Project No.: 2029041842
Sheet No.
1



Prince St Bypass
Horizontal Scale: 1" = 20'
Vertical Scale: 1" = 2'



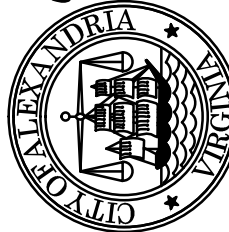
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**BYPASS STORM SYSTEM
PROFILES - ALT 1**

**WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION**



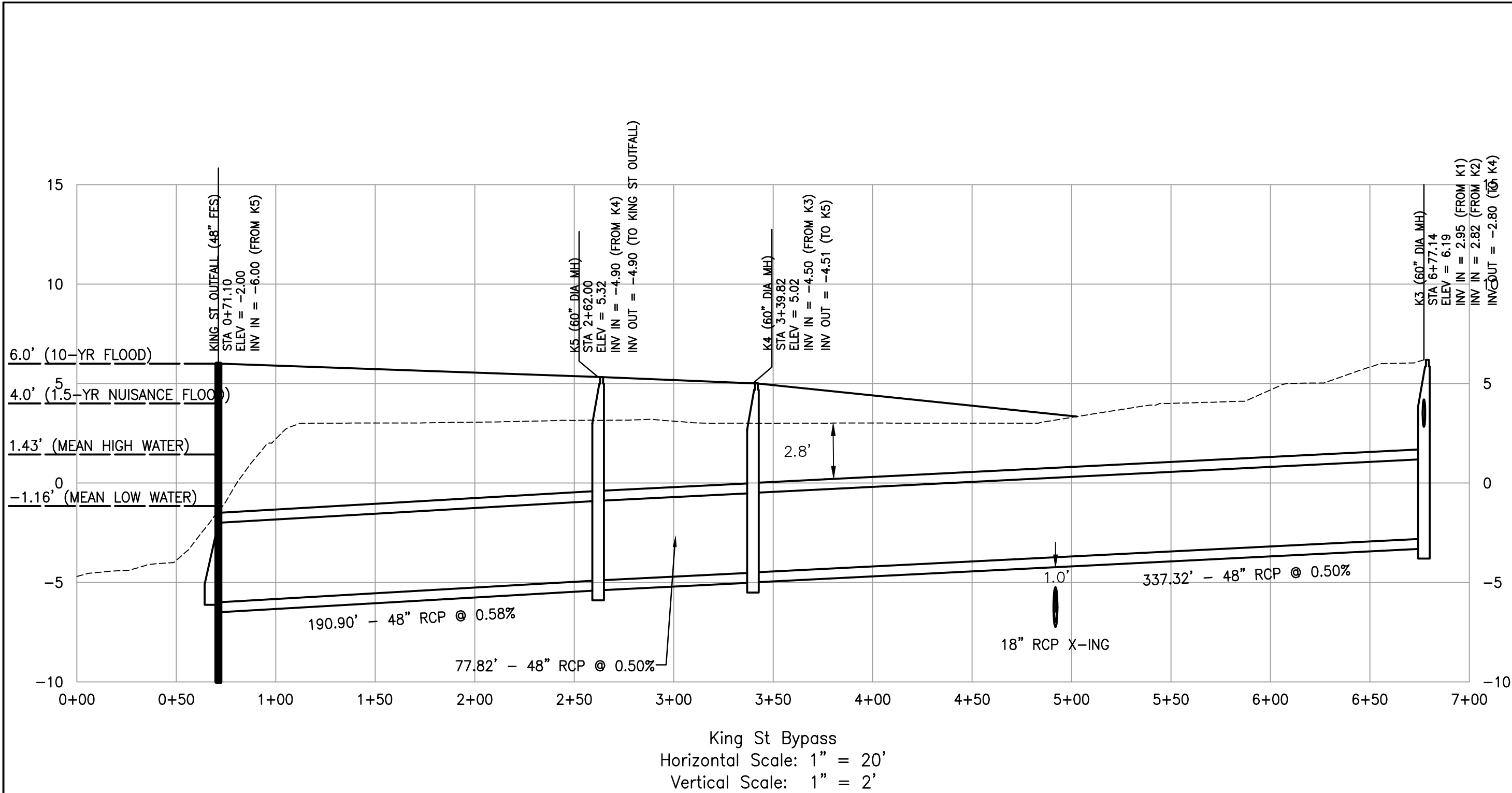
CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313

Date: AUGUST 2017

Scale: H:1" = 50' V:1" = 5'

Project No.: 2029041842

Sheet No.
2





STANTEC

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BYPASS STORM SYSTEM
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Alexandria, Virginia 22313

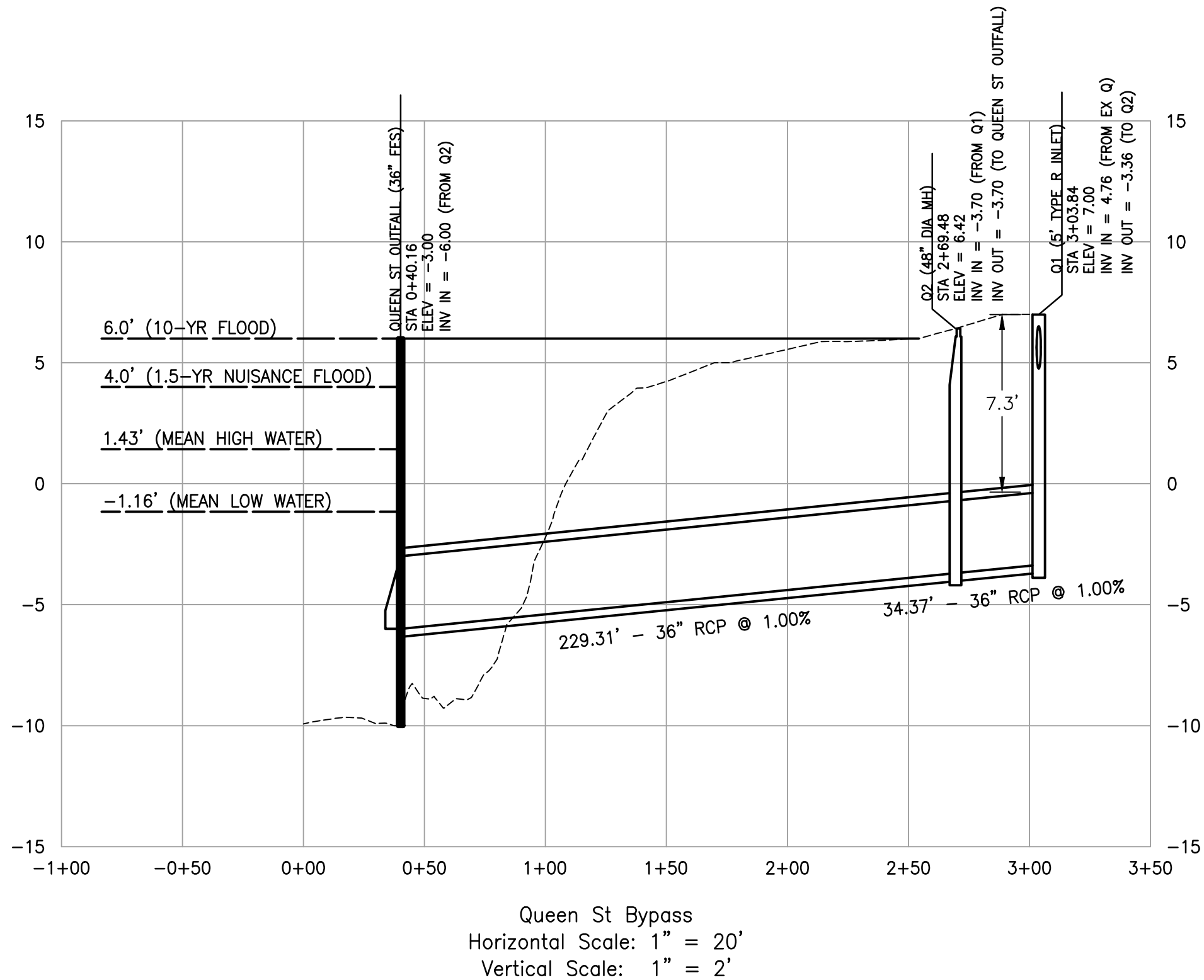


Date: AUGUST 2017

Scale: H:1" = 50' V:1" = 5'

Project No.: 2029041842

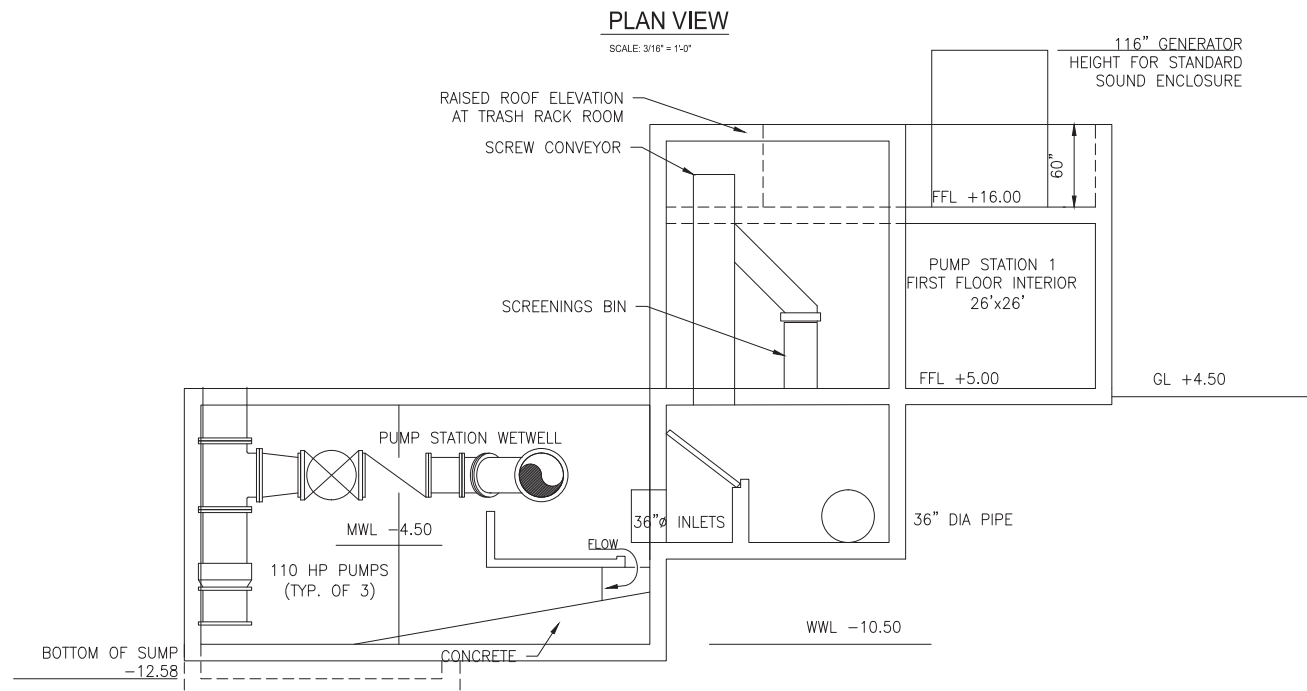
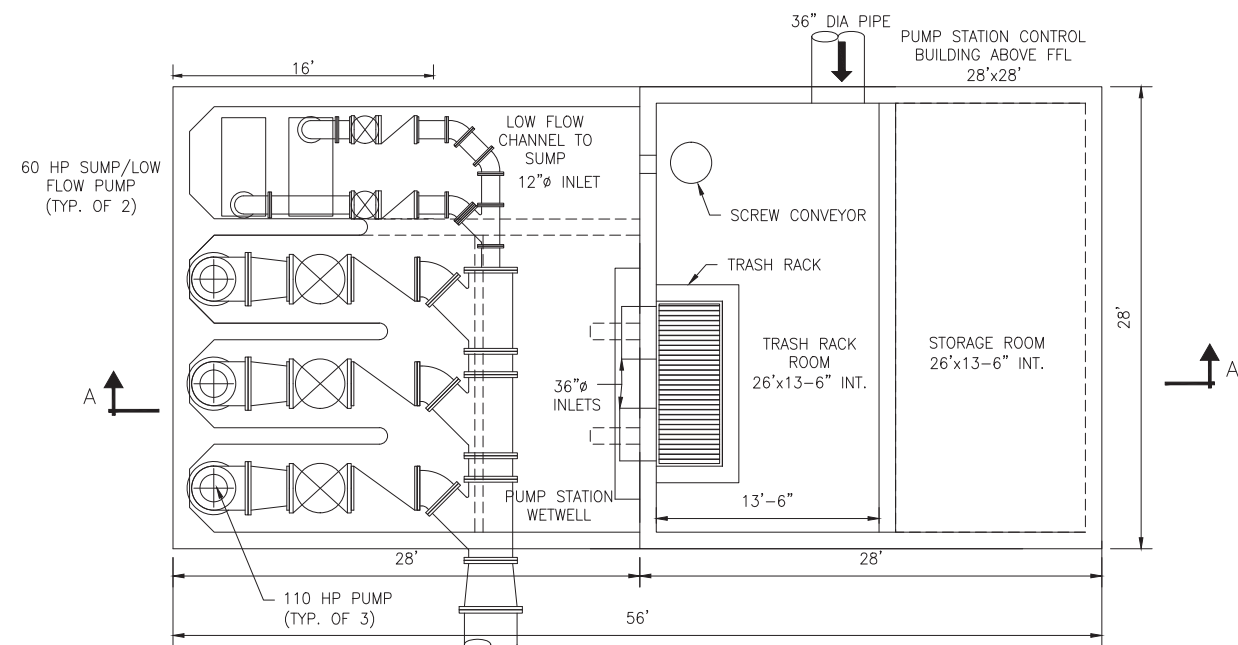
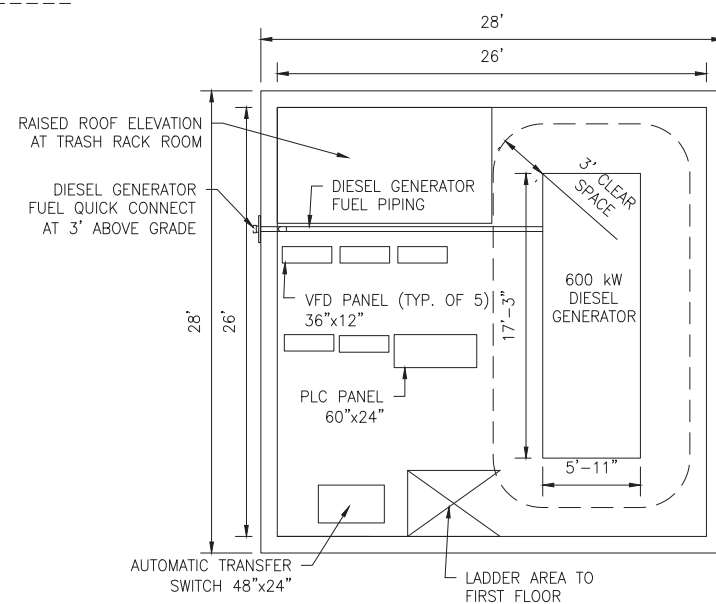
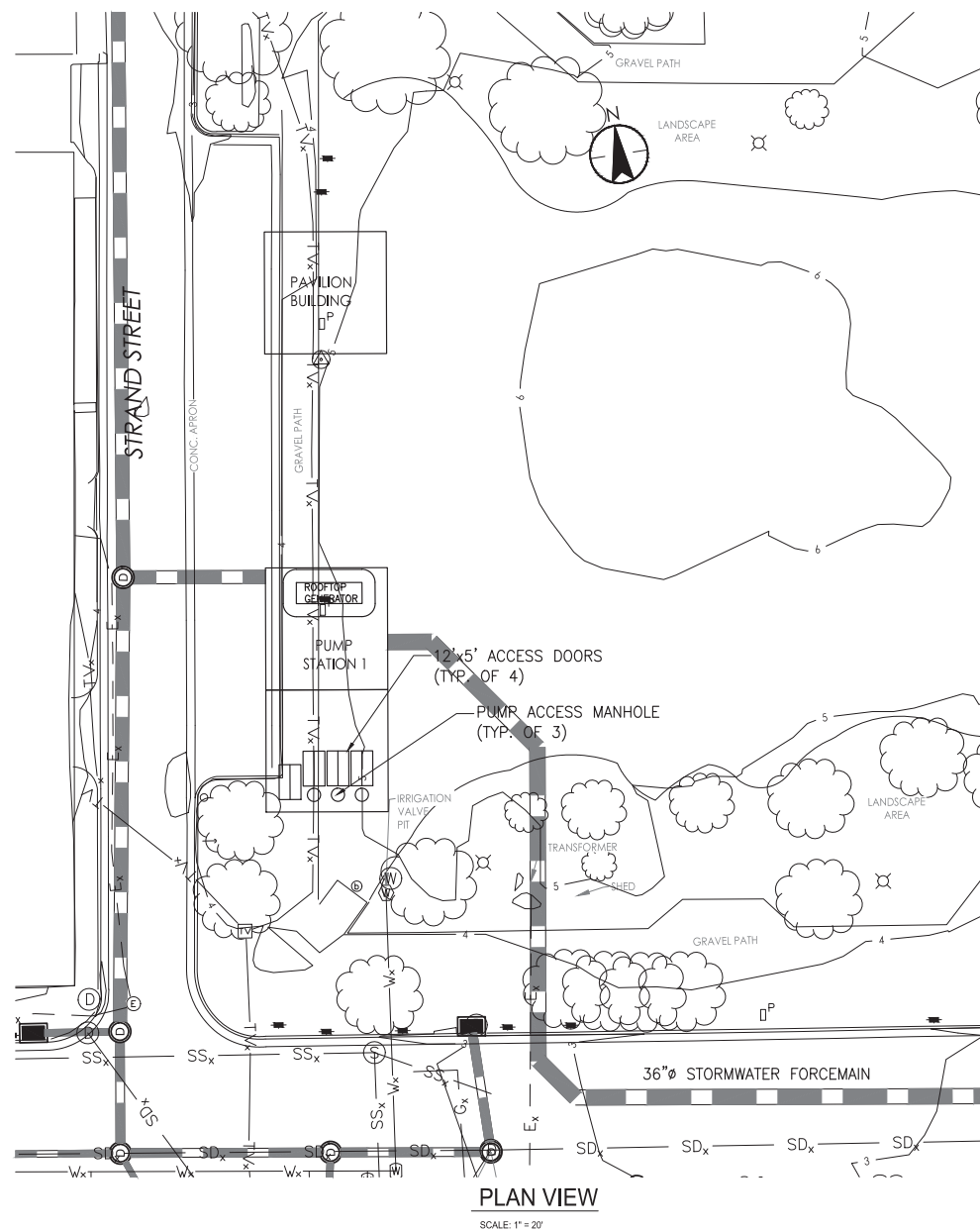
Sheet No.
3



**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix F PUMP STATION 1 LAYOUT

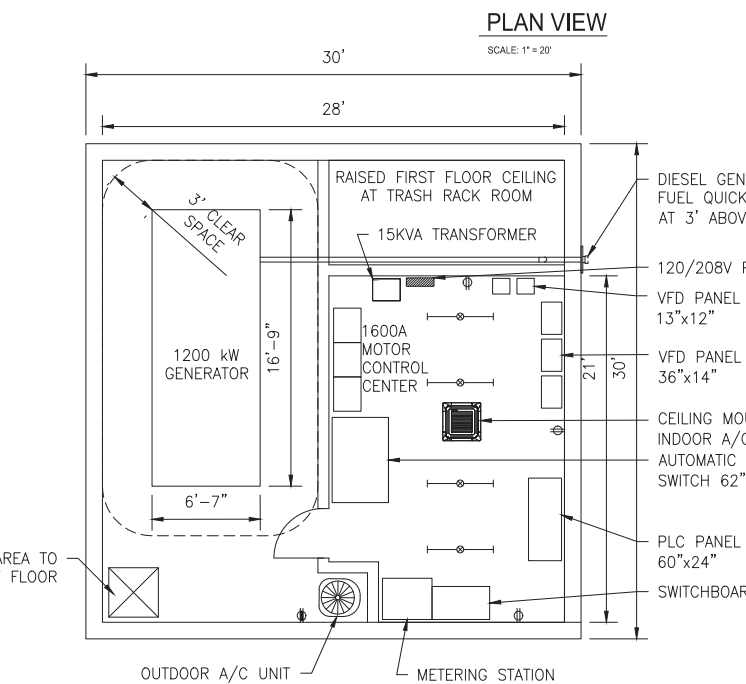
Appendix F PUMP STATION 1 LAYOUT



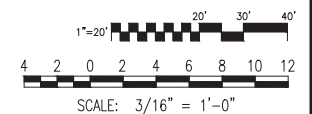
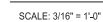
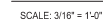
PUMP STATION 1 ALT. 1 CONCEPT PLAN

ALEXANDRIA, VA

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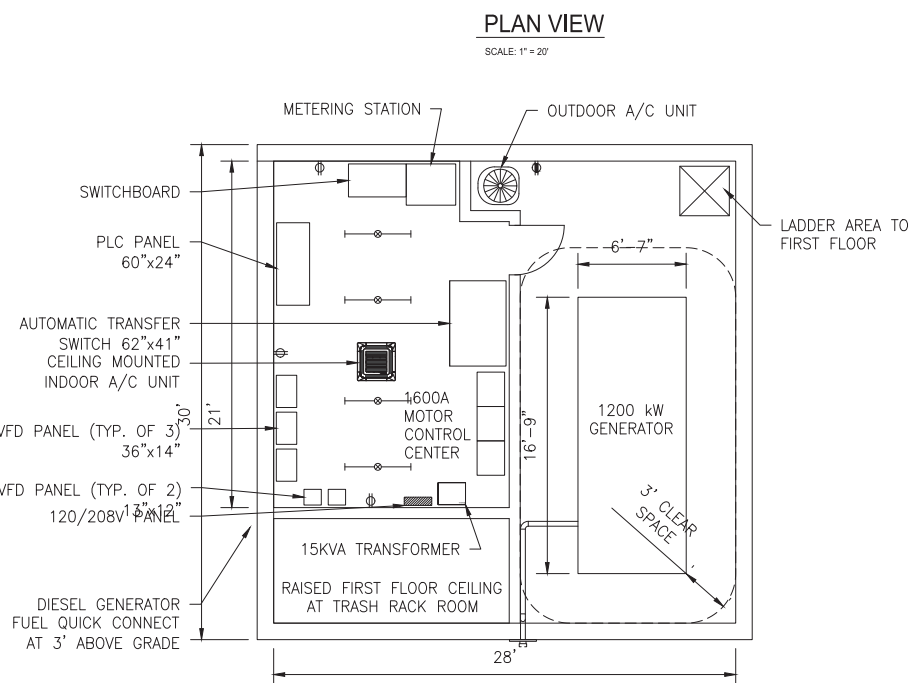


SCALE: 3/16" = 1'-0"

[illegible]

PRIORITY PLAN NO:	
X-X-1	
PROJECT NO: 2029041842	
LE:	AS NOTED
DATE:	OCTOBER 2017
GN:	GKK
WN:	GKK
CKED:	GJF

ATTACHMENT F



46'

30'

16'

13'-6"

TRASH RACK ROOM
28'x13-6" INT.

TRASH RACK

TRASH BIN

SCREW CONVEYOR

12'x3' OPENING

PUMP STATION CONTROL BUILDING
ABOVE FFL
30'x30'

PUMP STATION WETWELL

12"Ø INLET

LOW FLOW CHANNEL TO SUMP

60 HP SUMP/LOW FLOW PUMP
(TYP. OF 2)

310 HP PUMP
(TYP. OF 3)

48" DIA CHECK VALVE
(TYP. OF 3)

48" DIA PLUG VALVE
(TYP. OF 3)

60" DIA FORCEMAIN

37'

5'

17'

12" DIA CHECK VALVE
(TYP. OF 2)

12" DIA PLUG VALVE
(TYP. OF 2)

54" DIA PIPE

42" DIA PIPE

RAISED CEILING ELEVATION
AT TRASH RACK ROOM

1200/1600
12" DIA INLET

TOP OF GENERATOR
+23.58

PLAN VIEW

SCALE: 3/16" = 1'-0"

PLAN VIEW
SCALE: 3/16" = 1'-0"

12" DIA PLUG VALVE (TYP. OF 2)

RAISED CEILING ELEVATION AT TRASH RACK ROOM

1200/1600 KW / KVA GENERATOR

1600GAL TANK

60"

FFL +14.00

SCREENINGS BIN

PUMP STATION 1 FIRST FLOOR INTERIOR 28'x28'

FFL +5.00

GL +4.50

48" DIA CHECK VALVE (TYP. OF 3)

48" DIA PLUG VALVE (TYP. OF 3)

60" DIA FORCEMAIN

PUMP STATION WETWELL

PUMP ON/MAX WL -6.00

PUMP OFF ELEV. -9.00

310 HP PUMPS (TYP. OF 3)

12'X3' OPENING

ELEV. -14.00

CONCRETE

BOTTOM OF WETWELL -16.00

BOTTOM OF SUMP -17.00

SECTION A-A

Diagram illustrating the layout and dimensions of the Pump Station 1 Electrical Room. The room is divided into two main sections: the left section contains the Pump Station 1 Electrical Room and the PLC Panel, while the right section contains the 1200/1600 KW / KVA Generator and the 1600GAL Tank. The Motor Control Cabinet is located above the Generator. Dimensions are provided for the overall room height (17' and 14'), equipment height (8', 9', 10'-2", 9'-8"), and width (8'). A scale of 3/16" = 1'-0" is indicated.

SCALE: 3/16" = 1'-0"

MOTOR CONTROL CABINET

PUMP STATION 1 ELECTRICAL ROOM

PLC PANEL

1200/1600 KW / KVA GENERATOR

1600GAL TANK

Dimensions: 17', 8', 9', 10'-2", 9'-8", 14', 8'

1"=20' 20' 30' 40'

4 2 0 2 4 6 8 10 12

SCALE: $\frac{3}{16}" = 1'-0"$

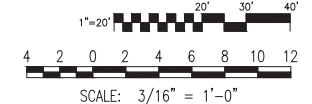
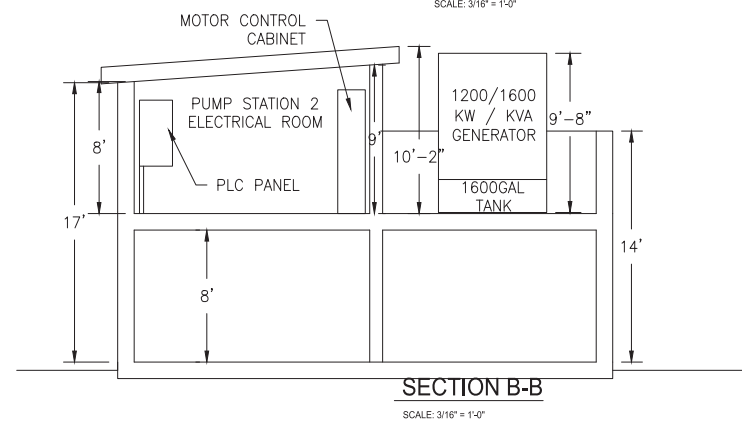
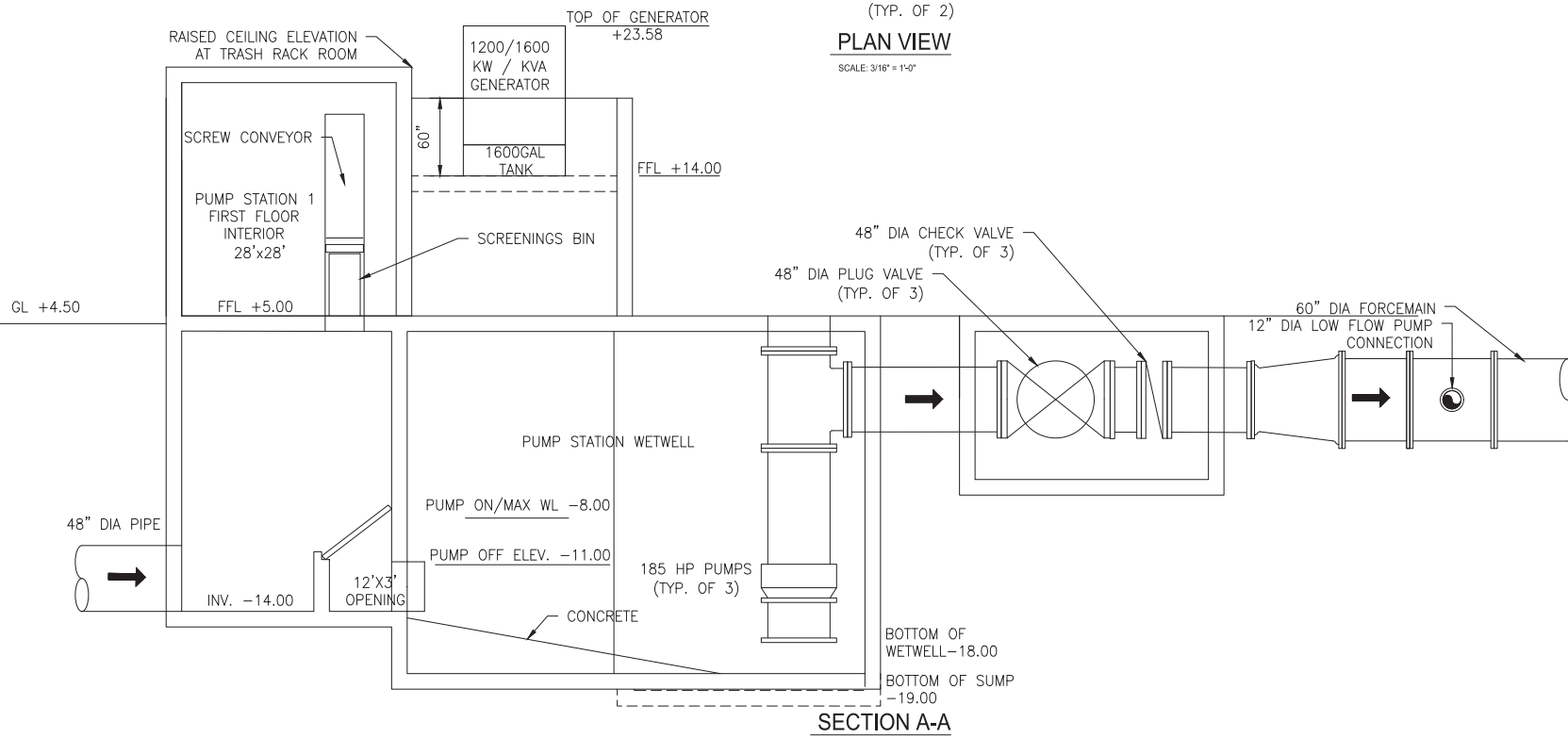
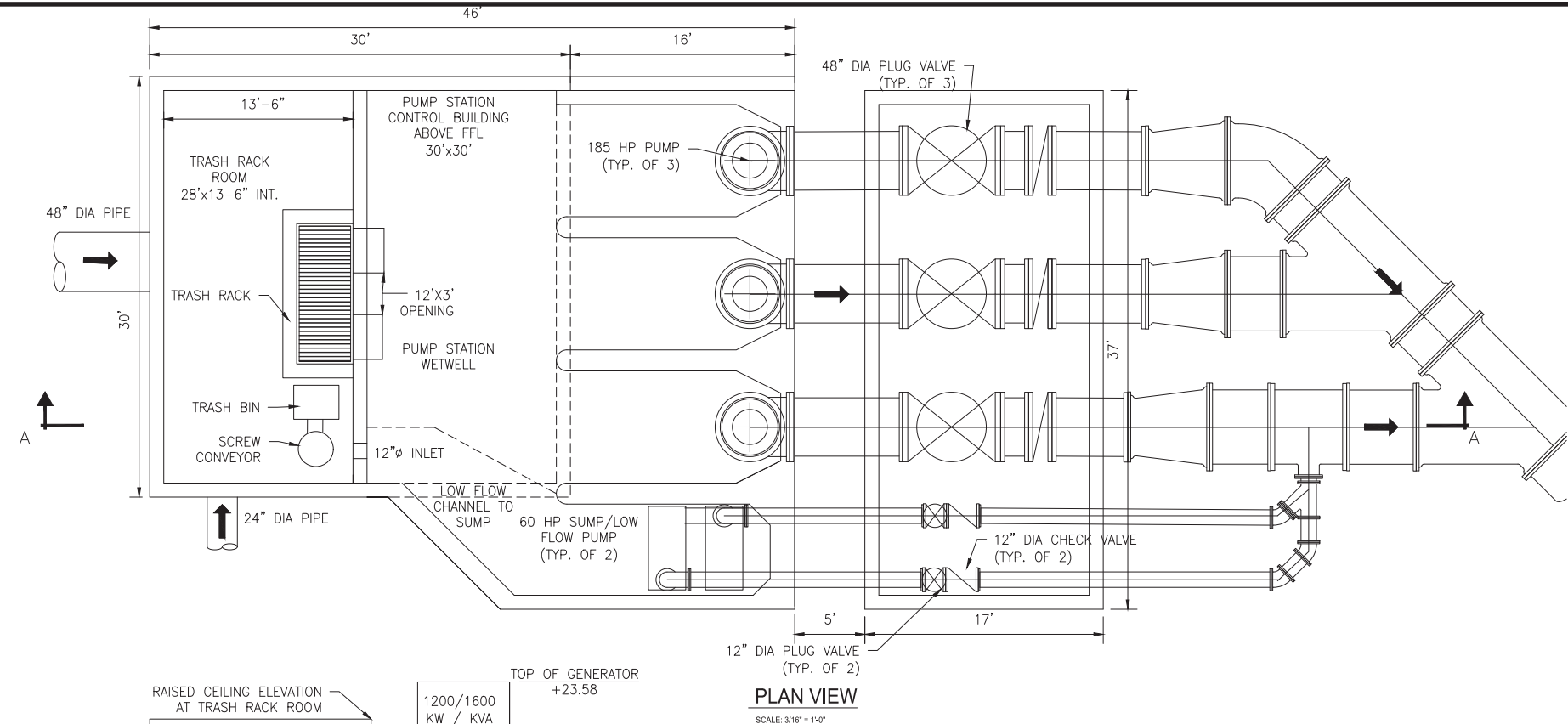
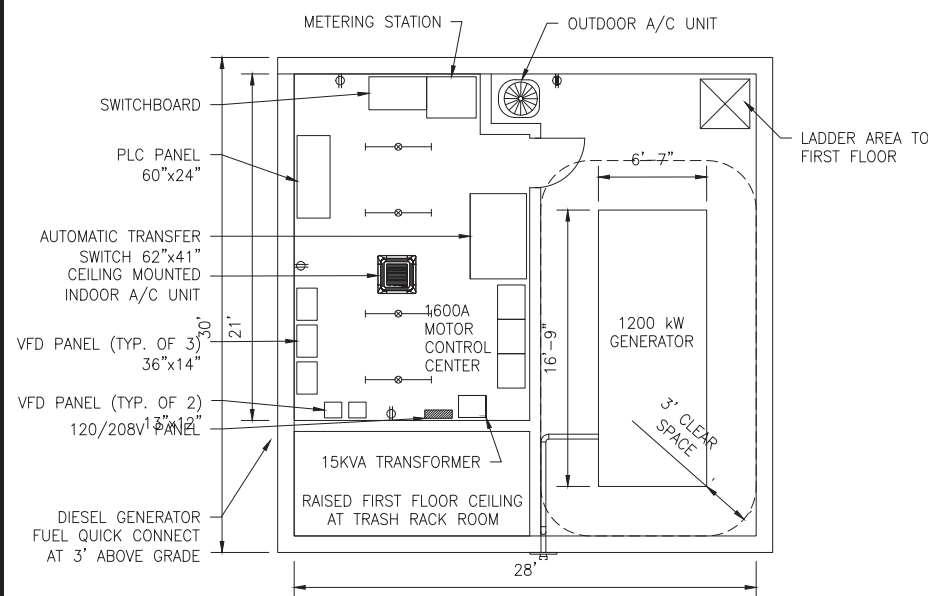
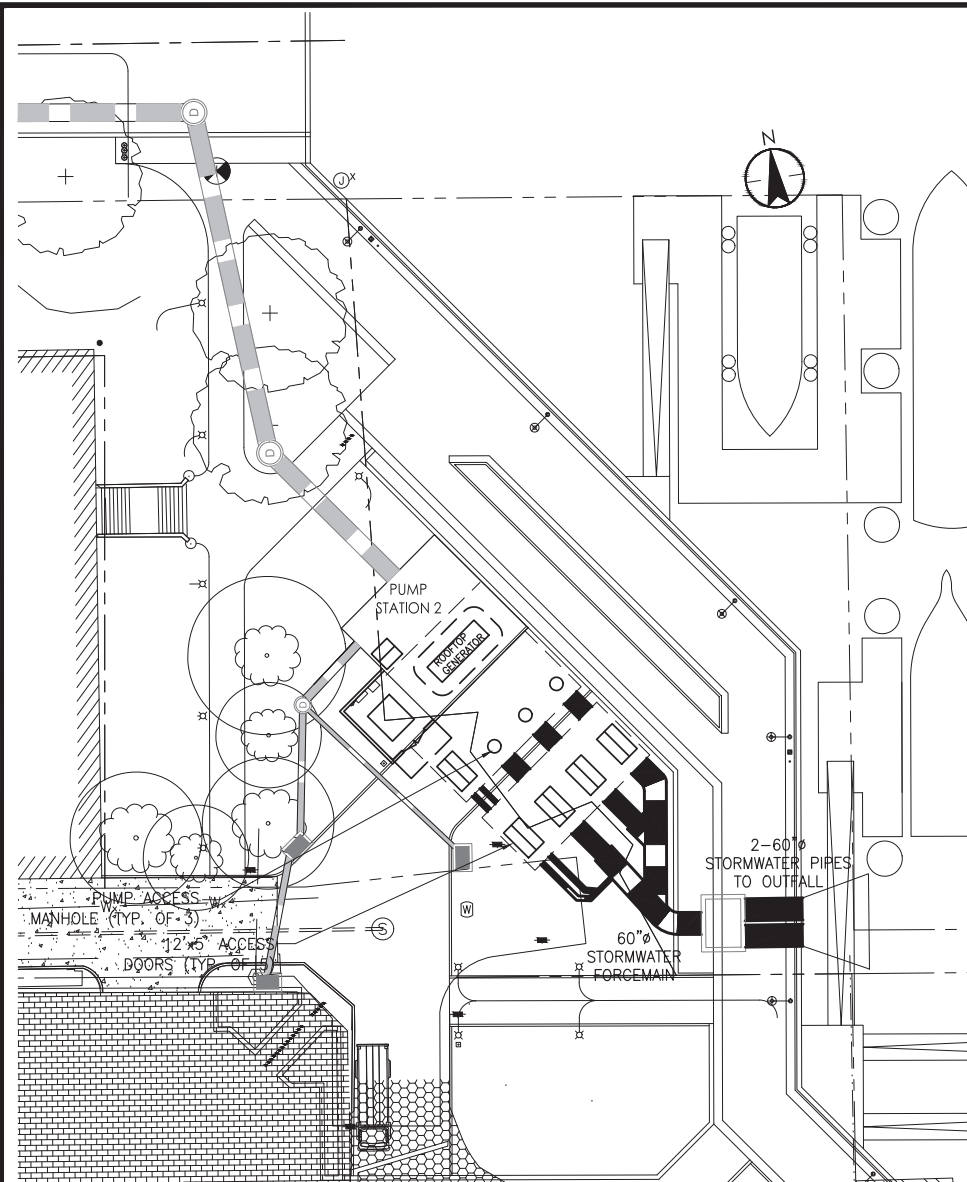
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AUTHORITY PLAN NO: X-X-1	
PROJECT NO: 2029041842	
SCALE: AS NOTED	
DATE: OCTOBER 2018	
DESIGN:	GKK
DRAWN:	GKK
CHECKED:	GJF
SHEET NO:	
ATTACHMENT F	

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix G PUMP STATION 2 LAYOUT

Appendix G PUMP STATION 2 LAYOUT



PUMP STATION 2 ALT. 3B CONCEPT PLAN

[illegible]

ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION MASTER STORM WATER MANAGEMENT PLAN

Appendix H WQIA

Appendix H WQIA

**Water Quality
Impact Assessment**

Alexandria Waterfront: Flood Mitigation
Implementation



Prepared for:
City of Alexandria, Virginia

Prepared by:
Megan McCollough, P.E., CFM
150 Riverside Parkway, Suite 301
Fredericksburg, Virginia 22406

September 2, 2016

Sign-off Sheet

This document entitled Water Quality Impact Assessment was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of the City of Alexandria (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by _____
(signature)

Megan McCollough, P.E., CFM

Reviewed by _____
(signature)

Josh Orndorff, P.E.

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WATER QUALITY IMPACT ASSESSMENT

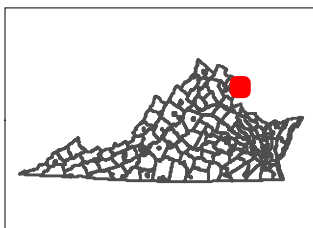
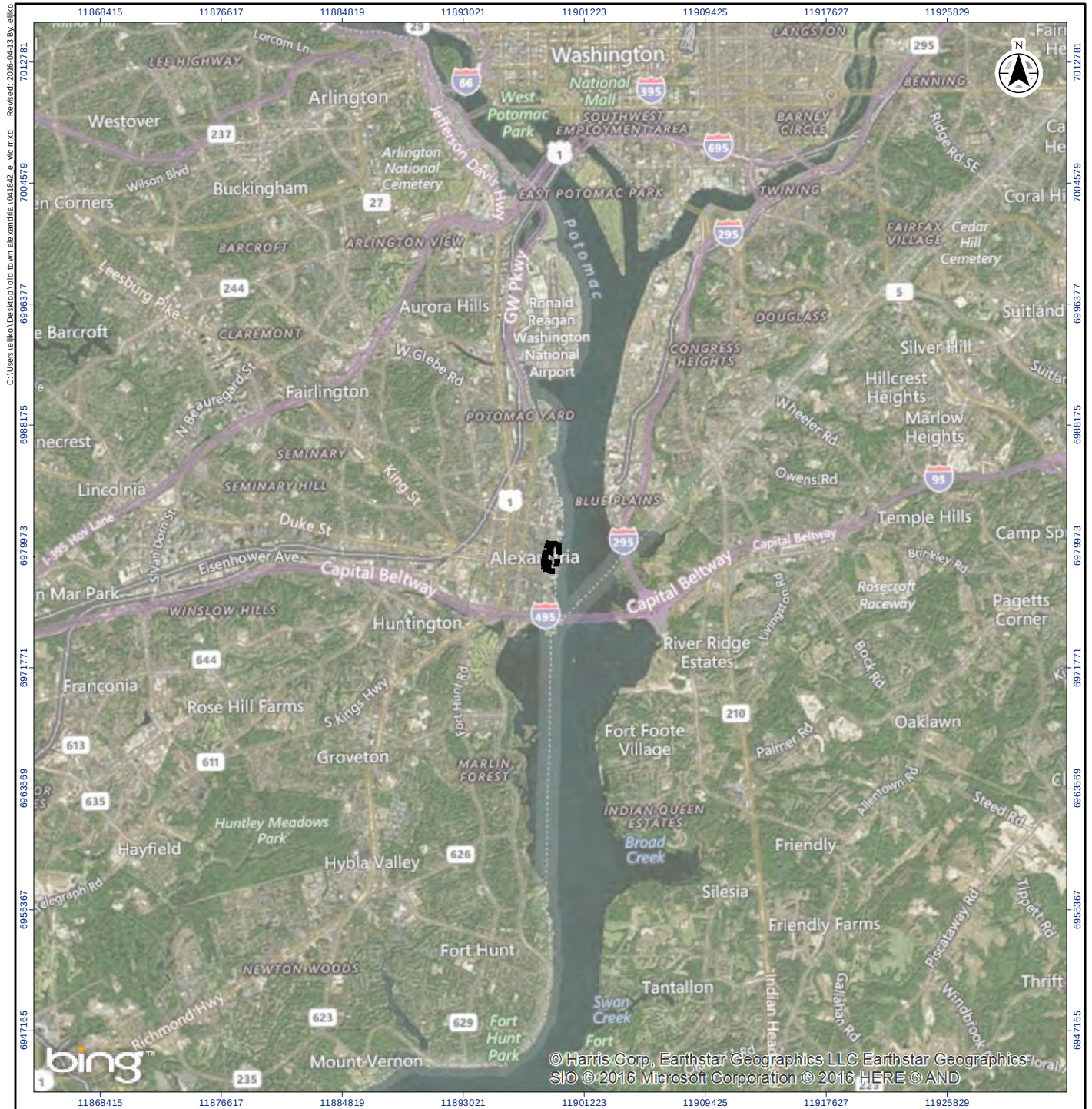
INTRODUCTION
September 2, 2016

1.0 INTRODUCTION

Stantec Consulting Services, Inc. (Stantec) has been retained by the City of Alexandria to prepare the necessary support documentation for the proposed project known as the Alexandria Waterfront: Flood Mitigation Implementation, located in Alexandria, Virginia (Figures 1 and 2) regarding potential impacts to lands within designated Chesapeake Bay Preservation Areas (CBPAs). The Core Area development to implement the Storm Water Management Plan proposed in this report has approximately 3 acres of disturbance within the Resource Protection Area (RPA) adjacent to the Potomac River, therefore a water quality major impact assessment is required. The limits of the RPA are shown on the Overall Drainage Divides graphic in Appendix A. This section of the WQIA represents the required assessment of the potential environmental impacts resulting from the proposed development as referenced in Article XIII. – *Environmental Management* of the City of Alexandria Code of Ordinances (Section 13-117).

The Chesapeake Bay Preservation requirements are administered in the City of Alexandria through Article XIII (Article) of the City of Alexandria Code of Ordinances (Code). This article is entitled *Environmental Management*, and contains the development standards for these areas. A water quality major impact assessment is “*required for development or redevelopment within RPAs or under an exception that involves more than 5,000 square feet of land disturbance; or for any development or redevelopment within the RMA which involves more than 5,000 square feet of land disturbance adjacent to an RPA, if required by the director of T&ES due to the presence or proximity of wetlands, potential for harmful discharge of contaminants from the property, or slopes greater than 15 percent which are proposed to be disturbed,*” per the Article. A major WQIA generally consists of a narrative that describes and site drawings that show the construction footprint, RPA components, wetlands and other jurisdictional features, any encroachments into the RPA, location of existing vegetation on-site and a plan for re-vegetation, and the type and location of any potential measures to mitigate the effect of the proposed development within the RPA. The following sections of this WQIA present this narrative, as well as a hydrogeological element and a vegetative element.





Legend

Project Limits

0 5,000 10,000
Feet
1:120,000 (at original document size of 8.5x11)



Project Location 2029041842
City of Alexandria, VA Prepared by ECL on 2016-03-16
Technical Review by IPS on 2016-04-12
Independent Review by LC on 2016-04-12

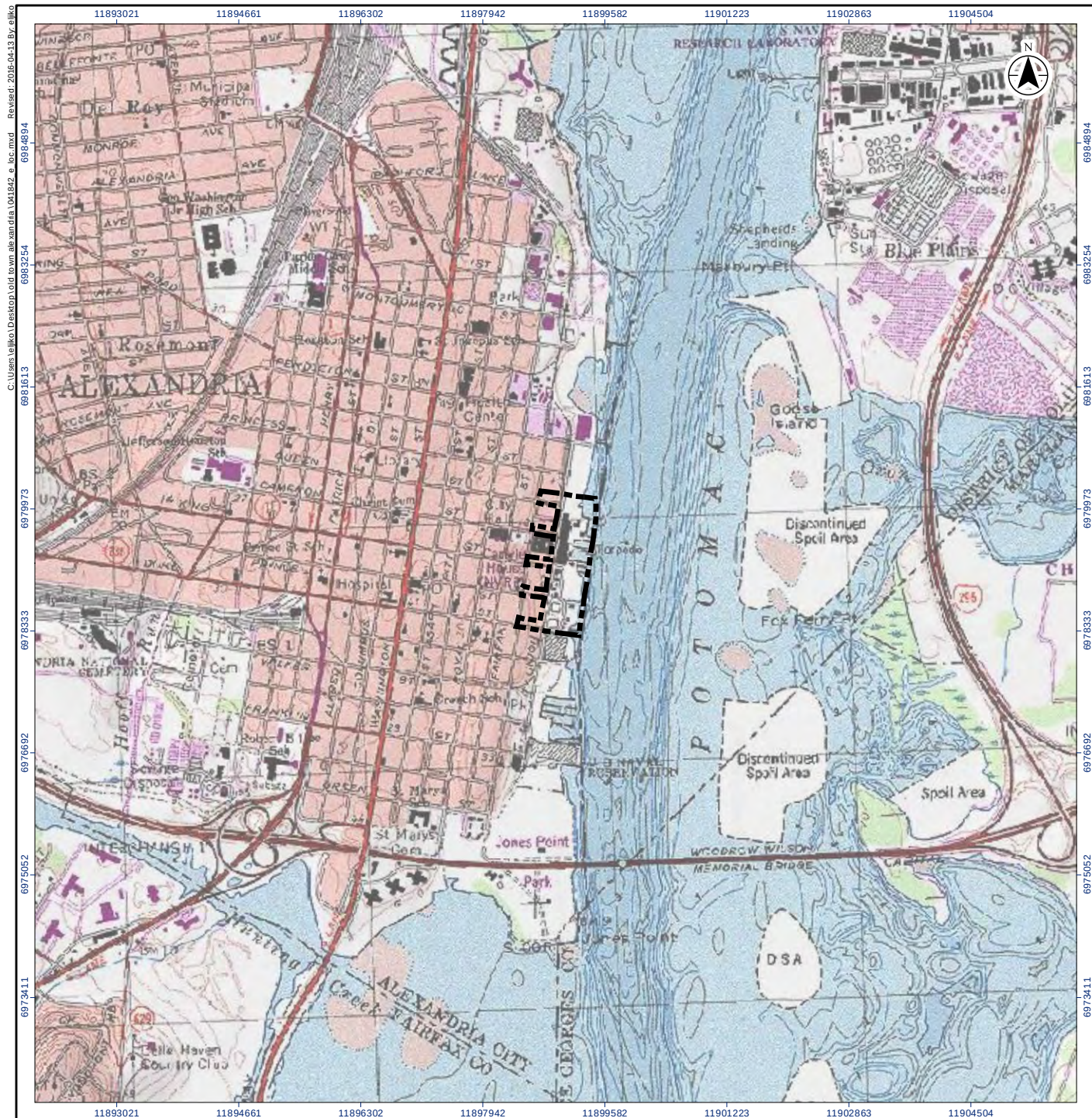
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City of Alexandria
Alexandria Waterfront

Figure No.
1
Title

Vicinity Map

- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Orthomage © Bing Maps
 3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

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Legend

Project Limits

0 1,000 2,000
Feet
1:24,000 (at original document size of 8.5x11)



Project Location 2029041842
City of Alexandria, VA Prepared by ECL on 2016-03-16
Technical Review by IPS on 2016-04-12
Independent Review by LC on 2016-04-12

Client/Project
City of Alexandria
Alexandria Waterfront

Figure No.
2

Title
Location Map

- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Topographic map © USGS 7.5 Minute Series Topographic Map

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WATER QUALITY IMPACT ASSESSMENT

GENERAL SITE ASSESSMENT
September 2, 2016

2.0 GENERAL SITE ASSESSMENT

The project area for the Alexandria Waterfront: Flood Mitigation Implementation project is approximately 17 acres, extending along approximately 0.5 miles of Potomac River shoreline. The site is located in the City of Alexandria, south of Washington DC, and west of the Potomac River. The site can be accessed from the terminus of Queen Street, Cameron Street, King Street, Prince Street, and/or Duke Street, which are located to the west (Figures 1 and 2). Based upon a desktop review of historic aerial imagery, the majority of the site consists of developed, urbanized area. The limited forested cover on-site is located within small park areas at the north, central, and south areas of the project limits. The overall site has been in its current land cover condition for at least the last five (5) years based upon this review.

The overall drainage area map provided in Exhibit 1 shows the limits of the RPA and associated 100-foot buffer on the project site. The RPA on-site is associated with the Potomac River. The RPA limits shown on the enclosed graphic are based on the City of Alexandria 2016 RPA Map. Stantec conducted a detailed investigation of waters of the U.S., including wetlands, within the project limits in March 2016. The request for preliminary jurisdictional determination (PJD, Appendix B) was submitted to the U.S. Army Corps of Engineers (Corps) on April 29, 2016, and is pending. Based on the on-site field work, Stantec concluded that the only jurisdictional feature on-site is the Potomac River. No wetlands are located within the project limits.

The proposed improvements within the Core Area include several infrastructure improvements including a structural bulkhead, bypass storm sewer system, storm sewer upgrades, and pump stations, to reduce the frequent flooding from heavy rainfall currently impacting businesses, residents, and existing infrastructure elements within this area of Alexandria. These flood mitigation measures are proposed in order to protect the Core Area to an elevation of at least 6.0', which is the 10-year flood elevation. The selected alternative minimizes impacts within the RPA; however, impacts occur at locations of some activities noted above, including the area of the pump stations. The permanent disturbance within the RPA for these proposed improvements is approximately 3 acres. The improvements will not result in significant disruption to the hydrology of the site nor will it significantly degrade aquatic vegetation. This WQIA addresses the minor decreases in the functional integrity of the RPA buffer resulting from the proposed encroachments, and proposed mitigatory measures.



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
September 2, 2016

3.0 HYDROGEOLOGICAL ELEMENT

3.1 EXISTING TOPOGRAPHY/SOILS/HYDROLOGY

The existing topography, soils, and hydrology of the site and immediately adjacent land were evaluated based on published information and maps. The topography of the site varies from very flat slopes under the developed areas to nearly vertical slopes with deep drops in the areas adjacent to the Potomac River. Elevation across the site ranges from elevation 10 feet (ft) at the high point of the site to approximately 2.5 ft along the shoreline. The site generally slopes toward the east, promoting drainage to the Potomac River.

The USGS 7.5-minute quad map, existing conditions mapping, and recent Virginia Geographic Information Network (VGIN) aerial imagery depict an area that is primarily developed, with a few minor forested areas within maintained waterfront park areas in the north, central and south portions of the site, adjacent to the Potomac River. The Potomac River is the only jurisdictional feature identified within the project limits, and may be classified as a non-vegetated stream channel. Adjacent lands to the project consist of densely developed urban areas.

The Soil Survey from NCRS (City of Alexandria, 2013 and District of Columbia, 2015) maps two (2) soil types within the Core Area boundary. The soil boundaries and labels are included on the soils map, which is provided in as part of the PJD (Appendix B). The hydrologic soil group classifications of the mapped soil types range from group C (well-drained) to group D (poorly-drained). Soils that have been classified as urban/previously disturbed are conservatively assumed to be classified as group D for the purposes of this report. Soils within the Core Area are primarily Urban land-Grist Mill, with a few shoreline and upland areas consisting of Grist Mill sandy loam soils. While the Urban land-Grist Mill soils do not have a permeability rating provided through the NRCS mapping, the Grist Mill sandy loam has a permeability of approximately 0.18 inches per hour. Depths to seasonal high groundwater tables for the project area range from 3.3 to greater than 6 feet, per the NRCS mapping; however it should be noted that surface water is abundant given the project location. The depth to restrictive layer (bedrock) is greater than six feet across the Core Area.

3.2 IMPACTS OF PROPOSED DEVELOPMENT

The purpose of the Core Area improvements is to provide flood mitigation measures along the Alexandria Waterfront to reduce the frequency of flooding. The total area of the project is approximately 17 acres, of which approximately 17.6% will be disturbed with the proposed improvements. The majority of this disturbed area is for the purpose of storm pipe replacement, and as such it is not altering the land cover characteristics. There will be a negligible 0.4% increase of impervious cover associated with the construction of two proposed pump stations. Given the nature and location of the project, permits that may be necessary include a Joint



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
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Permit Application for Construction in Waters of the U.S. and Wetlands, a NEPA document, an NPS permit for encroachment into the Potomac River bottom, and an MS4 permit.

As mentioned previously in this document, the proposed improvements within the Core Area include a structural bulkhead, bypass storm sewer systems, local storm sewer system upgrades, and two pump stations. The subsections below, as taken from the Master Storm Water Management Plan (MSWMP) summarize the preliminary design characteristics of these features:

3.2.1 STRUCTURAL BULKHEAD

A vertical, structural bulkhead at an elevation of 6.0' is proposed with the MSWMP. There will be two bulkheads running north-south along the Potomac shoreline. The first bulkhead will run from Duke Street to just north of King Street along approximately 1,300 feet of shoreline. The second bulkhead will run from Cameron Street to Queen Street along approximately 700 feet of shoreline. In some areas, this new bulkhead will be to the east of the existing U.S. Army Corps of Engineers bulkhead line. The bulkheads will provide protection up to and including the 10-year storm event, in order to minimize the damage from the frequent smaller flood events. There will be an elevated walkway along the bulkhead to provide pedestrian access along the shoreline.

3.2.2 BYPASS STORM SEWER SYSTEMS

A sealed storm sewer system will be proposed in order to convey upstream runoff directly to the river, which bypasses the pump stations. The bypass storm system will decrease the size of the drainage area to the pump station, such that higher runoff storm events will not overwhelm the pumps. The bypass storm systems will replace and upgrade the existing outfalls into the bulkhead. All structure tops along the bypass systems will need to be replaced with bolt-down tops in order to prevent uplift in the event the water level rises inside the structures.

It is suggested in the URS Flood Mitigation report to use either a duckbill structure or standard flap valve at each outfall into the Potomac River. It is advised to use a duckbill structure, such as one provided by Tideflex. The Tideflex duckbill allows flow out into the river but will not allow backflow into the system. Traditional flap valves cause maintenance issues, and metal flapgates are susceptible to corrosion and freezing. Tideflex duckbills open with as little as 1" of water pressure, and seals to prevent backflow and debris from entering the system. It is noted that City of Alexandria has used duckbill structures in the past which have not functioned well. It is recommended to use the Tideflex TF-1 check valve structure, and specifically sized for the outfall pipes outside diameter in order to reduce head loss and reduce deflection inside the valve due to the weight of water.

3.2.2.1 Duke Street

The existing Duke Street system outfalls into the existing bulkhead with a 18" RCP pipe at elevation -0.90. These outfall pipes will be replaced with new 24" RCP pipe. Adjacent to Duke



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
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Street and South Union Street is the proposed Robinson Terminal South development, which proposes four buildings for residential and commercial uses and six townhouse buildings.

3.2.2.2 Prince Street

The existing Prince Street system outfalls into the existing bulkhead with a 21" RCP pipe (best guess per available records). The exact location of this outfall cannot be determined at this time, but is referenced to outfall at elevation -2.00 per the Old Dominion Boat Club final site plan (dated January 2016 prepared by Christopher Consultants). Due to the existing cobblestone pavers along Prince St, it is not advisable to disturb the road west of South Union Street. Additional curb inlets will be replaced at the intersection with as little disturbance to Prince St pavers as possible, and will be routed to the pump station, as to alleviate the bypass system. Additional inlets along South Union Street will convey into the bypass system, and the system will convey approximately 4.5 Acres in 36" pipes.

3.2.2.3 King Street Bypass System

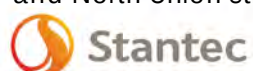
The existing King Street system outfalls into the existing bulkhead with a 24" RCP pipe (best guess per available records). The exact location of this outfall cannot be determined at this time. Additional curb inlets will be provided along King Street in order to convey flow through the rebuilt bypass system. The bypass system will convey approximately 12.7 Acres of upstream drainage area in 48" pipes. In order to alleviate the existing bypass system, additional inlets have been added at the intersection of King St and Union St, which convey flow to the pump station adjacent to Strand St.

3.2.2.4 Cameron Street Bypass System

The existing Cameron Street system outfalls into the existing bulkhead with a 18" RCP pipe (best guess per available records). The exact location of this outfall could not be determined at this time. These existing pipes run west-east along the north side of the Torpedo Factory. The existing bypass system carries drainage from approximately 8.4 Acres of upstream area. The URS 15% Concept Submission Design proposed to replace and up-size the existing bypass pipes, but it is the engineer's opinion that replacing these pipes would cause too much disturbance in the pedestrian circulation at the Torpedo Factory waterfront during construction. In order to alleviate the existing bypass system, additional inlets have been added at the intersection of Cameron St and Union St, and along Union Street, which convey flow to the pump station adjacent to Founder's Park.

3.2.2.5 Queen Street Bypass System

The existing Queen Street system outfalls into the existing river with a 30" RCP pipe (best guess per available records) at the north end of the Core Area, adjacent to Founder's Park. The exact location of this outfall could not be determined at this time. At the intersection of Queen Street and North Union Street, the existing grate inlet will be replaced with a larger grate inlet. The



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
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downstream pipes need to be replaced with 36" pipes. This bypass system will convey approximately 4.1 Acres of upstream drainage. The 15% Concept Submission Design by URS proposed an additional grate inlet to be built in Thompson Alley, north of Union Street. It is the engineer's opinion that this inlet is unnecessary due to the additional inlets proposed in Union St for the local storm system, as well as the desire to limit disturbance in the alley behind private homes.

3.2.3 LOCAL STORM SEWER SYSTEMS

The local storm sewer system is defined as the storm inlets and pipe network that conveys runoff to the proposed pump stations. This storm system will have structures placed at elevation 6.0' and lower in order to mitigate the frequent flooding caused by storms smaller than the 10-year. New inlets and pipes will replace existing in order to provide additional capacity and functionality. Some outfall locations at the existing bulkhead have been unable to be located and inspected due to debris and high water levels. Due to the age of the network, it is assumed some outfall pipes are full of debris or collapsed, and therefore will need to be replaced.

The local storm system to Pump Station A conveys runoff from Prince Street and King Street to the Pump located adjacent to Strand St. Inlets are proposed along the east end of Prince Street, at the intersection of King Street and Union Street, and in Strand St. The existing drainage pattern directs surface flow directly to the river. By proposing the bulkhead at elevation 6.0', grading is proposed in the area of the Waterfront Park in order to direct the surface flow into inlets and into Pump Station A. Preliminary grading in this area is provided by Olin, dated 07/22/2014.

The local storm system to Pump Station B was suggested to have several curb inlets at the intersection of Cameron St and Union St, and the alignment to run west to east along Thompson Alley, then turn north into the pump station. Upon investigating the surveyed conditions, there are several utility conflicts in Thompson Alley, including sanitary sewer, water, and gas. Due to the proximity between buildings (approximately 20') and utility conflicts, it is proposed to align the local storm system in Union Street, running to the north, then turning east at Queen Street, where the local system will run parallel to the Queen St bypass system. The common area to the north of Charhouse restaurant will be used as delivery truck loading and turn-around, and additional grate inlets will be provided in this area to convey runoff to Pump Station B. Preliminary grading in this area is provided by Olin, dated 07/22/2014.

Various alignments were considered for the local storm systems to balance the flows to each pump station. It was considered to convey flow from King Street north to Pump Station B. This alternative is not suggested because it would cause additional disturbance to Union Street, and does not honor the natural drainage divide.

WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
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3.2.4 PUMP STATIONS

Two pump stations will be proposed within the Core Area to handle storm water within the local storm sewer system. One pump station will be located Waterfront Park, adjacent to Strand St, and the other will be located near the farthest east end of Thompson Alley. Each pump station will contain a trash rack, wet well, pumps, back-up generator, back-up fuel source, force main piping to the bulkhead outfall, mechanical equipment, controls, and all related infrastructure. Each pump station site will include a pair of park pavilion buildings to elevate the pump station equipment above the flood plain, as well as incorporate park uses, such as storage, restrooms, and service areas. Final programming of the park pavilion will be provided by City of Alexandria.

Most of these improvements are located within previously developed areas, but both pump stations are located within existing open space park areas. As such, these minimally increase the impervious area as noted above, and will potentially result in the removal of a few trees. The proposed site grading associated with the improvements may also potentially result in removal of some trees. This will be discussed in more detail later in this document. The proposed improvements included within the Core Area are intended to reduce the frequency of flooding along the Alexandria Waterfront between Queen and Duke Streets. No stormwater management facilities intended for water quality control are proposed as part of this initial design advancement; however, this has been considered for the overall redevelopment area as part of the initial studies as well as adjacent projects. The overall conceptual SWM approach is discussed in more detail later in this report.

The project will result in a permanent impact of approximately 3 acres within the RPA for grading and construction of the mitigation improvements. Of the RPA impacts shown, approximately 1.50 acres is within the seaward 50 feet of the RPA buffer. A summary of the proposed RPA impacts is provided in Table 3-1 below. The buffer equivalency calculations are provided in later sections of this WQIA.

Table 3-1 RPA IMPACTS SUMMARY

RPA Impact	Acreage (+/-)
Site grading	2.34
Pump Station	0.03
Pipe Installation	0.54
Structural Bulkhead	0.09
<i>Total</i>	<i>3.00</i>



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
September 2, 2016

As the improvements are intended to provide public flood control, it is our understanding that the impacts associated with the pump station, pipe installation, and structural bulkhead are permitted within the RPA. The site grading, although necessary for installation of these improvements, does not provide the flood control itself and thus is understood not to be an exempt activity; however, the majority of this area will be revegetated. Only the pump station in the table above represents an increase in the impervious area and thus a minor decrease in the effective RPA buffer width. This Core Area is in close proximity to several historic, commercial, residential, and recreational locations, making this an attractive place for citizens and tourists to frequent. The construction of these improvements will benefit the local economy by reducing the flooding frequency, which in turn will make this area safer and subject to less flooding damage.

The project areas is fully contained within the approximate Zone AE 100-year floodplain for the project, as shown on the FEMA FIRMette map (Panel 5155190041E, effective date June 16, 2011), provided in Appendix C. Only minor elevation changes are proposed as part of the project for construction of the aforementioned features, including the proposed bulkhead in an effort to reduce flooding frequency; therefore, no adverse impact will be made to the existing floodplain boundary.

Given the findings of the delineation, the stream impacts will be limited to the areas where the bulkhead will be installed.

3.3 PROPOSED MITIGATION MEASURES

The RPA is deemed to provide a 40% removal of nutrients and a 75% removal of sediments for sheet-flows of runoff directed through the buffer. The functional value of the buffer in terms of nutrient and sediment removal is typically assessed in accordance with *Information Bulletin No. 3 – Draft Buffer Equivalency Guidance*, published by the Chesapeake Bay Local Assistance Department (CBLAD). As a majority of the contributing surface drainage area that currently is directed through the RPA buffer will remain that way, there will be a minimal reduction in the efficacy of the buffer at reducing non-point source (NPS) pollutants. This reduction in pollution removal capacity has been quantified and calculations are provided in Appendix D. Because the existing RPA buffer is not fully intact, it has not been credited with being fully effective. Under existing conditions, the average pollutant removal efficiency of the existing buffer is 23.7% based on CBLAD-provided efficiency for a 40-foot buffer width, which was established based on the total area of the park areas (open space) within the RPA area divided by the full shoreline length of the project. The amount of phosphorus removal provided by the portion of RPA buffer at the approximated permanent encroachment locations is estimated at 0.02 pounds TP/year.



WATER QUALITY IMPACT ASSESSMENT

HYDROGEOLOGICAL ELEMENT
September 2, 2016

3.3.1 SWM APPROACH

Detailed engineering design has not been completed for the Core Area; however, preliminary stormwater treatment calculations for this area of the project were completed as part of the *Design Schematic Pricing Set* by Olin. According to Sheet 35 of this plan set (Appendix E), various low impact development/green infrastructure facilities, including tree boxes, micro-bioretenion facilities, pervious pavers, dry swales, and/or underground cisterns may be proposed to provide water quality treatment and water quantity control throughout the project area. It should be noted that in preliminary quantification on Sheet 38 of this plan set (Appendix E), these facilities were estimated to provide an excess of 2.9 lbs TP/yr, which exceeds the 0.02 lbs TP/yr reduction in buffer efficacy described above. It is possible during detailed design that the assigned facility types and/or efficiencies may change, altering the final removal rate achieved. Irrespective of the actual pollutant amount removed, the final overall plan for the Alexandria Waterfront be designed in such a fashion that the project is in accordance with the City's MS4 permit requirements and considers the Minimum Control Measures outlined in the MS4 Program Plan.

3.3.2 EROSION AND SEDIMENT CONTROL PLANNING

Erosion and sediment control planning for the project has not yet been developed by the site engineer for the site as the design is in early phases. Erosion and sediment control measures shall be designed in accordance with the Virginia Erosion and Sediment Control Law, Standards and Specifications, and local requirements, to ensure that downstream waterways are protected from erosion, sedimentation, and flooding which may result from development. Prompt stabilization of the disturbed areas near and within the RPA will be critical to minimizing soil erosion.

WATER QUALITY IMPACT ASSESSMENT

VEGETATIVE ELEMENT
September 2, 2016

4.0 VEGETATIVE ELEMENT

Based upon the Overall Drainage Divides graphic in Appendix A, site visits, and through a desktop review of historic aerial imagery, the majority of the site consists of developed land, with a few limited maintained park areas consisting primarily of managed turf with some limited ornamental trees in the north, central, and south areas of the project limits.

As described previously in this WQIA, approximately 3 acres of the RPA will be impacted by the proposed improvements. Approximately 2.65 acres of the open space park areas within the project limits will be impacted by the proposed development, based on the treeline and limits of disturbance shown on the Overall Drainage Divides graphic in Appendix A. Detailed design is currently underway, and as such the specific trees to be removed have not yet been identified. Site clearing and grading within the vegetated areas, especially through the RPA, will be selective in nature, focusing on the removal of invasive species and non-specimen trees to enhance the landscape. These areas, with the exception of the proposed pump stations (0.06 acre) will be restored to vegetated open space following installation of the bypass storm sewer and storm sewer upgrades. It is not proposed to clear all trees and vegetation from the RPA, and selective clearing and maintenance is intended to be done in a manner such that tree canopy cover is maintained to the extent practicable.

Although no final landscaping design is available for the project at the time of this submittal, it is expected that future re-vegetation will be provided in such a manner to include native grass and herbaceous seed mixes to provide ground cover, supplemented with native canopy trees and shrubs to provide for pollutant removal and maximum erosion and sediment control. Further, significant trees will be preserved to the greatest extent possible. Trees will be selected such that they are similar to the desirable native species currently found in existing conditions and supplemented with additional native species to enhance the vegetative quality of the site.



WATER QUALITY IMPACT ASSESSMENT

CONCLUSION
September 2, 2016

5.0 CONCLUSION

The applicant proposes to construct the proposed flood mitigation measures within the Core Area to reduce the flooding frequency. The permanent disturbance within the RPA for these proposed improvements will impact approximately 3 acres of RPA buffer. As compensation for the proposed permanent CRPA buffer impacts, it is anticipated based upon early pre-design planning that over-treatment provided through SWM controls, possibly including low impact development and other green infrastructure measures will be proposed to protect water quality. The excess pollutant removal may provide pollutant removal far greater than that needed to offset the reductions in buffer efficiency. Documentation of overtreatment in context of buffer equivalency may be provided at detailed design.

In order to compensate for vegetation removed to accommodate the development, it is expected that future re-vegetation will be provided in such a manner to include native grass and herbaceous seed mixes to provide ground cover, supplemented with native canopy trees and shrubs to provide for pollutant removal and maximum erosion and sediment control. These trees will be planted so that the remaining buffer will be enhanced where possible. Trees will be selected such that they are similar to the desirable native species currently found in existing conditions and supplemented with additional native species to enhance the vegetative quality of the site. Further, significant trees on-site will be preserved to the greatest extent possible, and the overall tree canopy will similarly be kept intact to the extent practicable.

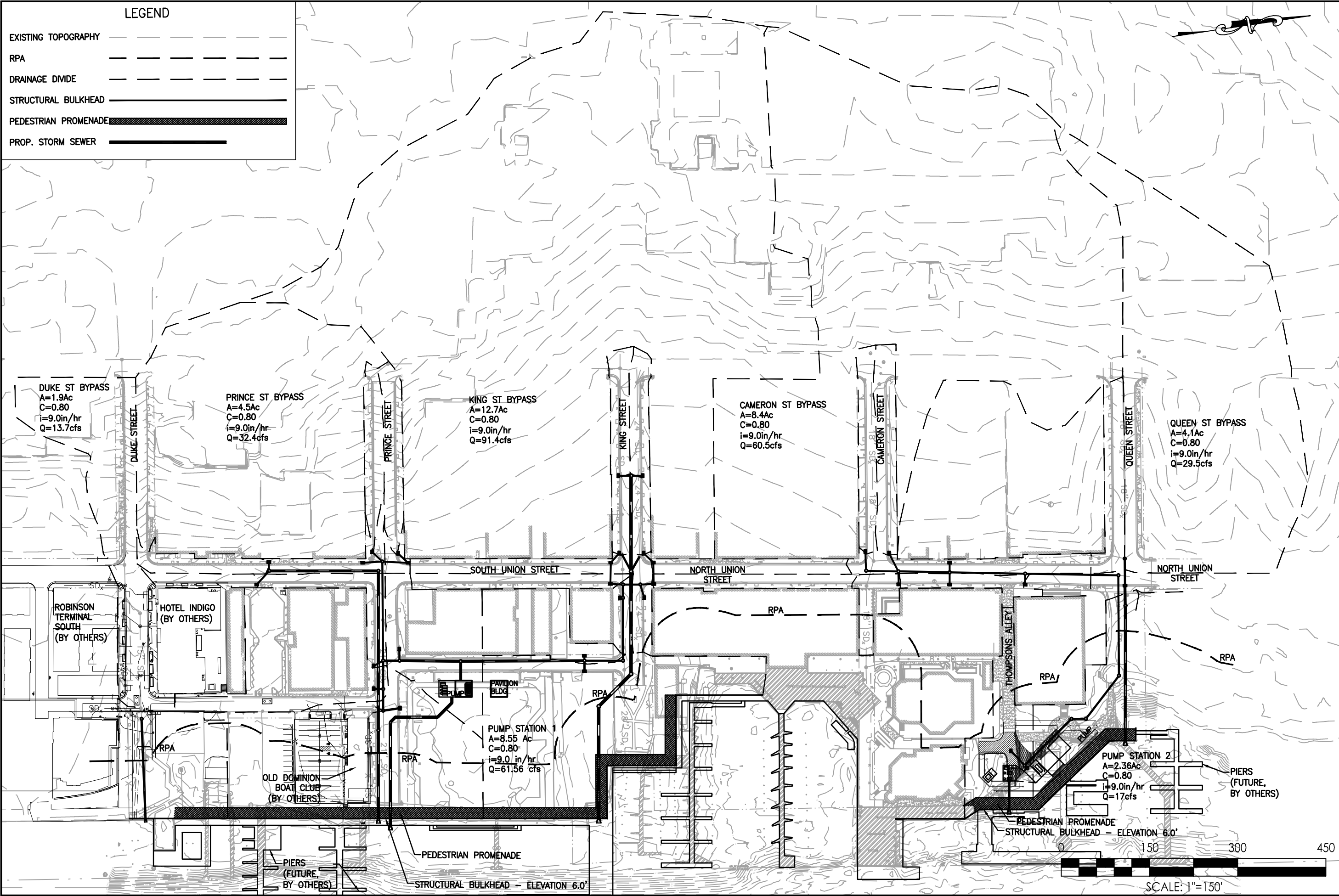


APPENDICES

**WATER QUALITY
IMPACT ASSESSMENT**

Appendix A OVERALL DRAINAGE DIVIDES
September 2, 2016

Appendix A OVERALL DRAINAGE DIVIDES





Stantec

Tel. 703.263.1220
Fax. 703.263.1221
www.stantec.com

OVERALL DRAINAGE DIVIDES - ALT 1

WATERFRONT FLOOD MITIGATION IMPLEMENTATION

CITY OF ALEXANDRIA, VIRGINIA

Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313



Date: AUGUST 2017
Scale: 1" = 150'
Project No.: 2029041842
Sheet No.
1

**WATER QUALITY
IMPACT ASSESSMENT**

Appendix B request for pjd
September 2, 2016

Appendix B REQUEST FOR PJD



Stantec Consulting Services Inc.

150 Riverside Parkway, Suite 301, Fredericksburg VA 22406-1094

April 29, 2016
File: 2029041842

Attention: Ms. Theresita Crockett-Augustine

U.S. Army Corps of Engineers
Northern Virginia Field Office
18139 Triangle Plaza, Suite 213
Dumfries, VA 22026

Dear Ms. Crockett-Augustine,

Reference: Request for Preliminary Jurisdictional Determination, Alexandria Waterfront, City of Alexandria, Virginia

Stantec Consulting Services Inc. (Stantec) has been retained by the City of Alexandria to conduct a detailed investigation of waters of the U.S., including wetlands, on the above-referenced project. The site is located within the Potomac River drainage basin in the City of Alexandria, Virginia. The project site is situated along the Potomac River, east of Lee Street, south of Quay Street, north of Wolfe Street, and can be accessed via the terminus of Queen Street, Cameron Street, King Street, Prince Street, and/or Duke Street (Figures 1& 2). A copy of the Pre-Application and/or Jurisdictional Waters Determination Request Form is provided in Appendix A.

Off-site Evaluation – Prior to conducting fieldwork, Stantec consulted the U.S. Geological Survey (USGS) 7.5-minute Topographical Quadrangle Map (quad map) for Alexandria, Virginia (created 1998), the National Wetlands Inventory Interactive Mapper (NWI), administered by the U.S. Fish and Wildlife Service, and the Web Soil Survey, administered by the Natural Resources Conservation Service (NRCS). The USGS quad map shows a level site comprised of developed land. The NWI map (Appendix B) depicts the tidal Potomac River within the project boundaries, with no wetland features present. Additionally, the soil survey (Appendix C) indicates that the site is underlain primarily by Urban land – Grist Mill and Grist Mill sandy loam, both of which are classified as non-hydric by the NRCS in the City of Alexandria.

On-site Evaluation – Fieldwork was conducted during March 2015 using the Routine Determination Method as outlined in the 1987 *Corps of Engineers Wetland Delineation Manual* and methods described in the 2010 *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0)*. The data sheets (Appendix D) used in this investigation are included, along with representative site photos (Appendix E) and the Delineation Map (Appendix F) showing the limits of wetlands and other water features, as well as data point locations.



April 29, 2016
Ms. Theresita Crockett-Augustine
Page 2 of 2

Reference: Request for Preliminary Jurisdictional Determination, Alexandria Waterfront, City of Alexandria, Virginia

Site Description – The only jurisdictional feature identified by Stantec within the project limits is the Potomac River. The jurisdictional limits identified in the field correspond to the approximate mean high tide elevation associated with the river. The majority of the waterfront is developed, with jurisdictional limits occurring along existing bulkheads and stabilized shoreline. Non-developed areas within the project consist of park land comprised of maintained open area, bounded by bulkheads and/or stabilized shoreline.

On behalf of our client, Stantec respectfully requests that the Corps confirm our delineation. We would appreciate the opportunity to meet with you on-site to present our fieldwork. Please call to set up a meeting date or to discuss any questions regarding our investigation.

Thank you for your cooperation in this matter.

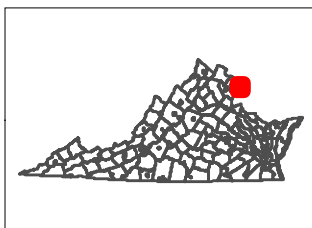
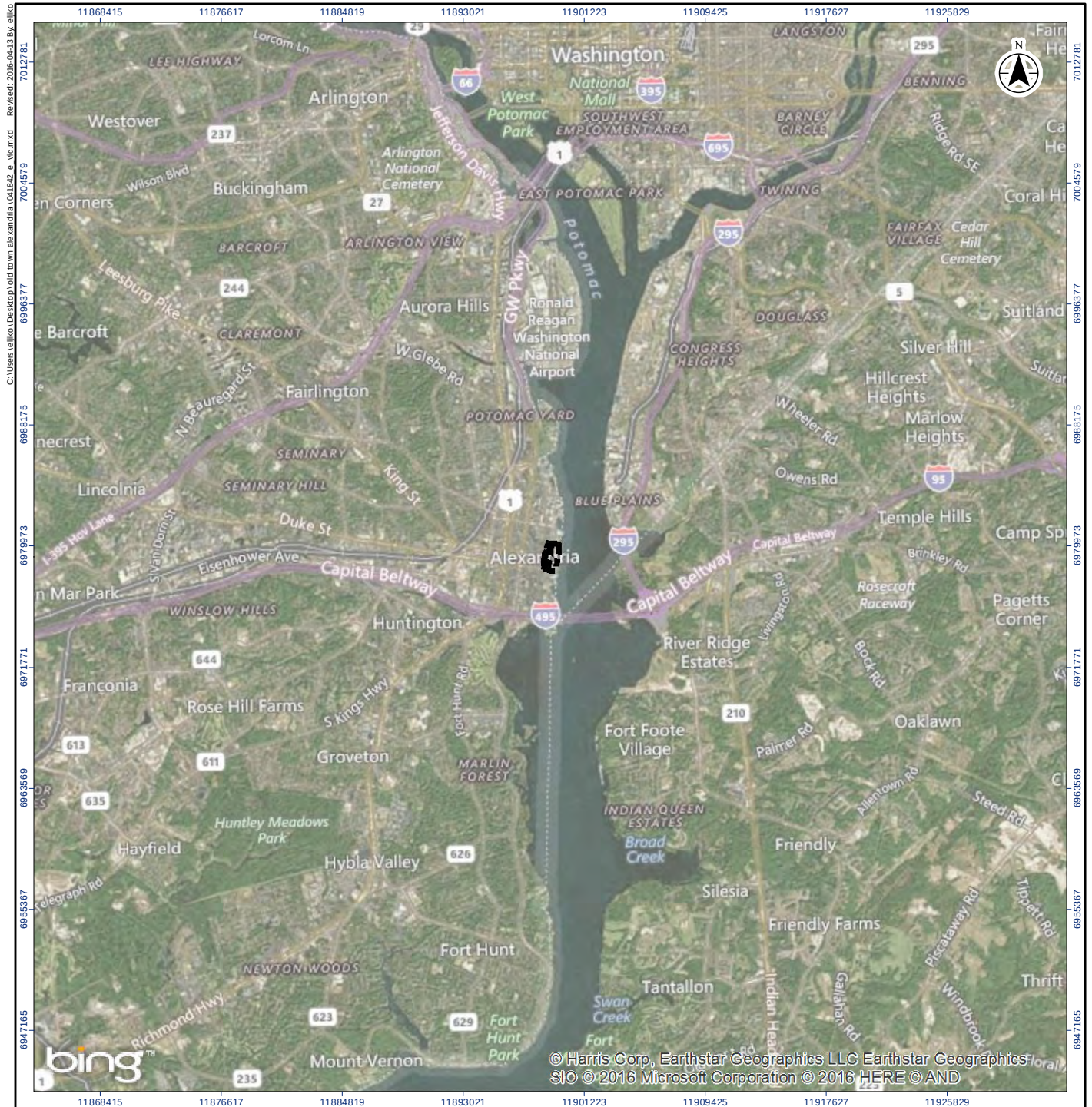
Regards,

STANTEC CONSULTING SERVICES INC.

Jason Mann
Senior Ecologist
Phone: (540) 785-5544
Fax: (540) 785-1742
jason.mann@stantec.com

Attachment: Figures 1, 2 and Appendices A, B, C, D, E & F

c. Loretta Cummings, Ph.D. – Stantec
Jeffrey Lohr, PE – Stantec



Legend

Project Limits

0 5,000 10,000
Feet
1:120,000 (at original document size of 8.5x11)



Project Location 2029041842
City of Alexandria, VA Prepared by ECL on 2016-03-16
Technical Review by IPS on 2016-04-12
Independent Review by LC on 2016-04-12

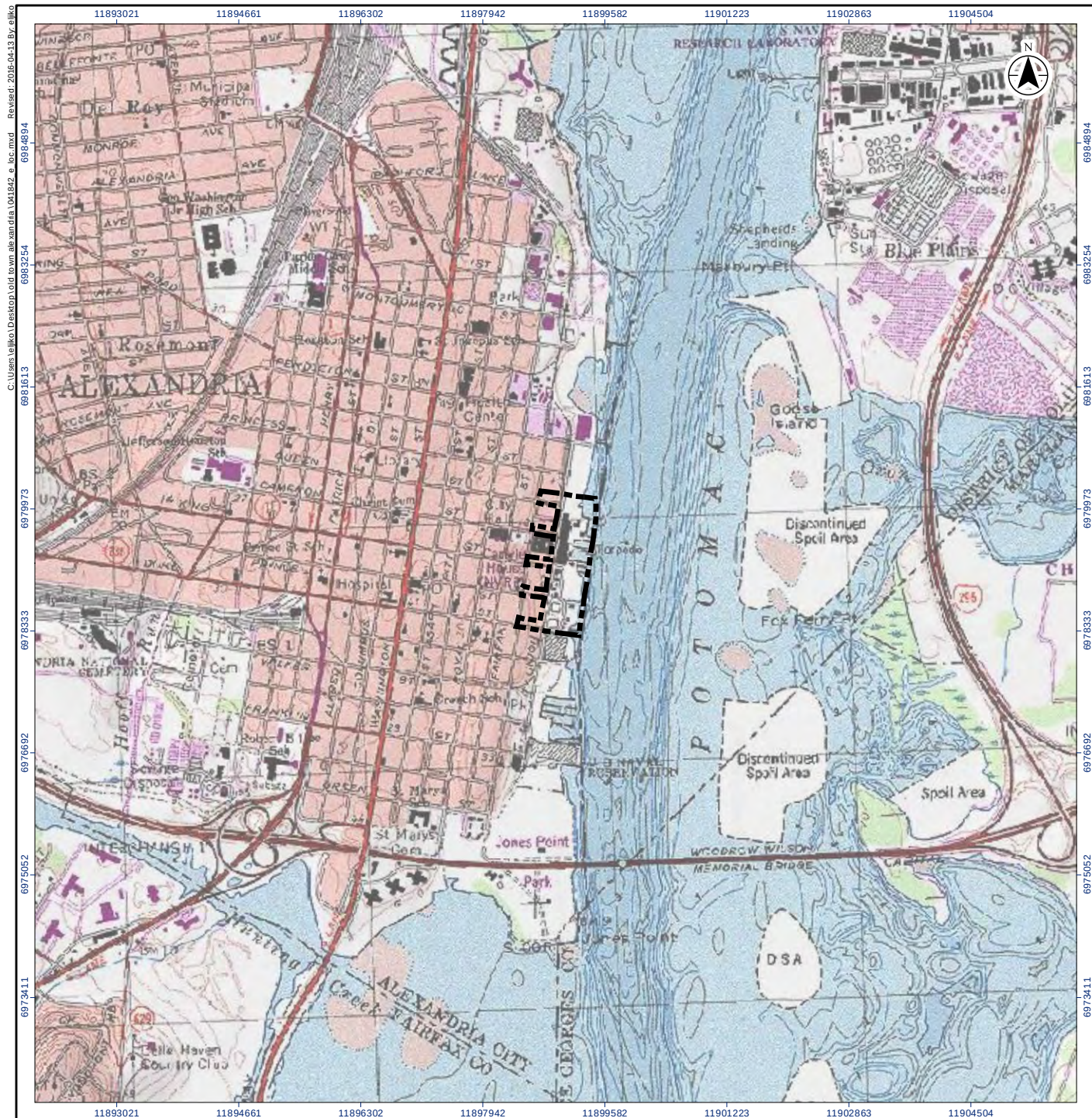
Client/Project
City of Alexandria
Alexandria Waterfront

Figure No.
1

Title
Vicinity Map

- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Orthomage © Bing Maps
 3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Legend

 Project Limits

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Feet
1:24,000 (at original document size of 8.5x11)



Project Location 2029041842
City of Alexandria, VA Prepared by ECL on 2016-03-16
Technical Review by IPS on 2016-04-12
Independent Review by LC on 2016-04-12

Client/Project
City of Alexandria
Alexandria Waterfront

Figure No.
2
Title

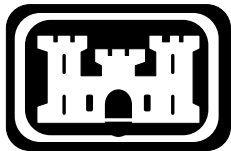
Location Map

- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Topographic map © USGS 7.5 Minute Series Topographic Map

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Appendix A

Pre-Application and JD Request Form



NORFOLK DISTRICT REGULATORY OFFICE PRE-APPLICATION AND/OR JURISDICTIONAL WATERS DETERMINATION REQUEST FORM

This form is used when you want to determine if areas on your property fall under regulatory requirements of the U.S. Army Corps of Engineers (USACE). Please supply the following information and supporting documents described below. This form can be filled out online and/or printed and then mailed, faxed, or e-mailed to the Norfolk District. Submitting this request authorizes the US Army Corps of Engineers to field inspect the property site, if necessary, to help in the determination process. **THIS FORM MUST BE SIGNED BY THE PROPERTY OWNER TO BE CONSIDERED A FORMAL REQUEST.**

The printed form and supporting documents should be mailed to:

U.S. Army Corps of Engineers, Norfolk District
Regulatory Office
803 Front Street
Norfolk, Virginia 23510-1096

Or faxed to (757) 201-7678

Or sent via e-mail to: CENAO.REG_ROD@usace.army.mil

Additional information on the Regulatory Program is available on our website at:

<http://www.nao.usace.army.mil/>

Please contact us at 757-201-7652 if you need any assistance with filling out this form.

Location and Information about Property to be subject to a Jurisdictional Determination:

1. Date of Request: April 12, 2016
2. Project Name: Alexandria Waterfront
3. City or County where property located: City of Alexandria
4. Address of property and directions (attach a map of the property location and a copy of the property plat):
The approximate 25.95-acre site is located within the Potomac River drainage basin in the City of Alexandria, Virginia. The project site is situated along the Potomac River, east of Lee Street, south of Quay Street, north of Wolfe Street, and can be accessed via the terminus of Queen Street, Cameron Street, King Street, Prince Street, and/or Duke Street.
5. Coordinates of property (if known): 38°48'16.93"N 77°02'23.68"W
6. Size of property in acres: 25.95
7. Tax Parcel Number / GPIN (if available):
8. Name of Nearest Waterway: Potomac River
9. Brief Description of Proposed Activity, Reason for Preapplication Request, and/or Reason for Jurisdictional Waters Determination Request: Flood mitigation

10. Has a wetland delineation/determination been completed by a consultant or the Corps on the property previously? ☐ YES ☐ NO ☒ UNKNOWN,

If yes, please provide the name of the consultant and/or Corps staff and Corps permit number, if available:

Property Owner Contact Information:

Property Owner Name: City of Alexandria ATTN: Tony Gammon
Mailing Address: 301 King Street
City: State: Zip: Alexandria, VA 22314
Daytime Telephone: 703-746-4155
E-mail Address: anthony.gammon@alexandria.gov

If the person requesting the Jurisdictional Determination is **NOT** the Property Owner, please also supply the Requestor's contact information here:

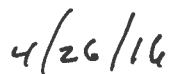
Requestor Name: Jason Mann, Stantec
Mailing Address: 150 Riverside Parkway, Suite 301
City: State: Zip: Fredericksburg, VA 22406
Daytime Telephone: 540-785-5544
E-mail Address: jason.mann@stantec.com

Additionally, if you have any of the following information, please include it with your request: wetland delineation map, other relevant maps, drain tile survey, topographic survey, and/or site photographs.

CERTIFICATION: I am hereby requesting a preapplication consultation or jurisdictional waters and/or wetlands determination from the U.S. Army Corps of Engineers, for the property(ies) I have described herein. I agree to allow the duly authorized representatives of the Norfolk District Corps of Engineers and other regulatory or advisory agencies to enter upon the premises of the project site at reasonable times to evaluate inspect and photograph site conditions. This consent to enter the property is superior to, takes precedence over, and waives any communication to the contrary. For example, if the property is posted as "no trespassing" this consent specifically supercedes and waives that prohibition and grants permission to enter the property despite such posting. I hereby certify that the information contained in the Request for a Jurisdictional Determination is accurate and complete:



Property Owner's Signature



Date

Appendix B

NWI Map

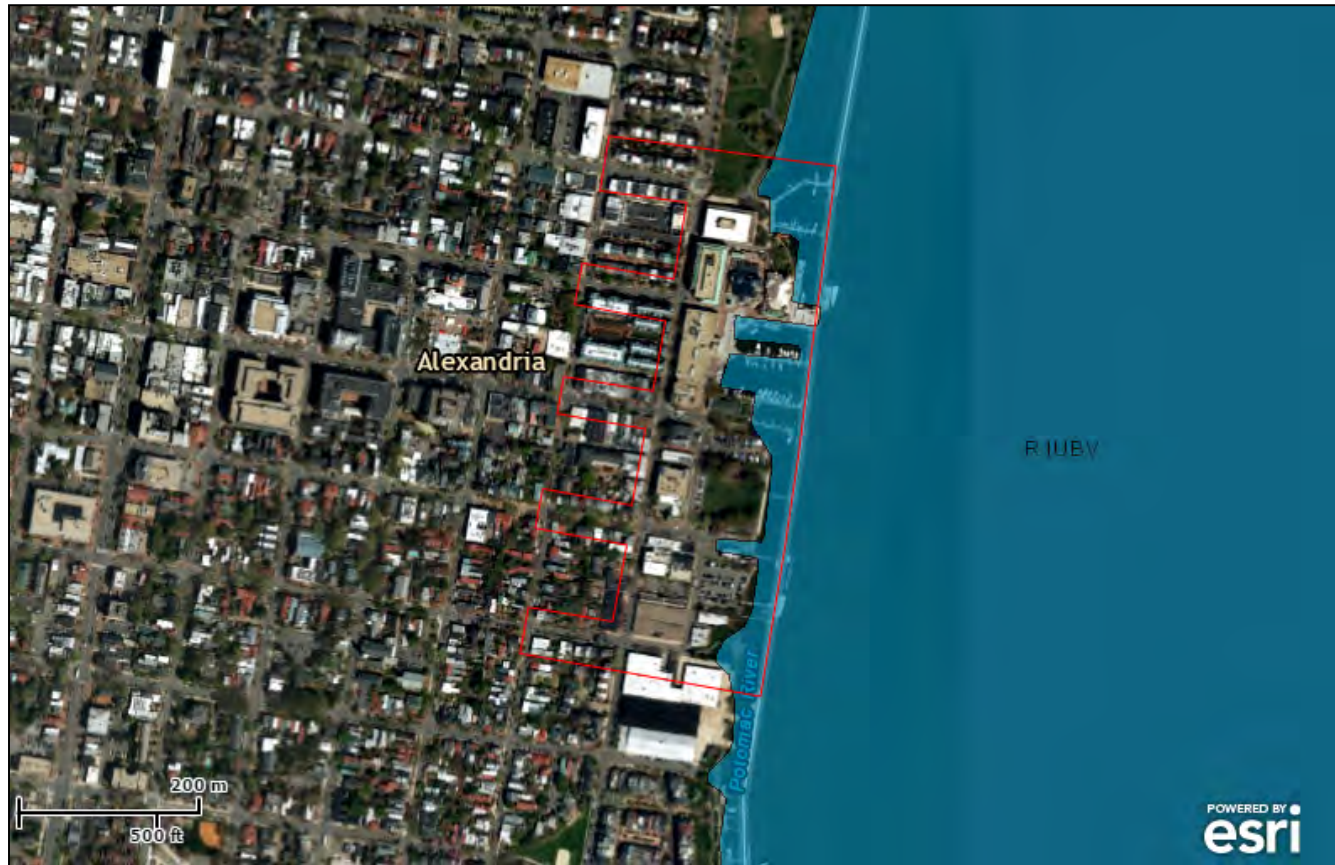


U.S. Fish and Wildlife Service

National Wetlands Inventory

Alexandria
Waterfront

Apr 6, 2016



Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

User Remarks:

Appendix C

Soils Map

Soil Map—Alexandria City, Virginia, and District of Columbia
(Alexandria Waterfront)



Map Scale: 1:3,610 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84



Natural Resources
Conservation Service

Web Soil Survey
National Cooperative Soil Survey

4/6/2016
Page 1 of 3

Soil Map—Alexandria City, Virginia, and District of Columbia
(Alexandria Waterfront)

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features



Blowout



Borrow Pit



Clay Spot



Closed Depression



Gravel Pit



Gravelly Spot



Landfill



Lava Flow



Marsh or swamp



Mine or Quarry



Miscellaneous Water



Perennial Water



Rock Outcrop



Saline Spot



Sandy Spot



Severely Eroded Spot



Sinkhole



Slide or Slip



Sodic Spot



Spoil Area



Stony Spot



Very Stony Spot



Wet Spot



Other



Special Line Features

Water Features



Streams and Canals

Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

Background



Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Alexandria City, Virginia
Survey Area Data: Version 6, Dec 13, 2013

Soil Survey Area: District of Columbia
Survey Area Data: Version 9, Sep 29, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Alexandria City, Virginia (VA510)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
40	Grist Mill sandy loam, 0 to 25 percent slopes	1.6	4.9%
98	Urban land-Grist Mill	24.2	72.8%
W	Water	3.6	10.8%
Subtotals for Soil Survey Area		29.4	88.4%
Totals for Area of Interest		33.2	100.0%

District of Columbia (DC001)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
W	Water	3.8	11.6%
Subtotals for Soil Survey Area		3.8	11.6%
Totals for Area of Interest		33.2	100.0%

Appendix D

Data Sheets

Wetland Determination Data Form - Atlantic and Gulf Coastal Plain Region Sampling Point Number: 1



Project: ALEXANDRIA WATERFRONT
 Applicant: CITY OF ALEXANDRIA
 City/County: CITY OF ALEXANDRIA
 State: VIRGINIA
 Investigator(s): J. MANN & B. CONNERS
 Date: 3/31/2016

Section/Township/Range: N/A
 Subregion (LRR or MLRA): LRR P
 Site Latitude: 38°48'16.93"N
 Site Longitude: 77°02'23.68"W
 Soil Map Unit Name: GRIST MILL SANDY LOAM, 0-25% SLOPES

Summary of Findings:

Hydrophytic Vegetation is Present: _____	Normal Circumstances: ☒ _____	NWI Classification: UPLAND
Hydric Soils are Present: _____	Disturbed Parameters (see Remarks): _____	Local Relief: NONE
Wetland Hydrology is Present: _____	Problematic Parameters (see Remarks): _____	Landform: FLAT
Sampled Area is within a Wetland: _____	Atypical Climate/Hydrology (see Remarks): _____	Slope %: 0-1%

Hydrology Parameter:

Primary Indicators:	Secondary Indicators:
☐ Surface Water (A1) ☐ Water Stained Leaves (B9) ☐ High Water Table (A2) ☐ Aquatic Fauna (B13) ☐ Saturation (A3) ☐ Marl Deposits (B15) ☐ Water Marks (B1) ☐ Hydrogen Sulfide Odor (C1) ☐ Sediment Deposits (B2) ☐ Oxidized Rhizospheres on Living Roots (C3) ☐ Drift Deposits (B3) ☐ Presence of Reduced Iron (C4) ☐ Algal Mat or Crust (B4) ☐ Recent Iron Reduction in Tilled Soils (C6) ☐ Iron Deposits (B5) ☐ Thin Muck Surface (C7) ☐ Inundation Visible on Aerial Imagery (B7) ☐ Other _____	☐ Surface Soil Cracks (B6) ☐ Sparsely Vegetated Concave Surface (B8) ☐ Drainage Patterns (B10) ☐ Moss Trim Lines (B16) ☐ Dry-Season Water Table (C2) ☐ Crayfish Burrows (C8) ☐ Saturation Visible on Aerial Imagery (C9) ☐ Stunted or Stressed Plants (D1) ☐ Geomorphic Position (D2) ☐ Shallow Aquitard (D3) ☐ FAC-Neutral Test (D5) ☐ Sphagnum Moss (D8)

Water Depths (inches):
 Surface Water: _____
 Water Table: _____
 Saturated soil: >20

Remarks: HYDROLOGY PARAMETER NOT MET.

Vegetation Parameter:

Dominant Species	Stratum	IND	%	Non-Dominant Species	Stratum	IND	%
<i>Poa pratensis</i>	Herbaceous	FACU	65	<i>Trifolium repens</i>	Herbaceous	FACU	5

% Dominant species FAC or wetter: 0 Prevalence Index: 4.0
 NOTE: SPECIES INDICATOR STATUS ACCORDING TO 2014 NATIONAL WETLAND PLANT LIST Calculated using all species present.

Rapid Test for Hydrophytic Vegetation: _____
 Dominance Test >50%: _____
 Prevalence Index is ≤ 3.0: _____
 Problematic Hydrophytic Vegetation: _____

Remarks: VEGETATION PARAMETER NOT MET.

Soil Parameter:

Depth (inches)	Matrix		Redox Features				Texture
	Color (Moist)	%	Color (Moist)	%	Type	Loc	
0-4	10YR 3/3	100					SILT LOAM
4-20	10YR 4/4	100					SILTY CLAY LOAM

Hydric Soil Indicators:

☐ Histosol (A1) ☐ Coast Prairie Redox (A16) ☐ Histic Epipedon (A2) ☐ Sandy Mucky Mineral (S1) ☐ Black Histic (A3) ☐ Sandy Gleyed Matrix (S4) ☐ Hydrogen Sulfide (A4) ☐ Sandy Redox (S5) ☐ Stratified Layers (A5) ☐ Stripped Matrix (S6) ☐ Organic Bodies (A6) ☐ Dark Surface (S7) ☐ 5cm Mucky Mineral (A7) ☐ Polyvalue Below Surface (S8) ☐ Muck Presence (A8) ☐ Thin Dark Surface (S9) ☐ 1 cm Muck (A9) ☐ Loamy Mucky Mineral (F1) ☐ Depleted Below Dark Surface (A) ☐ Loamy Gleyed Matrix (F2) ☐ Thick Dark Surface (A12) ☐ Depleted Matrix (F3)	☐ Redox Dark Surface (F6) ☐ Depleted Dark Surface (F7) ☐ Redox Depressions (F8) ☐ Marl (F10) ☐ Depleted Ochric (F11) ☐ Iron-Manganese Masses (F12) ☐ Umbric Surface (F13) ☐ Delta Ochric (F17) ☐ Reduced Vertic (F18) ☐ Piedmont Floodplain Soils (F19) ☐ Anomalous Bright Loamy Soils (F20)	Indicators for Problematic Hydric Soils ☐ 1cm Muck (A9) ☐ 2cm Muck (A10) ☐ Reduced Vertic (F18) ☐ Piedmont Floodplain Soils (F19) ☐ Anomalous Bright Loamy Soils (F20) ☐ Red Parent Material (TF2) ☐ Very Shallow Dark Surface (TF12) ☐ Other _____
--	---	--

Restrictive Layer (If Observed)
 Type: _____
 Depth (inches): _____

Remarks: SOIL PARAMETER NOT MET.

Appendix E

Representative Site Photos

Representative Photographs – Request for Preliminary Jurisdiction Determination



Photograph 1: Riprap stabilized shoreline at northern end of project, adjacent to Founders Park and near the terminus of Queen Street.



Photograph 2: Founders Park and northern end of project, looking east from Union Street.

Representative Photographs – Request for Preliminary Jurisdictional Determination



Photograph 3: Bulkhead along the waterfront at northern end of project, near the terminus of Thompson's Alley.



Photograph 4: Bulkhead along the waterfront in central portion of project, near the terminus of King Street.

Representative Photographs – Request for Preliminary Jurisdictional Determination



Photograph 5: Bulkhead along the waterfront at southern end of project, adjacent to Waterfront Park and near the terminus of Prince Street.



Photograph 6: Bulkhead along the waterfront at southern end of project, near the terminus of Duke Street.

Appendix F

Delineation Map

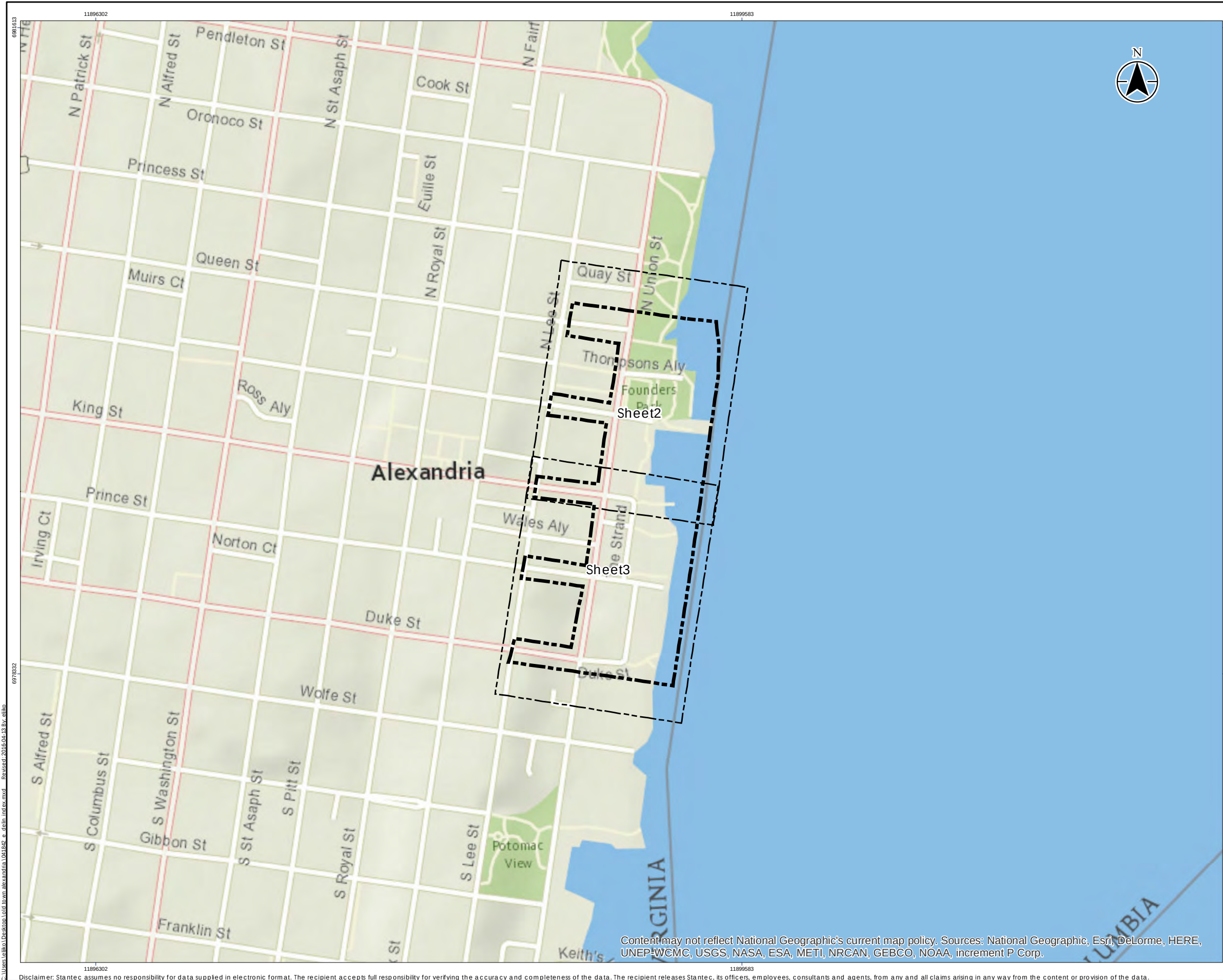


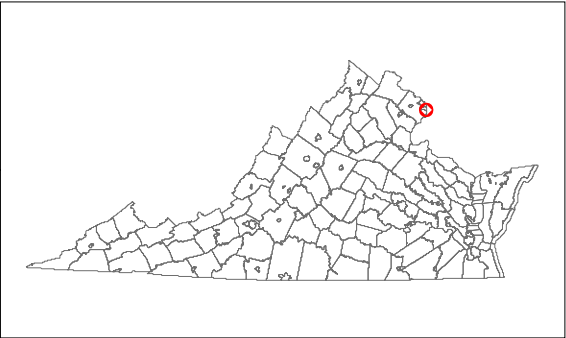
Figure No.
3
Title
Delineation Map

Client/Project
**City of Alexandria
Alexandria Waterfront**

Project Location
City of Alexandria, Virginia
2029041842
Prepared by ECL on 2016-03-16
Technical Review by TPS on 2016-04-12
Independent Review by LC on 2016-04-12

0 500 1,000 Feet
1:6,000 (At original document size of 11x17)

Project Limits



- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Orthoimagery © Bing Maps
 3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation
 4. The approximate limits of waters of the U.S., including wetlands, have not been field survey located and are for planning purposes only
 5. Topography provided by City of Alexandria GIS 2015



C:\Users\jalko\Desktop\old town alexandria\041842_e_delineation.mxd Revised: 2016-04-13 by: ellio 6978332

Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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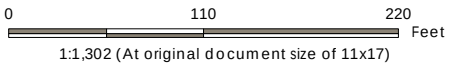
Figure No.
3

Title
Delineation Map

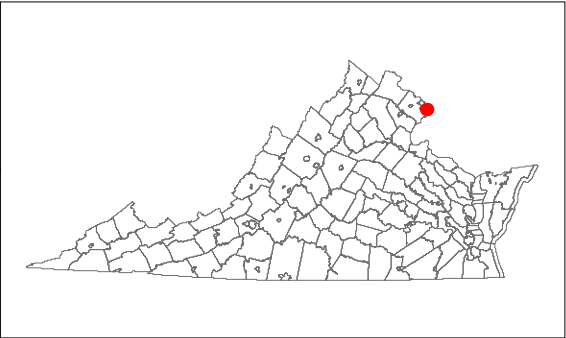
Client/Project
City of Alexandria
Alexandria Waterfront

Project Location
City of Alexandria, Virginia

2029041842
Prepared by ECL on 2016-03-16
Technical Review by TPS on 2016-04-12
Independent Review by LC on 2016-04-12



- 1 ● Data Point Location
- ① ➔ Photo Location
- Approximate Tidal Waters Limits
- Project Limits
- 2-Foot Contours



- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Orthoimagery © Bing Maps
 3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation
 4. The approximate limits of waters of the U.S., including wetlands, have not been field survey located and are for planning purposes only
 5. Topography provided by City of Alexandria GIS 2015





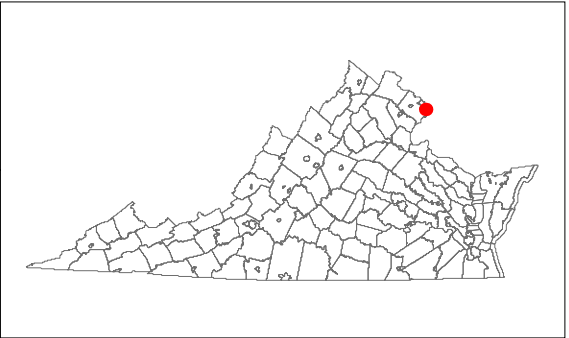
Figure No.
3
Title
Delineation Map

Client/Project
**City of Alexandria
Alexandria Waterfront**

Project Location
City of Alexandria, Virginia
2029041842
Prepared by ECL on 2016-03-16
Technical Review by TPS on 2016-04-12
Independent Review by LC on 2016-04-12

0 110 220 Feet
1:1,302 (At original document size of 11x17)

- 1 ● Data Point Location
- ① Photo Location
- Approximate Tidal Waters Limits
- Project Limits
- 2-Foot Contours

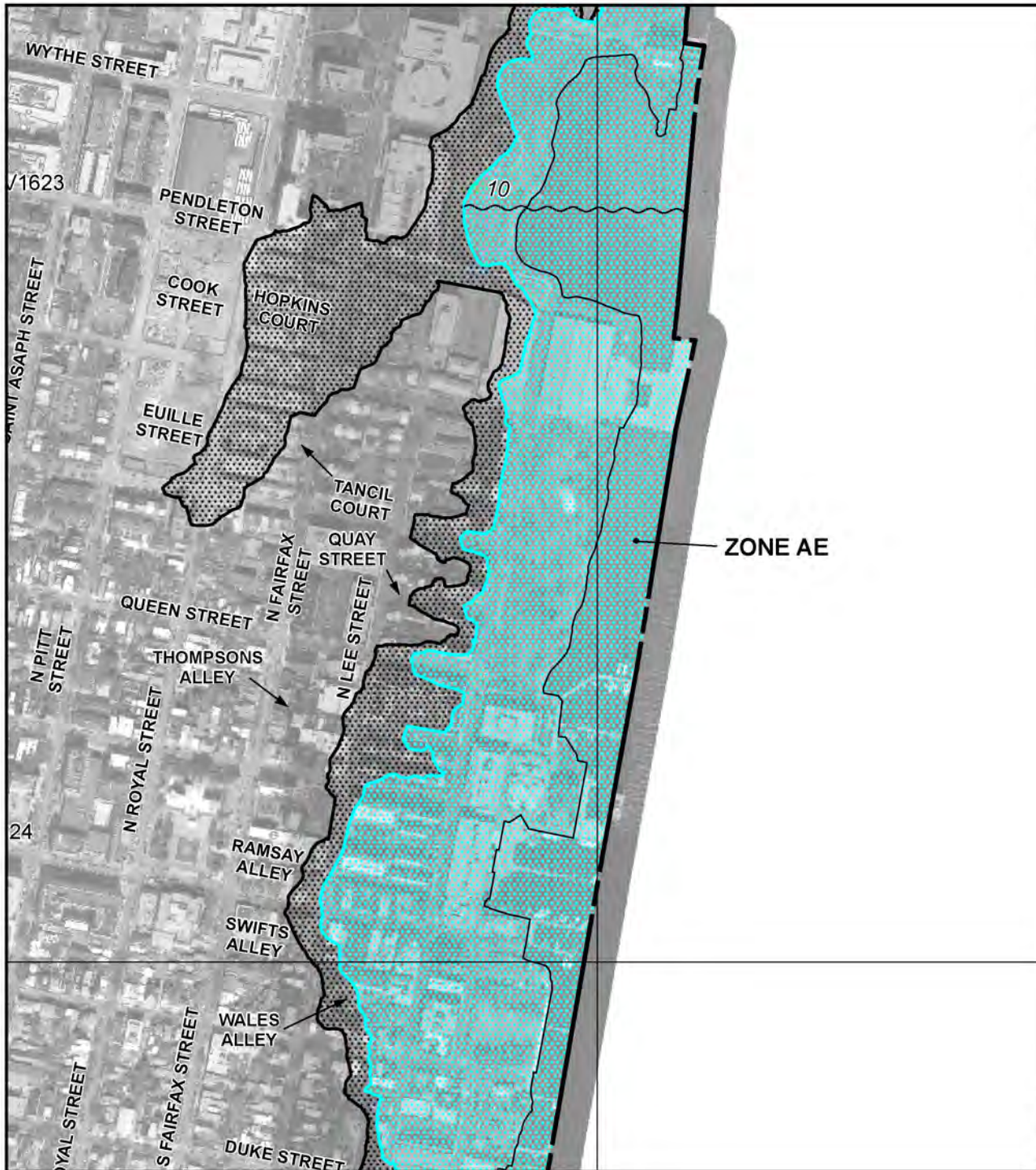


- Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
 2. Orthoimagery © Bing Maps
 3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation
 4. The approximate limits of waters of the U.S., including wetlands, have not been field survey located and are for planning purposes only
 5. Topography provided by City of Alexandria GIS 2015

**WATER QUALITY
IMPACT ASSESSMENT**

Appendix C FEMA FIRMette
September 2, 2016

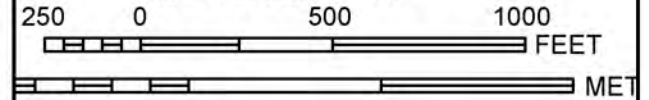
Appendix C FEMA FIRMETTE



ZONE AE



MAP SCALE 1" = 500'



NFIP

PANEL 0041E

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
CITY OF ALEXANDRIA,
VIRGINIA
INDEPENDENT CITY

PANEL 41 OF 45

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALEXANDRIA, CITY OF (INDEPENDENT CITY)	515519	0041	E

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.



MAP NUMBER
5155190041E

MAP REVISED
JUNE 16, 2011

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

**WATER QUALITY
IMPACT ASSESSMENT**

Appendix D BUFFER EQUIVALENCY CALCULATIONS
September 2, 2016

Appendix D BUFFER EQUIVALENCY CALCULATIONS

Buffer Equivalency Calculations - adapted from
Information Bulletin No. 3 - Draft Buffer Equivalency Guidance

RPA AREA #1 - FULL 100-FT BUFFER ON EITHER SIDE OF ONSITE STREAM CHANNEL

Step 1 - Determine the Pollutant Load (L) generated by the drainage area of the buffer

$$L = 0.000047 \text{ (lbs/in-ft)} * \text{annual rainfall (in)} * \text{lot width (ft)}$$

(Note: assumes 200 ft. of overland sheet flow and 16% impervious)

Lot width = Length of shoreline over which average buffer area was derived (ft) = 2640 (Shoreline of Project)
Annual Rainfall (in) = 40

$L = 4.96 \text{ lbs TP / yr total load to buffer}$

Step 2 - Determine maximum Load Removed by the existing buffer

$$R_{\text{exist}} = L * \text{Removal Efficiency}$$

Existing Buffer (ft) = 46.035
Removal Efficiency (%) = 23.7

Removal Efficiency based on
interpolations/extrapolations from CBLAD-
provided efficiencies for buffers greater than
50 ft. from Info. Bulletin No. 10

$R_{\text{exist}} = 1.18 \text{ lb TP / yr}$
--

Step 3 - Determine the Load Removed by the remaining buffer

$$R_{\text{proposed}} = L * \text{Removal Efficiency}$$

Remaining Buffer (ft) = 45.5
Removal Efficiency (%) = 23.5

Removal Efficiency based on
interpolations/extrapolations from CBLAD-
provided efficiencies for buffers greater than
50 ft. from Info. Bulletin No. 10

$R_{\text{proposed}} = 1.16 \text{ lb TP / yr}$

Step 4 - Determine the Pollutant Load Associated with the Decrease in Buffer Efficiency

$$RR = R_{\text{exist}} - R_{\text{proposed}}$$

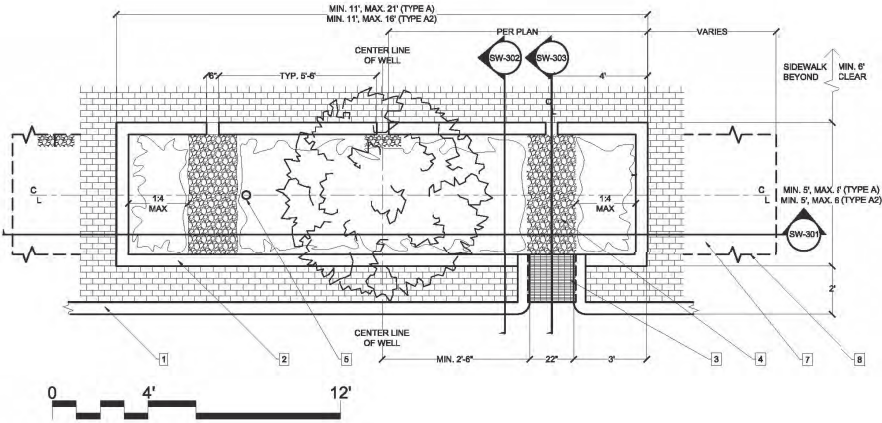
$RR = 0.02 \text{ lb TP / yr}$

**WATER QUALITY
IMPACT ASSESSMENT**

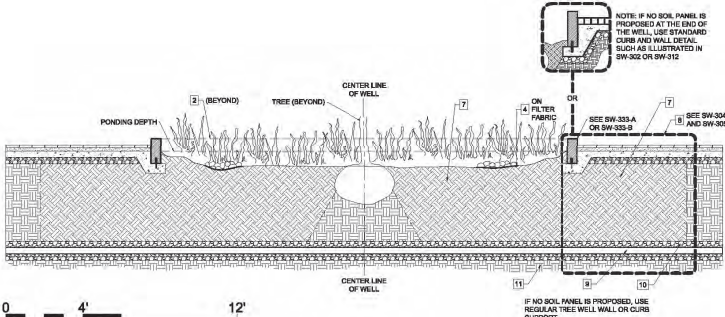
Appendix E PRICING DESIGN SCHEMATIC (OLIN PLAN EXCERPT)
September 2, 2016

**Appendix E PRICING DESIGN SCHEMATIC (OLIN PLAN
EXCERPT)**

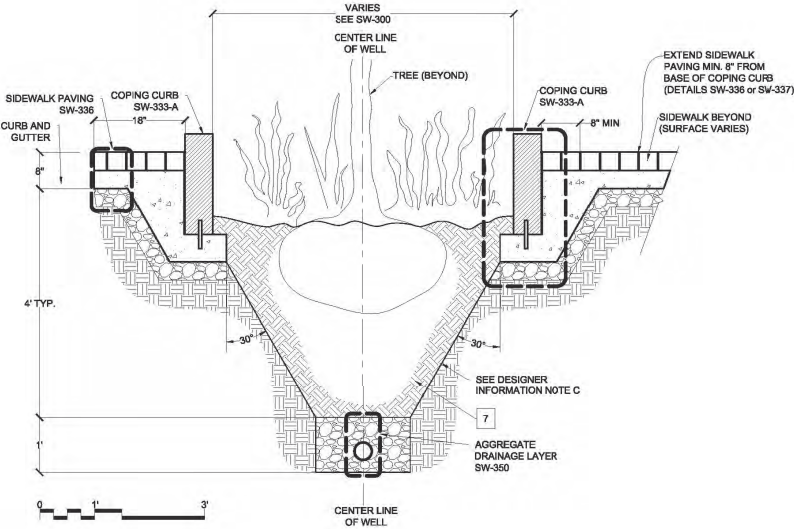
p:\projects\13097 - alexandria waterfront\001.00\101864 conceptual\c-500 site details.dwg plotted: 8/5/2014 11:05 AM by michael pizzino



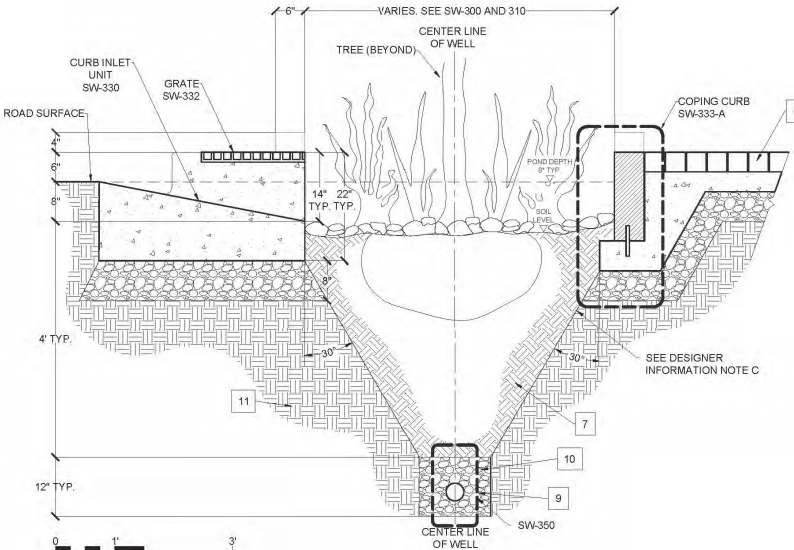
SW-300 BMP TREE WELL PLAN



SW-301 SECTION ELEVATION 'A'



SW-302 SECTION ELEVATION 'B'



SW-303 INLET SECTION

BMP NARRATIVE

THE COMMONWEALTH OF VIRGINIA HAS ENACTED NEW STORMWATER MANAGEMENT AND BMP REGULATIONS AS OF JULY 1, 2013. LOCAL JURISDICTIONS ARE REQUIRED TO MEET THESE NEW REGULATIONS BY JULY 1, 2014 AND THUS PROJECTS NOT ACQUIRING A VSPM PERMIT BEFORE JULY 1, 2014 WILL BE REQUIRED TO MEET THE NEW REGULATIONS. AS A PART OF THE NEW REGULATIONS THERE ARE TWO TYPES OF DEVELOPMENT: "NEW DEVELOPMENT" AND "REDEVELOPMENT" EACH WITH THEIR OWN SET OF REQUIREMENTS, THESE REGULATIONS ARE FOCUSED ON AND LIMIT THE AMOUNT OF PHOSPHORUS LOADING THE SITE IS PERMITTED TO RELEASE, EITHER THROUGH REDUCTION FROM THE PRE-DEVELOPMENT CONDITION OR A STATIC NUMBER THE SITE IS REQUIRED TO MEET.

REQUIREMENTS:

- WATER QUALITY (BMP) REQUIREMENTS:
 - STATE: 9VAC25-870-63
 - CITY OF ALEXANDRIA: 13-109.E
- "REDEVELOPMENT" REQUIREMENTS
 - STATE: 9VAC25-870-63.A.2(A)
 - CITY OF ALEXANDRIA: 13-109.E.4
- NO INCREASE IN IMPERVIOUS:
 - STATE: 9VAC25-870-63.A.2(A)
 - CITY OF ALEXANDRIA: 13-109.E.4(A)(B)
- NET INCREASE IN IMPERVIOUS:
 - STATE: 9VAC25-870-63.A.2(C)
 - CITY OF ALEXANDRIA: 13-109.E.4(C)
- "NEW DEVELOPMENT" REQUIREMENTS:
 - STATE: 9VAC25-870-63.A.1
 - CITY OF ALEXANDRIA: 3-109.E.5
- ADDITIONAL ALEXANDRIA REQUIREMENT:
 - "FOR NEW DEVELOPMENT" AND "DEVELOPMENT ON PRIOR DEVELOPED LANDS" (3) AND (4) ABOVE, THE ENTIRE "ALEXANDRIA WATER QUALITY VOLUME DEFAULT" FROM THE SITE SHALL BE TREATED."

BMP IMPLEMENTATION STRATEGY:

GIVEN THERE IS A NET INCREASE IN IMPERVIOUS AREA WITHIN THE SITE, WE ARE ASSUMING THE PROMENADE WILL BE CONSIDERED "NEW DEVELOPMENT" AND THE REMAINDER OF THE SITE WILL NEED TO MEET THE "REDEVELOPMENT" REQUIREMENTS. IT SHOULD BE NOTED THAT THE GROUNDWATER ELEVATION HAS NOT BEEN ESTABLISHED YET AND WILL BE NEEDED TO VALIDATE THIS CONCEPTUAL BMP DESIGN.

BMP FILTERING DEVICES:

- FILTERTERRA OR SIMILAR TREE BOX FILTER
 - IDEALLY SITUATED ADJACENT TO THE ROAD TO TREAT ROAD RUNOFF BUT CAN BE USED ELSEWHERE TO ACHIEVE TREATMENT.
 - CAN BE LINKED WITH THE PERVIOUS PAVERS TO ACHIEVE A SECOND LEVEL OF TREATMENT.
 - WATER FILTERS THROUGH THE MEDIA TO AN UNDERDRAIN AND OUT TO THE STORM SYSTEM OR CISTERN
- MICRO-BIORETENTION
 - USED TO TREAT ROAD RUNOFF IN SELECT LOCATIONS, BUT ALSO TO TREAT SIDEWALK AREAS.
 - SHEET FLOW ENTERS FROM THE SURFACE OR DRAINAGE CHANNEL FROM THE ROAD AND IS FILTERED THROUGH THE MEDIA TO AN UNDERDRAIN AND OUT TO THE STORM SYSTEM OR CISTERN.
- PERVIOUS PAVERS
 - OPTIONAL PERVIOUS PAVERS ALONG THE PROMENADE.
 - FIRST LEVEL OF TREAT AND CAN BE TREATED AGAIN WITH NEARBY TREE BOX FILTERS OR THE DRY SWALE.
- DRY SWALE
 - SECOND LEVEL OF TREATMENT IF PAVERS USED, OR FIRST LEVEL OF TREATMENT IF PROMENADE IS AN IMPERMEABLE SURFACE.
 - ALSO WOULD TREAT ADDITIONAL LAWN AND SIDEWALK AREAS.
- UNDERGROUND CISTERN:
 - MINIMAL LEVEL OF TREATMENT (BASED ON RUNOFF REDUCTION VOLUME).
 - RUNOFF CAPTURED BY THE CISTERN IS TO BE RE-USED TO IRRIGATE THE ADJACENT LAWN AREAS.

MISCELLANEOUS ITEMS

THE STORMWATER DIVIDES DEVELOPED BY URS CORP. HAVE BEEN HELD AS MUCH AS POSSIBLE, A PORTION OF THE BIORETENTION AT POINT LUMLEY DRAINS TO THE STORM SYSTEM THAT OUTFALLS AT THE END OF DUKE STREET, THE REMAINDER OF POINT LUMLEY AND ALL OF WATERFRONT PARK DRAINS THE PROPOSED STORM SYSTEM AND PUMP STATION-1, ALONG THE STRAND BETWEEN PRINCE STREET AND KING STREET, SIMILAR TO THAT SHOWN IN THE URS CORP. DRAINAGE AREA MAP.

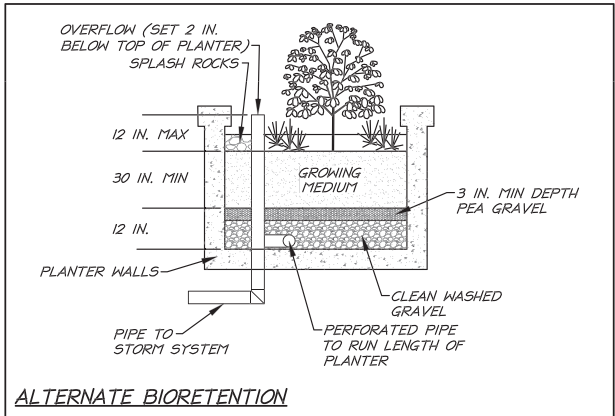
THE WALKWAYS AND ROADWAYS ARE CONSIDERED IMPERVIOUS IN THE STORMWATER QUALITY COMPUTATIONS EXCEPT FOR THE PROMENADE WHICH IS COMPUTED UTILIZING THE PERVIOUS PAVES COMPUTATIONS.

CISTERN

IT IS INTENDED THAT THE PROPOSED CISTERN AT THE END OF PRINCE STREET WILL BE USED FOR SUPPLEMENTARY IRRIGATION FOR THE ADJACENT TURF AND LANDSCAPE AREAS.

PER SPECIFICATION NO. 6 FROM THE VA DEPARTMENT OF ENVIRONMENTAL QUALITY DESIGN SPECIFICATIONS, "THE ANNUAL RUNOFF VOLUME REDUCTION AND POLLUTANT REMOVAL PERFORMANCE CREDITS OF RAINWATER HARVESTING SYSTEMS ARE A FUNCTION OF THE CISTERN TANK SIZE, CONFIGURATION, AND WATER DEMAND OR USE." BASED ON THESE FACTORS THE RUNOFF REDUCTION AND POLLUTANT REMOVAL VARIES.

POLLUTANT LOAD REDUCTION IS REALIZED THROUGH REDUCTION OF THE VOLUME OF RUNOFF LEAVING THE SITE AND, WHEN APPLICABLE, A DOWNSTREAM TREATMENT PRACTICE. ANNUAL RUNOFF REDUCTION VOLUME CREDIT IS ONLY AWARDED FOR DEDICATED YEAR-ROUND DRAINAGE/INLETMAN FOR THE WATER. SEASONAL PRACTICES (SUCH AS IRRIGATION) MAY BE INCORPORATED INTO THE SITE DESIGN, BUT THE CISTERN DESIGN MUST BE SUPPLEMENTED BY A SECONDARY RUNOFF REDUCTION DRAINAGE PRACTICE WITH EQUAL OR GREATER DRAWDOWN RATE DURING THE NON-SEASONAL MONTHS IN ORDER TO BE CREDITED WITH ANNUAL RUNOFF REDUCTION VOLUME CREDIT (FOR STORMWATER PURPOSES).



ALTERNATE BIORETENTION

ALL CONSTRUCTION SHALL CONFORM TO THE CURRENT CITY OF ALEXANDRIA AND VIRGINIA DEPARTMENT OF TRANSPORTATION STANDARDS AND SPECIFICATIONS.

Lighting Designer
Horton Lees Brogden Lighting Design
200 Park Ave South, Suite 1401
New York, NY 10003
212.674.5580

Civil Engineer
christopher consultants, ltd.
9900 Main Street, Fourth Floor
Fairfax, VA 22031
703.273.6820

Marine Engineer
Mofatt & Nichol
1509 W. Swann Ave. Suite 255
Tampa, FL 33606
813.258.8818

Local Landscape Architect
Parker Rodriguez Inc.
101 N. Union St. Suite 230
Alexandria, VA
703.548.5010

OLIN
LANDSCAPE ARCHITECTURE
PHILADELPHIA, PA 19106
TEL 215.440.0000 / FAX 215.440.0041
WWW.OLINDESIGN.COM
OLIN PARTNERSHIP, LTD.

15-30% DESIGN SCHEMATIC
NOT FOR CONSTRUCTION

WATERFRONT SMALL AREA PLAN IMPLEMENTATION

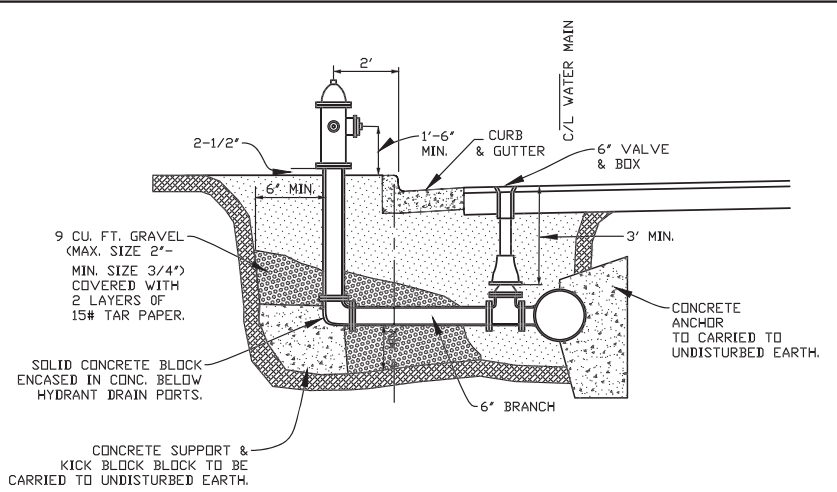
CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313



SITE DETAILS

DESIGN ENGINEER:		MGP		Date:		REVISIONS	
CADD ENGINEER:		MGP		Date:		INITIALS	COMMENTS
CITY ENGINEER:				Date:			
DIRECTOR T&ES:				Date:			

Scale: AS SHOWN Project No. 13097.001.00 Sheet C-500



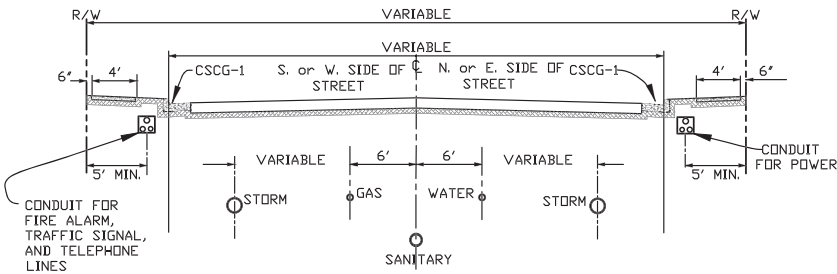
1. FIRE HYDRANT: MUELLER CENTURION - CATALOG # A423 WITH 1-1/2 INCH PENTAGON OPERATING NUT; LEFT TURN TO OPEN TWO 2-1/2" HOSE NOZZLES AND ONE 4" HOSE NOZZLE.
2. VALVE: MUELLER GATE VALVE - CATALOG # A2380-20, WITH 6 INCH MECHANICAL JOINTS, 2 INCH SQUARE NUT, LEFT TURN TO OPEN.
3. LOCATIONS IS TO BE AS SHOWN ON PLANS. VARIANCE OF THE 2' MIN. FROM THE FACE OF THE CURB SHALL BE REVIEWED ON AN INDIVIDUAL BASIS BY THE CITY ENGINEER.

SCALE 1:2.667

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

FIRE HYDRANT INSTALLATION

CSFH-1 PAGE 9



SECTION OF TYPICAL STREET

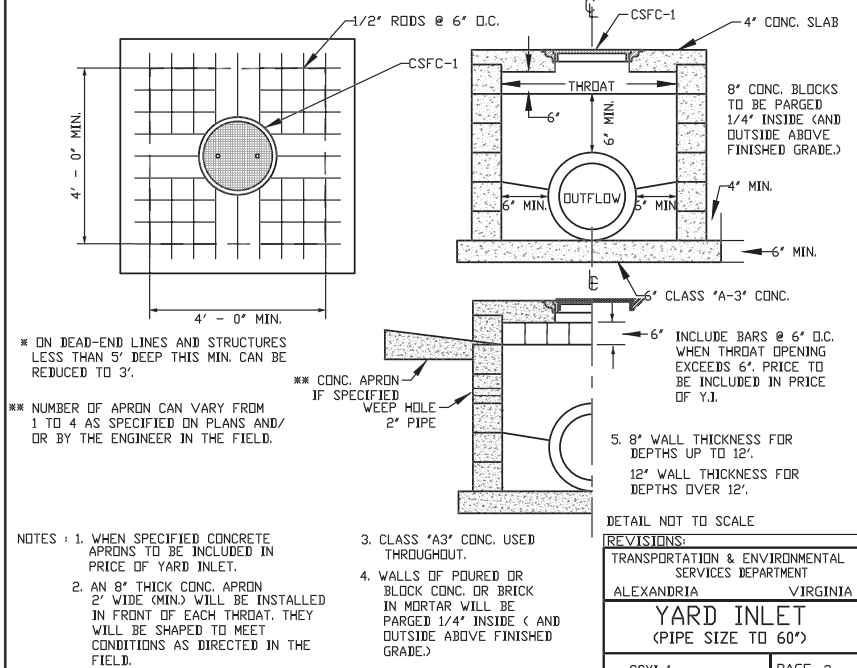
- NOTES: 1. LOCATIONS MAY ONLY BE CHANGED WITH WRITTEN APPROVAL FROM THE CITY ENGINEER.

DETAILS NOT TO SCALE

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

STANDARD LOCATION OF SEWER & UTILITIES

CSSU-1 PAGE 21



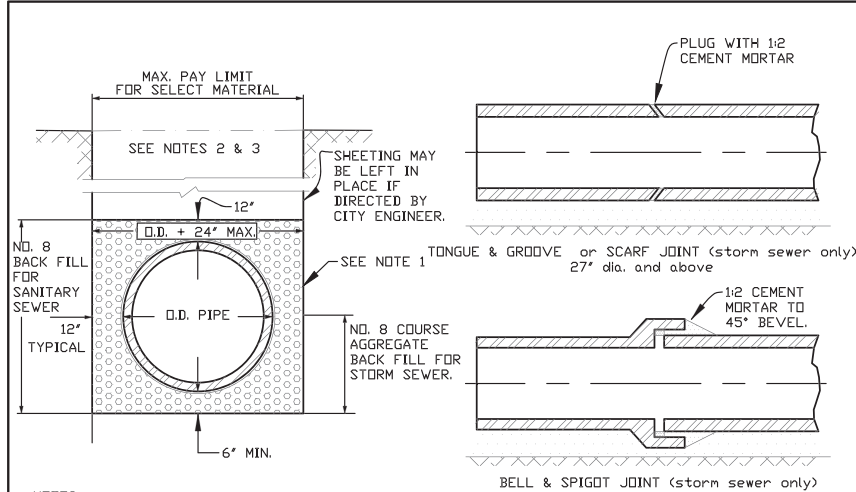
- NOTES: 1. WHEN SPECIFIED CONCRETE APRONS TO BE INCLUDED IN PRICE OF YARD INLET.
2. AN 8" THICK CONC. APRON 2' WIDE (MIN.) WILL BE INSTALLED IN FRONT OF EACH THROAT. THEY WILL BE SHAPED TO MEET CONDITIONS AS DIRECTED IN THE FIELD.
3. CLASS "A3" CONC. USED THROUGHOUT.
4. WALLS OF POURED OR BLOCK CONC. OR BRICK IN MORTAR WILL BE PARGED 1/4" INSIDE & OUTSIDE ABOVE FINISHED GRADE.
5. 8" WALL THICKNESS FOR DEPTHS UP TO 12'.
12" WALL THICKNESS FOR DEPTHS OVER 12'.
6. CLASS "A3" CONC. USED THROUGHOUT.
7. INCLUDE BARS @ 6" O.C. WHEN THROAT OPENING EXCEEDS 6". PRICE TO BE INCLUDED IN PRICE OF Y.I.
8. 8" WALL THICKNESS FOR DEPTHS UP TO 12'.
12" WALL THICKNESS FOR DEPTHS OVER 12'.
9. CLASS "A3" CONC. USED THROUGHOUT.
10. INCLUDE BARS @ 6" O.C. WHEN THROAT OPENING EXCEEDS 6". PRICE TO BE INCLUDED IN PRICE OF Y.I.

DETAIL NOT TO SCALE

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

YARD INLET (PIPE SIZE TO 60")

CSYI-1 PAGE 3



NOTES:

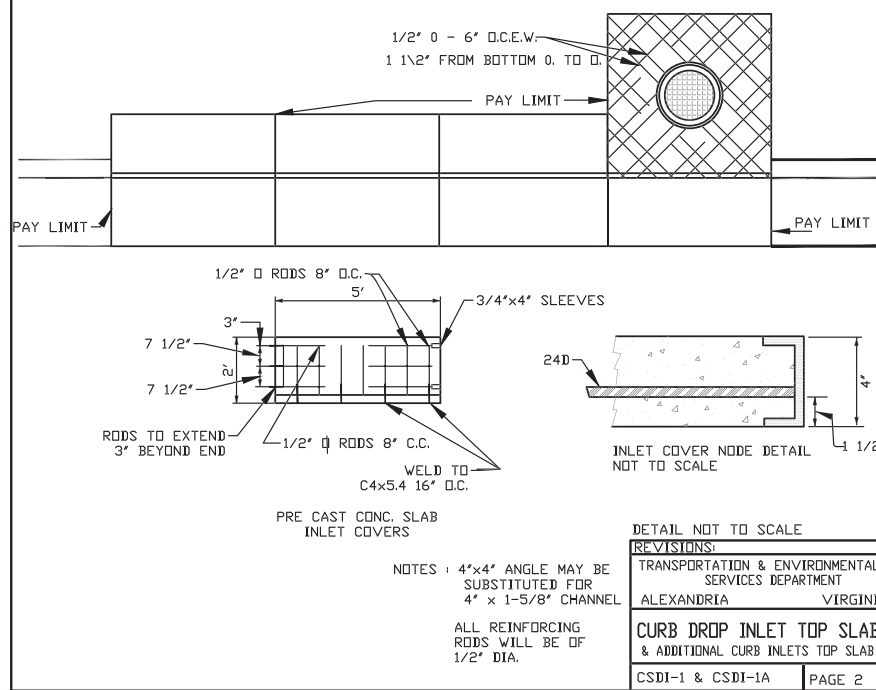
1. NO. 8 COARSE AGGREGATE BACK-FILL TO 1" OVER SANITARY SEWER, OR TO CENTERLINE OF STORM SEWER.
2. EXCAVATED MATERIAL BACK FILLED IN 6" LAYER TO 95% COMPACTION, SELECT MATERIAL, WHERE CALLED FOR, MAY BE USED AS SEPARATE PAY ITEM.
3. BACK FILL IN RIGHT OF WAY TO BE SELECT GRANULAR MATERIAL APPROVED BY CITY ENGINEER.
4. RUBBER GASKET TYPE JOINTS SHALL BE USED FOR ALL SANITARY SEWERS.

DETAILS NOT TO SCALE

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

JOINTING & BEDDING FOR PIPE & TRENCH SECTIONS

CSJT-1 PAGE 16

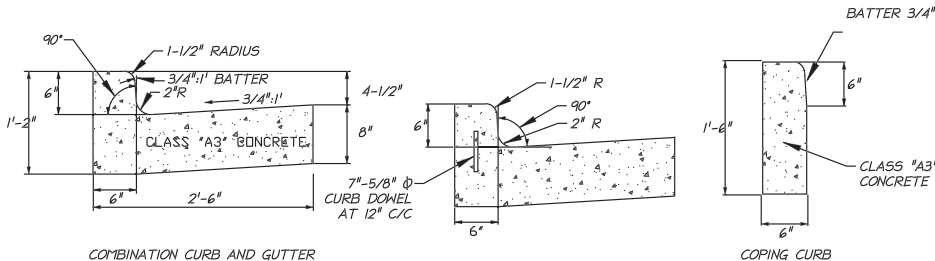


DETAIL NOT TO SCALE

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

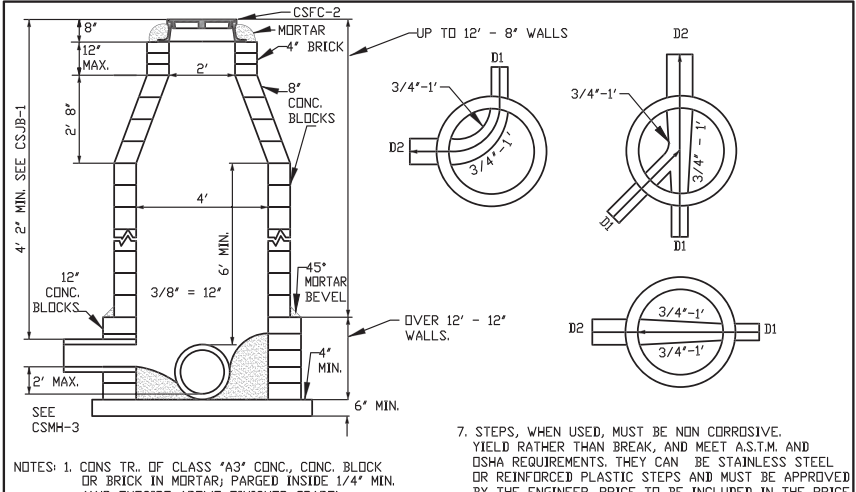
CURB DROP INLET TOP SLAB & ADDITIONAL CURB INLETS TOP SLAB

CSDI-1 & CSDI-1A PAGE 2



COMBINATION CURB AND GUTTER

CURB AND GUTTER (CSCG-1)



- NOTES: 1. CONS TR. OF CLASS "A3" CONC. CONC. BLOCK OR BRICK IN MORTAR; PARGED INSIDE 1/4" MIN. (AND OUTSIDE ABOVE FINISHED GRADE).
2. TO DEPTH OF 12" WALLS WILL BE 8" THICK, BELOW 12" WALLS WILL BE 12" THICK.
3. CHANNEL BEND TO BE GREATEST POSSIBLE RADIUS.
4. CHANNEL MAY BE FORMED OF CONC. AND FINISHED SMOOTH; FORMED OF HALF PIPE AND FITTINGS, OR FORMED OF BRICKWORK.
5. INVERT TO SLOPE 3/4" : 1 TOWARD CHANNEL.
6. MAIN CHANNEL INVERT WILL PITCH DOWN UNIFORMLY FROM THE INLET ACCORDING TO CONDITIONS.

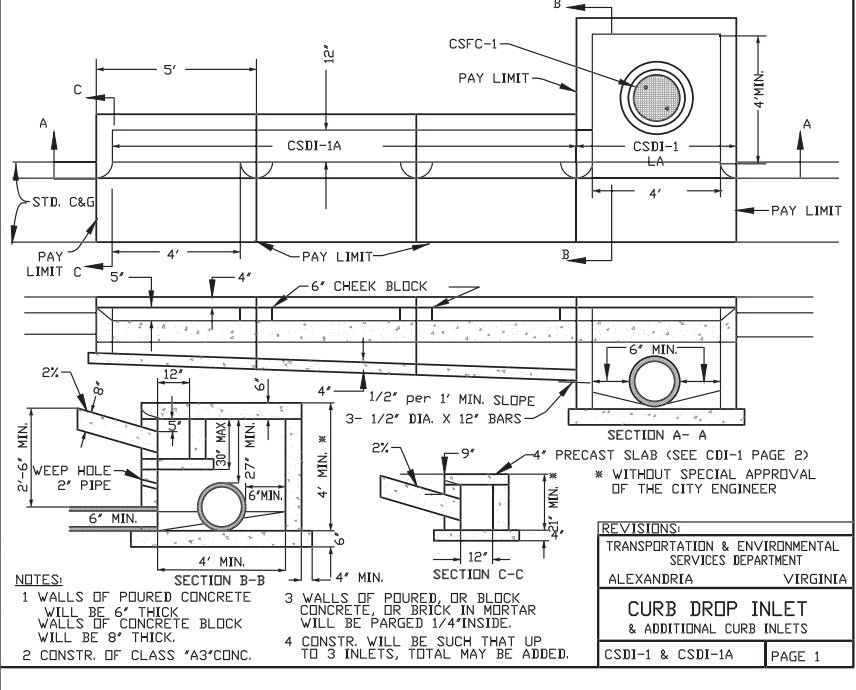
7. STEPS, WHEN USED, MUST BE NON CORROSIVE. YIELD RATHER THAN BREAK, AND MEET A.S.T.M. AND OSHA REQUIREMENTS. THEY CAN BE STAINLESS STEEL OR REINFORCED PLASTIC STEPS AND MUST BE APPROVED BY THE ENGINEER. PRICE TO BE INCLUDED IN THE PRICE OF THE MANHOLE COMPLETE IN PLACE.

DETAIL NOT TO SCALE

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

TYPE -1 MANHOLE (PIPE SIZE TO 36")

CSMH-1 PAGE 4

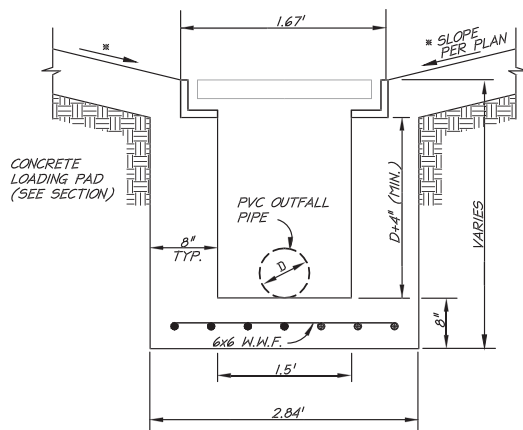


- NOTES: 1. WALLS OF POURED CONCRETE OR BLOCK CONCRETE, OR BRICK IN MORTAR WILL BE PARGED 1/4" INSIDE.
2. CONSTR. OF CLASS "A3" CONC.
3. WALLS OF POURED, OR BLOCK CONCRETE, OR BRICK IN MORTAR WILL BE PARGED 1/4" INSIDE.
4. CONSTR. WILL BE SUCH THAT UP TO 3 INLETS, TOTAL MAY BE ADDED.

REVISIONS:
TRANSPORTATION & ENVIRONMENTAL SERVICES DEPARTMENT
ALEXANDRIA VIRGINIA

CURB DROP INLET & ADDITIONAL CURB INLETS

CSDI-1 & CSDI-1A PAGE 1



ALL CONSTRUCTION SHALL CONFORM TO THE CITY OF ALEXANDRIA STANDARDS (N.T.S.)

OLIN
LANDSCAPE ARCHITECTURE
101 N. Union St. Suite 230
Alexandria, VA 22301
TEL 215.440.0030 / FAX 215.440.0041
WWW.OLINARCHITECTS.COM
OLIN PARTNERSHIP, L.L.C.

Local Landscape Architect
Parker Rodriguez Inc.
101 N. Union St. Suite 230
Alexandria, VA 22301
703.548.5010

Marine Engineer
Morlat & Nichol
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Fairfax, VA 22031
703.273.6820

Lighting Designer
Horton Lees Brogden Lighting Design
200 Park Ave South, Suite 1401
New York, NY 10003
212.674.5580

WATERFRONT SMALL AREA PLAN IMPLEMENTATION

15-30% DESIGN SCHEMATIC NOT FOR CONSTRUCTION



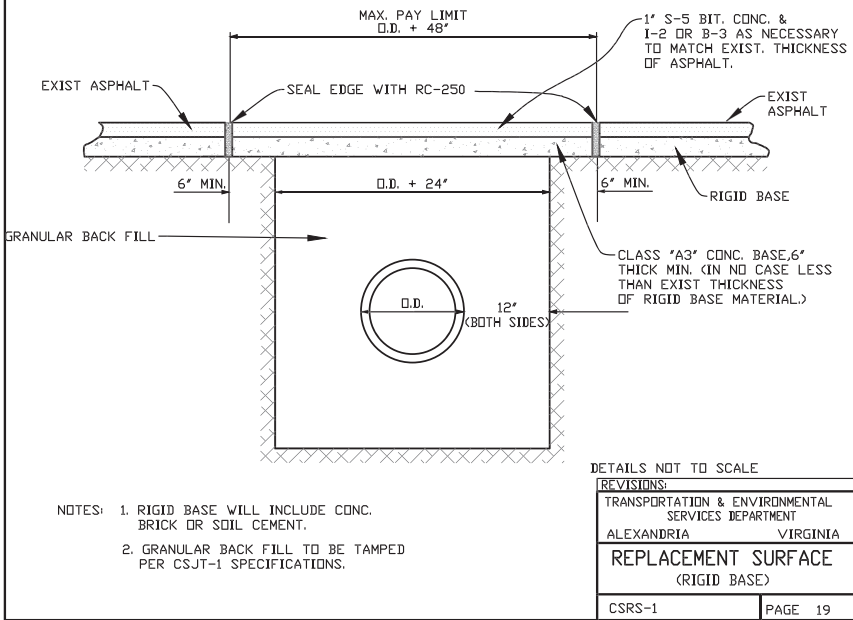
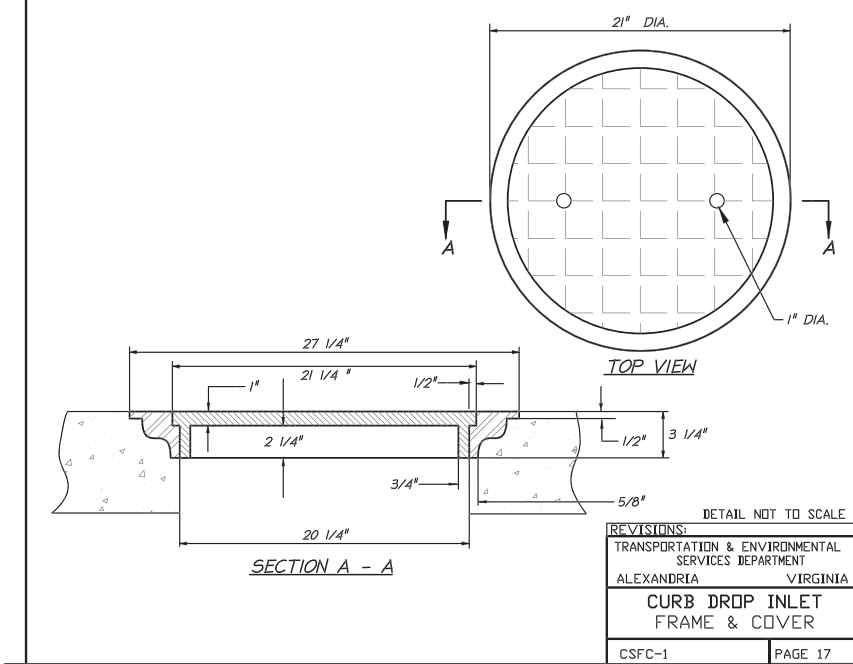
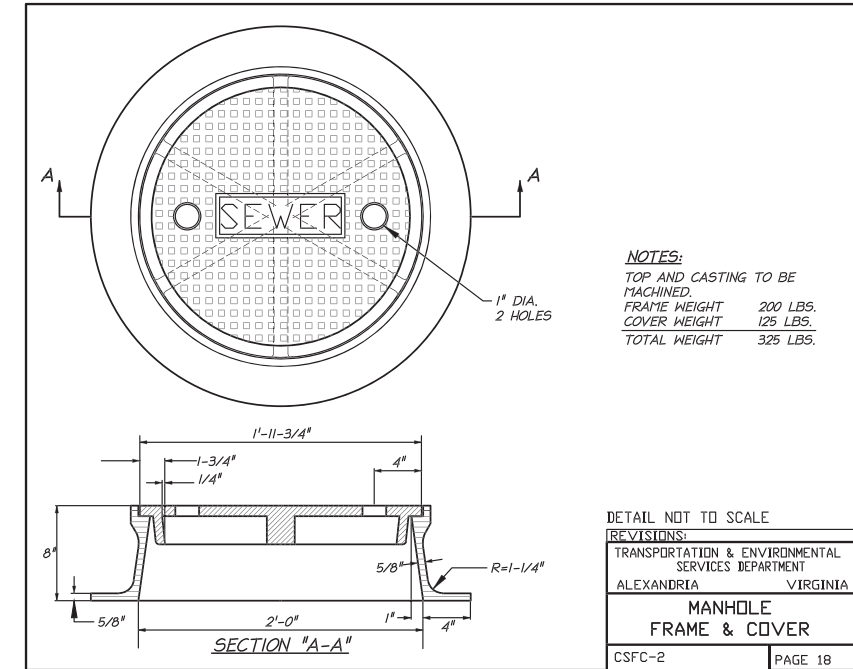
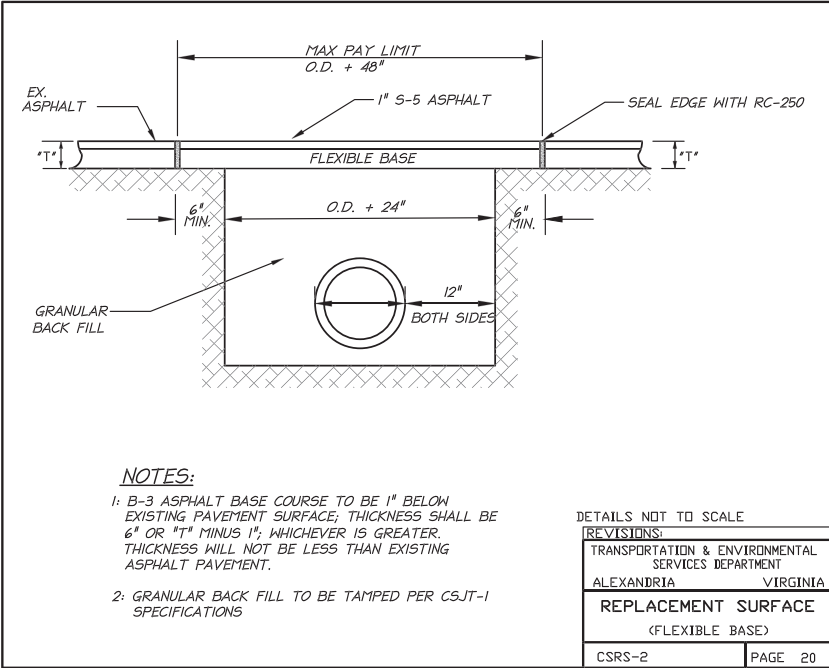
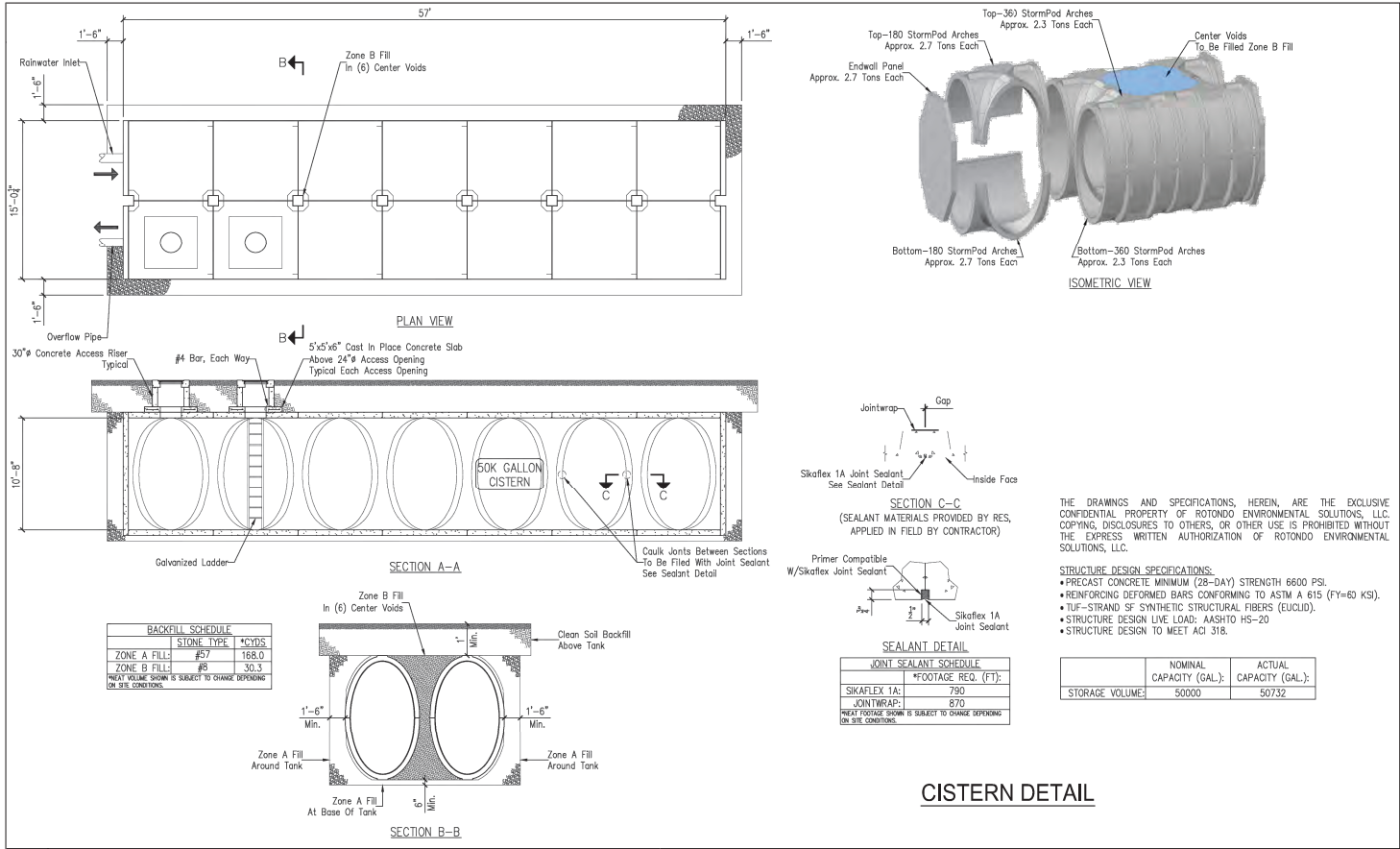
CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313

SITE DETAILS

DESIGN ENGINEER: MGP Date: _____
CADD ENGINEER: MGP Date: _____
DIVISION CHIEF: _____
CITY ENGINEER: _____
DIRECTOR T&ES: _____

REVISIONS
Date: _____ INITIALS _____ COMMENTS _____

Scale: AS SHOWN Project No. 13097.001.00 Sheet C-501



OLIN

LANDSCAPE ARCHITECTURE

101 N. Union St. Suite 230
Alexandria, VA 22314
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WWW.OLINARCHITECTS.COM

Local Landscape Architect

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Marine Engineer

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Lighting Designer

Horton Lees Brogden Lighting Design

200 Park Ave South, Suite 1401
New York, NY 10003
212.674.5580

15-30% DESIGN SCHEMATIC

NOT FOR CONSTRUCTION

WATERFRONT SMALL AREA PLAN IMPLEMENTATION

CITY OF ALEXANDRIA, VIRGINIA

Department of Project Implementation

P. O. Box 178
Alexandria, Virginia 22313

SITE DETAILS

DESIGN ENGINEER: MGP

CADD ENGINEER: MGP

DIVISION CHIEF:

CITY ENGINEER:

DIRECTOR T&ES:

REVISIONS

INITIALS

COMMENTS

Date:

Date:

Date:

Date:

Date:

Scale: AS SHOWN

Project No. 13097.001.00

Sheet C-502

p:\projects\13057 - alexandria waterfront\001.00\101864 conceptual\c-700 preliminary bmp computations.dwg plotted: 8/5/2014 11:05 AM by michael pizzino

Virginia Runoff Reduction Method ReDevelopment Worksheet v2.7 Revised April 2013
Site Data

Project Name: Alexandria Waterfont Conceptual BMP
Date:

data input cells
calculation cells
constant values

Post-ReDevelopment Project & Land Cover Information
Total Disturbed Acreage 6.64

Constants

Annual Rainfall (inches) 43
Target Rainfall Event (inches) 1.00
Phosphorus EMC (mg/L) 0.26
Target Phosphorus Target Load (lb/acre/yr) 0.41
Pj 0.90
Nitrogen EMC (mg/L) 1.86

Pre-ReDevelopment Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	2.68	2.68
Impervious Cover (acres)	0.00	0.00	0.00	3.96	3.96
Total					6.64

Post-ReDevelopment Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	2.16	2.16
Impervious Cover (acres)	0.00	0.00	0.00	4.48	4.48
Total					6.64

Area Check
Okay Okay Okay Okay

Rv Coefficients	A soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Land Cover Summary	Listed	Adjusted ¹	Land Cover Summary	
Pre-ReDevelopment			Post-ReDevelopment	
Forest/Open Space Cover (acres)	0.00	0.00	Forest/Open Space Cover	0.00
Composite Rv(forest)	0.00	0.00	Composite Rv(forest)	0.00
% Forest	0%	0%	% Forest	0%
Managed Turf Cover (acres)	2.68	2.16	Managed Turf Cover (acres)	2.16
Composite Rv(turf)	0.25	0.25	Composite Rv(turf)	0.25
% Managed Turf	40%	35%	% Managed Turf	35%
Impervious Cover (acres)	3.96	3.96	ReDev. Impervious Cover (acres)	3.96
Rv(impervious)	0.95	0.95	Rv(impervious)	0.95
% Impervious	60%	65%	% Impervious	65%
Total Site Area (acres)	6.64	6.12	Total ReDev. Site Area (acres)	6.12
Site Rv	0.67	0.70	ReDev. Site Rv	0.70
			Post-ReDevelopment Treatment Volume (acre-ft)	0.3585
Pre-Development Treatment Volume (acre-ft)	0.3693	0.3585	Post-ReDevelopment Treatment Volume (cubic feet)	15,616
Pre-Development Treatment Volume (cubic feet)	16,088	15,616	Post-ReDevelopment Load (TP) (lb/yr)	9.81
Pre-Development Load (TP) (lb/yr)	10.11	9.81		

¹Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.

Maximum % Reduction Required Below Pre-ReDevelopment Load 20%

TP Load Reduction Required for Redeveloped Area (lb/yr) 1.96

Total Load Reduction Required (lb/yr) 2.88

Pre-Development Load (TN) (lb/yr) 72.31 Post-Development Load (TN) (lb/yr) 78.25

Site Results

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E
IMPERVIOUS COVER	0.42	1.18	0.74	1.74	0.15
IMPERVIOUS COVER TREATED	0.30	1.18	0.74	1.74	0.15
TURF AREA	0.22	0.62	0.43	1.07	0.00
TURF AREA TREATED	0.17	0.62	0.43	1.07	0.00
AREA CHECK	OK.	OK.	OK.	OK.	OK.

Phosphorous

TOTAL PHOSPHOROUS LOAD REDUCTION REQUIRED (LB/YEAR) 2.88

RUNOFF REDUCTION (cft) 6152

PHOSPHOROUS LOAD REDUCTION ACHIEVED (LB/YR) 5.79

ADJUSTED POST-DEVELOPMENT PHOSPHOROUS LOAD (TP) (lb/yr) 5.16

REMAINING PHOSPHOROUS LOAD REDUCTION (LB/YR) NEEDED! CONGRATULATIONS! YOU EXCEED THE TARGET REDUCTION BY 2.9 LB/YEAR!

Drainage Area A - Drains to URS outfall at Duke Stree¹

Drainage Area A Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.220	0.220	0.25
Impervious Cover (acres)	0.00	0.00	0.00	0.420	0.420	0.95
Total					0.64	

Drainage Area B - Drains to the Pump station via the cistern on Prince Street

Drainage Area B Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.620	0.62	0.25
Impervious Cover (acres)	0.00	0.00	0.00	1.180	1.18	0.95
Total					1.80	

Drainage Area C - Drains to Pump Station

Drainage Area C Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	1.071	1.07	0.25
Impervious Cover (acres)	0.00	0.00	0.00	1.740	1.74	0.95
Total					2.81	

Drainage Area D - King Street

Drainage Area D Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.15	0.15	0.95
Total					0.15	

Drainage Area E - Thompsons Alley

Drainage Area E Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres) – undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) – disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.43	0.43	0.25
Impervious Cover (acres)	0.00	0.00	0.00	0.74	0.74	0.95
Total					1.17	

Local Landscape Architect
Parker Rodriguez Inc.
101 N. Union St. Suite 230
Alexandria, VA
703.548.5010
www.thedesignstudio.com
OLIN LANDSCAPE ARCHITECTURE
1509 W. Swann Ave. Suite 255
Fairfax, VA 22031
703.273.6820
Civil Engineer
christopher consultants, ltd.
200 Park Ave South, Suite 1401
New York, NY 10003
212.674.5580
Lighting Designer
Horton Lees Brogden Lighting Design
200 Park Ave South, Suite 1401
New York, NY 10003
212.674.5580

WATERFRONT SMALL AREA PLAN IMPLEMENTATION



CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313

PRELIMINARY BMP
COMPUTATIONS

DESIGN ENGINEER: MGP Date: _____
CADD ENGINEER: MGP Date: _____
DIVISION CHIEF: Date: _____
CITY ENGINEER: Date: _____
DIRECTOR T&ES: Date: _____

REVISIONS
INITIALS COMMENTS
Date: _____
Date: _____
Date: _____
Date: _____

Scale: AS SHOWN Project No. 13057.001.00 Sheet C-700

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

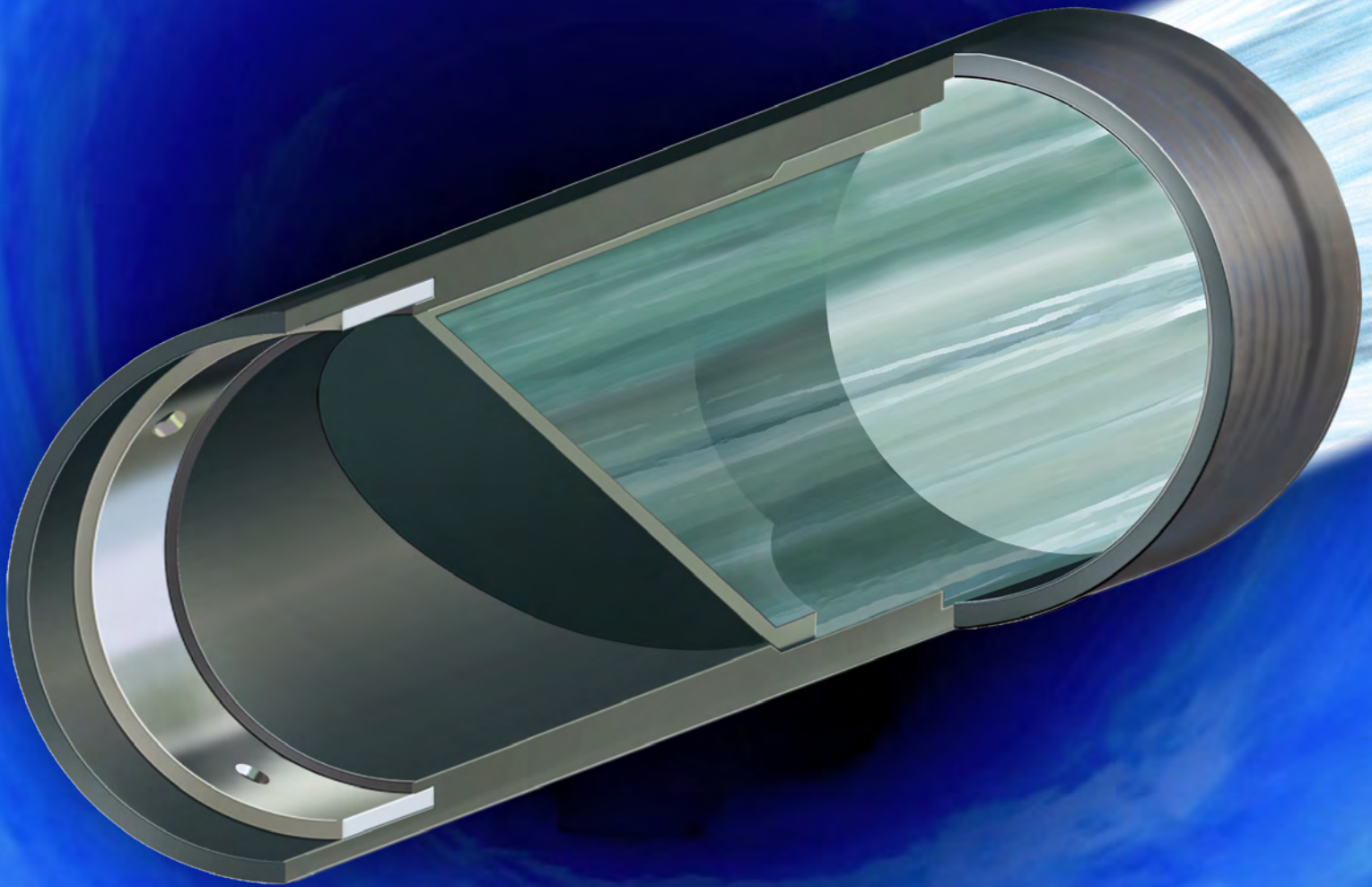
Appendix I CHECKMATE VALVE

Appendix I CHECKMATE VALVE

Red Valve®

THE CHECKMATE® ADVANTAGE

The World's Most Reliable Check Valve
Engineering Guide



Red Valve Company, Inc.

Continuing a Legacy of Innovation, Leadership and Customer Service

More than 60 years ago, Red Valve Company was founded on a simple promise: provide the highest quality engineered valves backed by an unsurpassed level of technical innovation and customer service. With that promise began a legacy of leadership—and a never-ending quest to solve the world's toughest flow control challenges while exceeding our customers' expectations.

As the world leader in Pinch Valve and Check Valve technology, that legacy lives on every day at Red Valve Company, and the innovative CheckMate® Inline Check Valve is proof. The CheckMate® Inline Check Valve is rooted in the same superior understanding of elastomer technology as the legendary Tideflex® Check Valve, one of the most well-known valves proven for providing reliable long-lasting backflow prevention, across the globe.

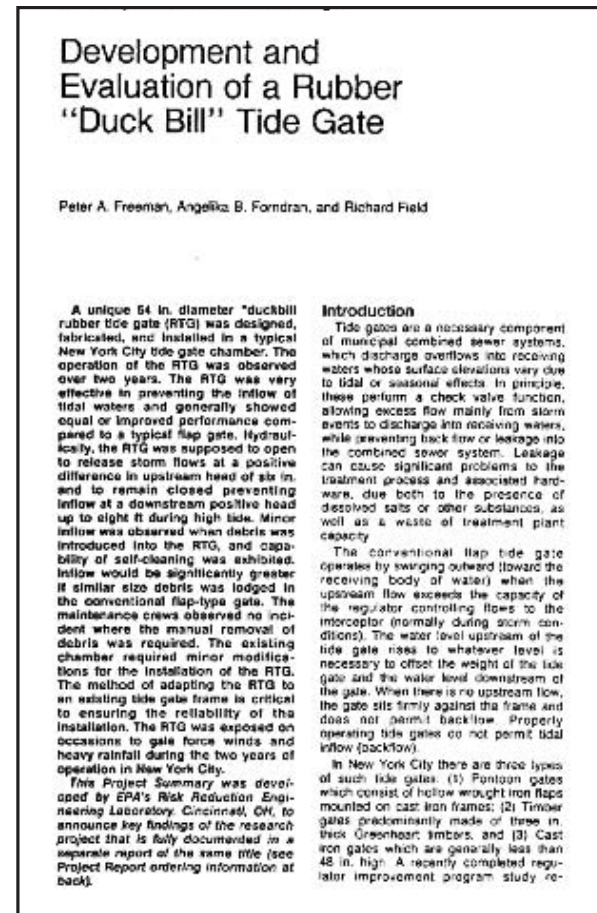
Being a world leader in valve technology is more than a slogan—it's a promise, carried forward by the hundreds of dedicated Red Valve employees and sales representatives around the world. Call us any time. We are ready to speak with you personally—right now.



The patented CheckMate® Inline Check Valve is rooted in the same superior understanding of elastomer technology as the legendary Tideflex® Check Valve, one of the most well-known valves in the world.

A Pioneer in the Check Valve Industry

In 1984, the United States Environmental Protection Agency (EPA) commissioned Red Valve Company to develop and test an alternative to tide gate valves. In their report, Development and Evaluation of a



Rubber "Duck Bill" Tide Gate, the EPA states, "Increasing the reliability and performance of tide gates has a beneficial impact on the general pollution abatement program for the nation's waterways."

In response, Red Valve Company developed and patented its elastomer "duckbill" Tideflex® Check Valve to eliminate the operational and maintenance problems associated with flapgate check valves, including corrosion of mechanical parts, freezing open or shut, warping and clogging due to entrapped debris.

The EPA rigorously tested the Tideflex® Check Valve for two years and found that the valve showed, "Significant improvement over flapgate valves in terms of leakage inflow, entrapment of debris, capability to self clean and susceptibility to marine fouling."

Since the creation of the Tideflex® Check Valve in 1984, years of research and development, testing and proven performance has led to the globalization of the TF-2 Tideflex® Check Valve and the next generation Tideflex® TF-1. With improved flow efficiency characteristics and the latest technology in elastomers, Red Valve continues to deliver on its promise of staying on the forefront of technology and new product development. The Tideflex® name is respected and recognized around the world as the most reliable valve for backflow prevention. It is also worth noting that the first Tideflex® Check Valve sold in 1984 is still in service today, with more than 700,000 Tideflex® Check Valves in service around the world, reliably solving inflow and intrusion problems.

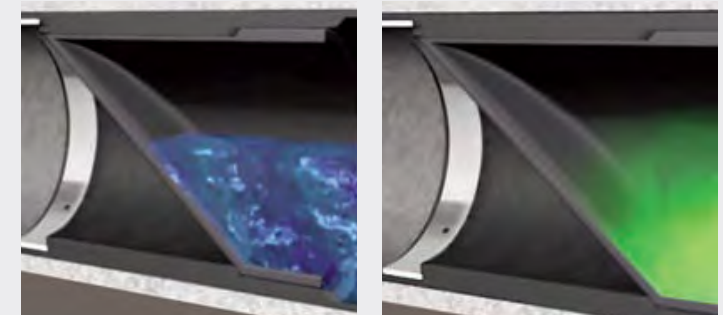
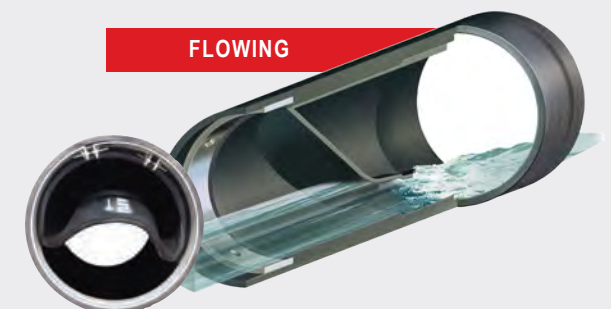


CheckMate® Valve Solves City's Odor Problem

When foul odors were plaguing a soybean producing town in Illinois, officials turned to Red Valve for the most reliable, cost-effective solution.

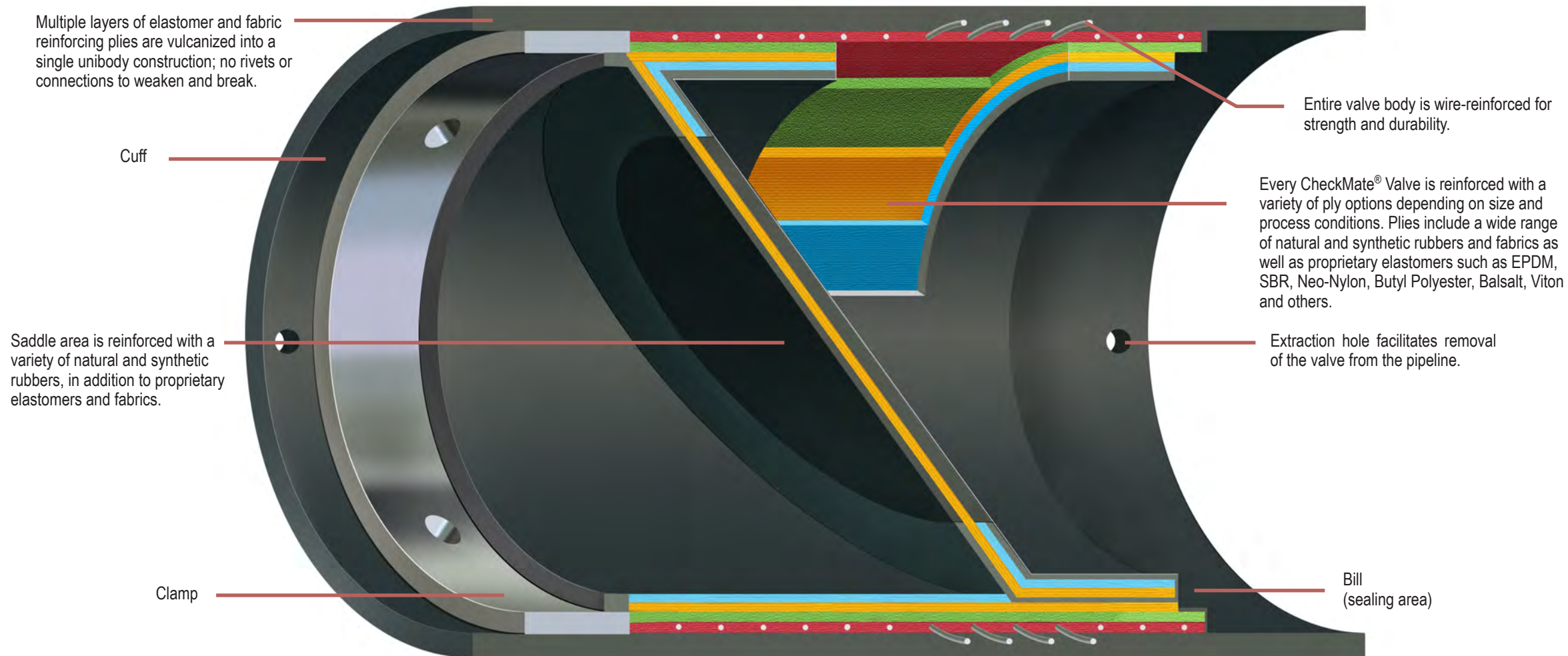
A chemical deodorizing system and a pump station were also evaluated, but far exceeded budget constraints. The CheckMate® Inline Check Valve proved to be the perfect solution.

The CheckMate® Inline Valve was installed in 2012 and has worked flawlessly ever since, completely blocking the backdraft of the odor. Best of all, there has been zero maintenance expense. According to a public works official, ***"This is one of the most cost-effective solutions to a nagging quality of life problem the City has ever implemented. We are now looking at other parts of the combined sewer system that has a few small odor problems due to escaping sewer gas."***



For an animated demonstration of the CheckMate® in operation, please visit: <http://www.tideflex.com/checkmate>

There Is Only One CheckMate® Inline Valve!



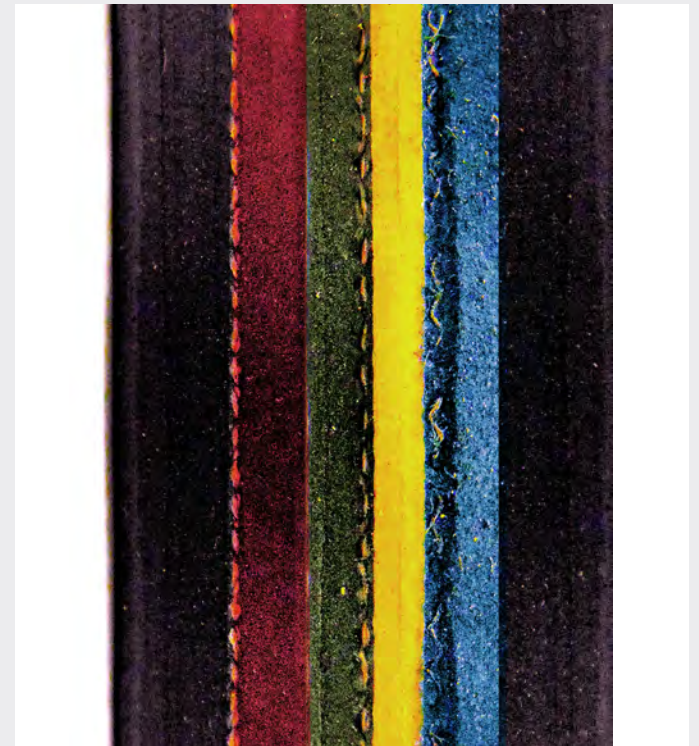
The CheckMate® Inline Check Valve: Accept No Substitutes!

The innovative CheckMate® Inline Check Valve has quickly become the specified choice for inline residential, municipal and commercial areas where complete, dependable backflow prevention is critical. It has also become the valve of choice for municipal and industrial applications such as storm water, wastewater, highway runoff, CSO, SSO and flood control by preventing unwanted backflow that can cause surges and flooding. The CheckMate® Inline Check Valve minimizes damage to wetlands, beaches and residential areas and

eliminates hydraulic surges to wastewater treatment plants, saving municipalities millions of dollars in maintenance and treatment costs.

One of the keys to the CheckMate® Valve's exceptional dependability and longevity is Red Valve's unmatched elastomer experience—experience, application knowledge and engineering know-how. Every CheckMate® Inline Check Valve is hand-fabricated, made of multiple layers of varying natural and

synthetic elastomers, wire and fabric-reinforced plies, all of which are vulcanized into a robust unibody valve. Unlike competing designs, there are no molded parts or mechanical fasteners and rivets that will loosen, act as catch points, break or corrode—ever. The key to CheckMate® Valve's longevity, performance and low headloss characteristics is the design and construction.



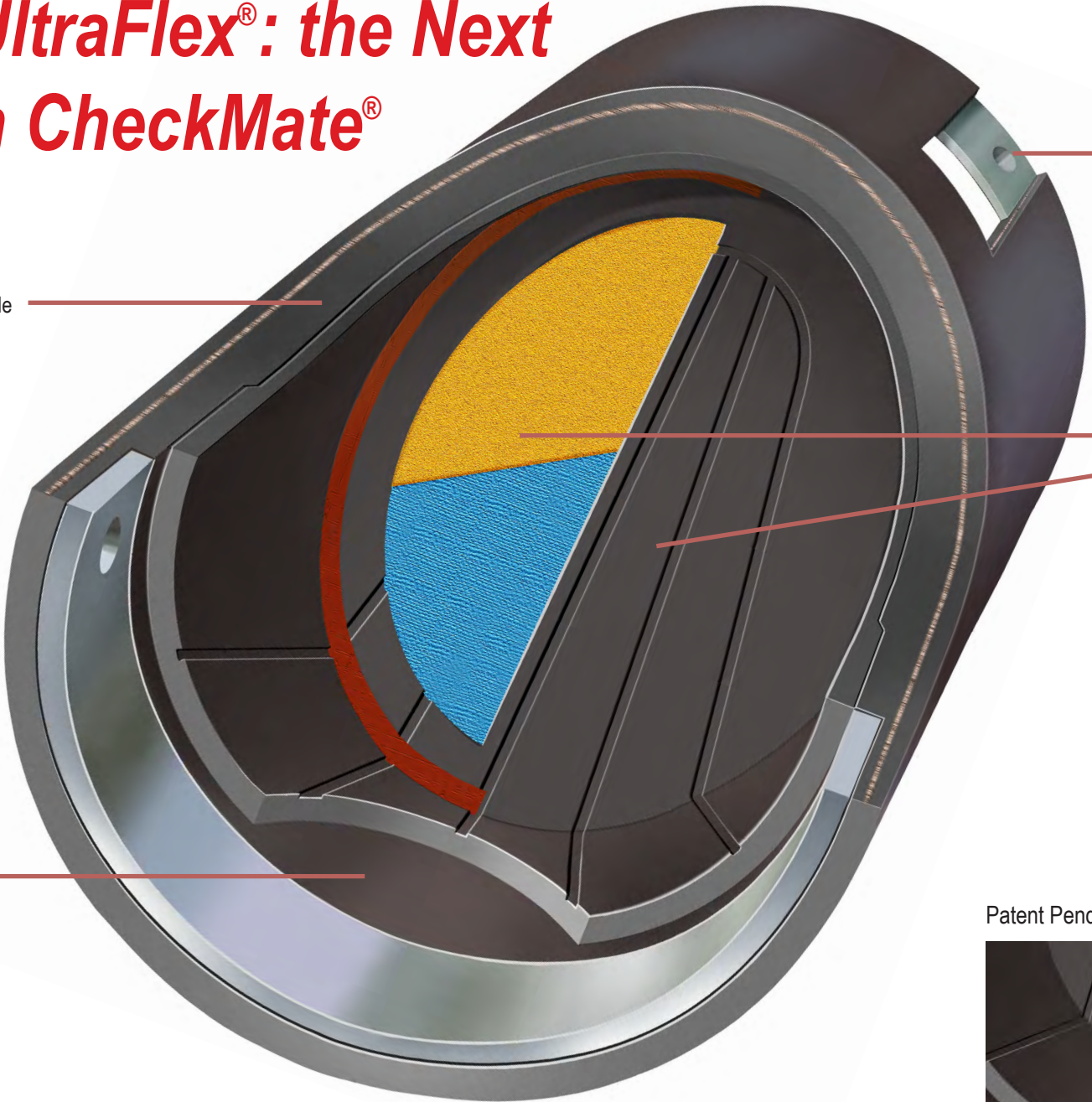
Red Valve's legendary elastomer technology and knowledge is the real story behind the CheckMate® Valve's unrivaled performance. Every CheckMate® Valve is reinforced with various natural and synthetic plies, specifically engineered for your specific application.



CheckMate® Inline Check Valves use state-of-the-art elastomers and fabric technology with no metal hinges, rivets, fasteners or moving parts. The valve's unibody construction is ideally suited for CSO and diversion chamber applications and installed inside the pipeline on either the upstream or downstream side of a diversion chamber.

Introducing UltraFlex®: the Next Generation in CheckMate® Technology!

Entire valve is vulcanized into a single unibody construction; no rivets or connections to weaken and break.



Clamp

Saddle area features strategically placed reinforcing ribs and segmented pads customized for each application.

The "Arc Notch" in the UltraFlex® Valve's bill functions as a hinge, greatly reducing the forces required to unseat the valve. This patented design achieves a very low snap-open pressure.

Unmatched Elastomer Research, Innovation and Knowledge

The patented CheckMate UltraFlex® Inline Check Valve features drastically improved hydraulic and performance characteristics to its predecessor, the original CheckMate® Check Valve. Strategically placed reinforcing ribs, segmented pads and the "Arc Notch" bill combine to significantly improve flow efficiency with significantly reduced headloss, while providing absolute backflow protection.

Once upstream head pressure reaches a specific level, CheckMate® Inline Check Valves are designed to "snap" or "pop"

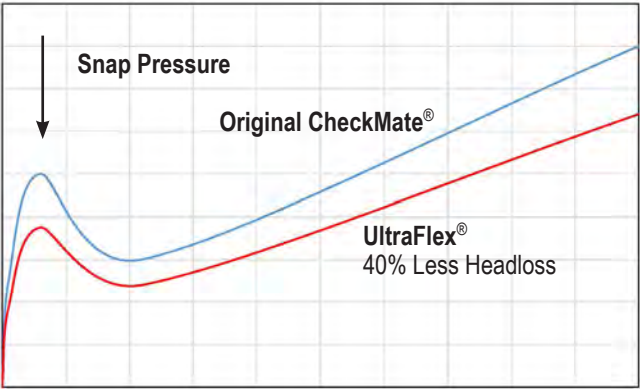
open, allowing the rapid discharge of flow. The new UltraFlex®, with its patented "Arc Notch" and optimized construction, allows the next generation CheckMate® Valve to open 40% sooner. As a result, the pipeline and entire collection system drains up to 40% faster. Because the UltraFlex® Valve "snaps" or "pops" open with less head pressure, pipeline capacity is significantly increased while the chance for standing water to collect upstream of the valve is totally eliminated.

Patent Pending



Strategically placed reinforcing ribs, segmented pads and the bill's unique "Arc Notch" combine to significantly improve flow efficiency with significantly reduced headloss while providing absolute backflow protection.

UltraFlex® Boasts 40% Lower "Snap Pressure"



The new CheckMate UltraFlex® Valve boasts a 40% lower snap pressure requirement to open or unseat the valve, without compromising the valve's ability to seal. This greatly improves capacity in pipelines and the rapid drainage of upstream flow through the valve. With its patented "Arc Notch" design, the CheckMate UltraFlex® Inline Check Valve boasts a significantly improved flow efficiency, due to reduced head pressure levels required to "snap" open the valve.



When upstream head reaches 50-75% of pipe diameter (for example, 9" head in a 12" valve), the UltraFlex® bill "snaps" open into a concave shape, allowing substantially more flow with the same amount of head. The valve will progressively open with increased head and flow. Picture shows moment when the valve "snaps" open.



The CheckMate® Valve will crack open and flow with as little as 1" of head pressure.



Once the CheckMate® Valve "snaps" open, it achieves rapid discharge of flow.

Independently Tested, Field Validated



Independent Hydraulic Testing

CheckMate® Inline Check Valves are independently tested to determine their hydraulic characteristics in both free and submerged discharge applications. Published hydraulic data is validated through this independent testing, and Finite Element Analysis data is also provided to ensure the CheckMate® Valve meets your exact specifications. CheckMate® Valves are ideally suited for interceptor, manhole and outfall pipelines because

they allow flow to discharge with very little headloss and prevent backflow. The CheckMate® Valve's innovative inline design allows it to be easily installed without modifications to existing structures, making it the perfect choice for both municipalities and commercial property owners.

To supplement independent hydraulic testing, Red Valve continually conducts research and development and additional in-house testing to improve existing products and develop new products.



Thousands of CheckMate® Inline Check Valves are currently in service around the globe.

Features and Benefits of CheckMate®

- Extremely Low Headloss
- No Moving Mechanical Parts to Corrode, Catch Debris or Fail
- Heavy Duty Elastomer Unibody Construction
- Quick and Easy Installation
- Seals Around Debris
- Operates on Differential Pressure, Totally Passive
- Virtually No Maintenance
- Self-draining, 1" of Cracking Pressure
- Silent, Non-slamming
- Available in Sizes 3" (75 mm) to 84" (2100 mm)
- Extensive Independent Hydraulic Testing



CheckMate® Valves are ideally suited for interceptor, manhole and outfall pipelines, because they maximize pipeline storage and capacity while preventing backflow into upstream pipelines, collection systems and sewage treatment plants.

Simple Design for Simple Installation

The CheckMate® Inline Check Valve is extremely easy to install, regardless of the existing environment or piping. Its inherent design makes it the most user-friendly inline check valve on the market today. From the upstream or downstream end of the pipe, simply insert the valve into position and clamp it into place. Typically, no modification to the pipe or structure is required to install the CheckMate®. Because the CheckMate® is recessed inside of the pipe, additional permitting is not required. The results are construction cost savings, reduced installation time, and reduced operational costs.

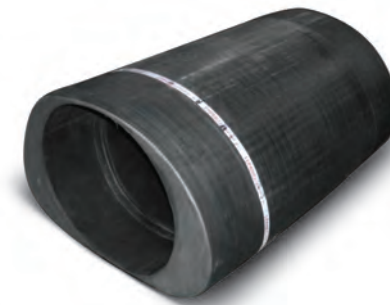


CheckMate® Valves are easily installed regardless of difficult pipe end geometry or pipes in poor end condition. There is no need to rebuild headwalls.

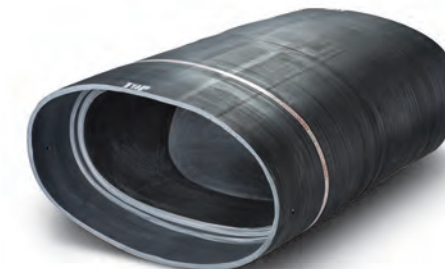
A Wide Range of Shapes and Sizes

Elliptical, Arch and Rectangular Pipes

Elliptical, Arch and Rectangular Pipes for drainage and flood prevention projects have become popular, particularly in high water table areas with shallow surface gradients. CheckMate® Inline Check Valves are the perfect solution as they can be customized to meet your specifications.



Elliptical Pipe CheckMate®



Arch Pipe CheckMate®



Rectangular Pipe CheckMate®

Rubber Flanged

Rubber Flanged CheckMate® Valves can be manufactured with an integral rubber upstream or downstream flange. The flanged CheckMate® gets inserted into the host pipe, then can be bolted to a mating flange or anchored to a concrete headwall. The flange can be circular with standard drilling, or circular, square or rectangular with custom flange drilling. The valve is supplied with retaining rings for mounting.

Thimble Inserts

A CheckMate® Thimble Insert is simply a CheckMate® Valve that is factory installed, clamped and pinned into flanged or plain-end pipe. The thimble insert assembly can either be inserted into the I.D. of the host pipe, or can be mounted to a mating flange or concrete headwall and extend beyond the pipe. Plain end thimble inserts are inserted into the host pipe and non-shrink grout is placed between the thimble insert O.D. and host pipe I.D. to form the seal.



There is no need to rebuild headwalls, as is required with less advanced inline check valves (above)



Upstream Flanged CheckMate®



CheckMate® Thimble Insert



Red Valve Company, Inc.

Tideflex®
Technologies

600 N. Bell Ave.
Carnegie, PA 15106

PHONE:
412/279-0044

FAX:
412/279-7878

www.redvalve.com

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Red Valve®

Valve Selection Guide for Wastewater Treatment

Red Valve®

MUNICIPAL COLLECTION AND DISTRIBUTION
Total System Solutions



“Rely on Red” for a Total System Solution to Your Water and Wastewater Treatment Challenges

No other company can match Red Valve's “Total System Solution” for water and wastewater treatment plants and municipal collection and distribution systems.

Since 1953, Red Valve has provided products for each phase of collection, distribution, separation, aeration, treatment and final discharge. Our complete product line provides customers with one source for on/off and control valves, check valves, pressure measurement, expansion compensation, air diffusers and effluent diffusers. All Red Valve products are designed to handle the rigors of handling raw sewage, sludge, scum and grit with abrasion-resistant, non-clogging designs.

Contact us today for a free copy of our new “Total System Solution” brochure for Municipal Collection and Distribution, or our comprehensive Valve Selection Guide for Wastewater Treatment.

CHECKMATE ULTRAFLEX SLIP-IN INLINE CHECK VALVES

Specification TT-CMUF-SL

PART 1: GENERAL

1.01 SUBMITTALS

A. Submit product literature that includes information on the performance and operation of the valve, materials of construction, dimensions and weights, elastomer characteristics, headloss, flow data and pressure ratings.

B. Upon request, provide shop drawings that clearly identify the valve materials of construction and dimensions.

1.02 QUALITY ASSURANCE

A. Supplier shall have at least twelve (12) years experience in the design and manufacture of "CheckMate™" style elastomeric check valves.

B. Manufacturer shall have designed, fabricated and have at least five (5) current installation of a "CheckMate" style elastomeric check valves in the 72" (1800mm) size. Manufacturer must provide documentation, including project name, location, and references.

C. Manufacturer shall have conducted independent hydraulic testing to determine headloss, jet velocity and vertical opening height characteristics on a minimum of three (3) sizes of CheckMate Valves ranging from 6" (150mm) through 24" (600mm). The testing must have been conducted for free discharge (pressurized and open channel flow discharging to atmosphere) and submerged conditions.

PART 2: PRODUCTS

2.01 CHECKMATE ULTRAFLEX ELASTOMERIC CHECK VALVES

A. Check Valves are to be all rubber and the flow operated check type with slip-in cuff connection. The entire CheckMate Ultraflex Valve shall be ply reinforced throughout the body, saddle and bill, which is cured and vulcanized into a one-piece unibody construction. A separate valve body or pipe used as the housing is not acceptable. The valve shall be manufactured with no metal, mechanical hinges or fasteners, which would be used to secure any component of the valve to a valve housing. The port area of the saddle shall contour into a circumferential sealing area (the "bill") that is concentric with the pipe which shall allow passage of flow in one direction while preventing reverse flow. The entire valve shall fit within the pipe inside diameter. The saddle area of the valve must be flat, not conical, and integral with the rubber body above centerline in order to not produce any areas or voids that can collect or trap debris. The valve must be easily installed in pipes with poor end condition without the need to modify or utilize the headwall or structure to seal and anchor the valve. Once installed, the CheckMate Ultraflex Valve shall not protrude beyond the face of the structure or end of the pipe.

B. The CheckMate Ultraflex Valve shall incorporate multiple concave grooves molded integrally into the flat saddle wall thickness extending longitudinally a minimum of 80% of the length of the saddle to reduce opening resistance and reduce headloss.

C. The CheckMate Ultraflex Valve shall incorporate a custom shaped notch in the end of the bill to reduce cracking pressure. The notch shall be at the invert/bottom of the bill and symmetrical about the valve centerline. The longitudinal length of the notch shall be no greater than half the length of the bill.

D. The outside diameter of the upstream and downstream sections of the valve must be circumferentially in contact with the inside diameter of the pipe.

E. Slip-in style CheckMate Ultraflex Valves will be furnished with a set of stainless steel expansion clamps. The clamps, which will secure the valve in place, shall be installed in the upstream or downstream cuff of the valve, depending on installation orientation, and shall expand outwards by means of a turnbuckle. Each band shall be pre-drilled allowing for the valve to be pinned and secured into position in accordance with the manufacturer's installation instructions.

F. Manufacturer must have flow test data from an accredited hydraulics laboratory to confirm pressure drop and hydraulic data.

E. Company name, plant location, valve size patent number, and serial number shall be bonded to the check valve.

2.02 FUNCTION

A. When line pressure exceeds the backpressure, the line pressure forces the bill and saddle of the valve open, allowing flow to pass. When the backpressure exceeds the line pressure, or in the absence of any upstream or downstream pressure, the bill and saddle of the valve is forced closed, preventing backflow.

2.03 MANUFACTURER

A. All valves shall be Series CMUF-SL slip-in CheckMate Ultraflex Valves as manufactured by Tideflex Technologies®, A Division of Red Valve Company, Carnegie, PA 15106. All valves shall be manufactured in the U.S.A.

PART 3: EXECUTION

3.01 INSTALLATION

A. Valve shall be installed in accordance with manufacturer's written Installation and Operation Manual and approved submittals.

3.02 MANUFACTURER'S CUSTOMER SERVICE

A. Manufacturer's authorized representative shall be available for customer service during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

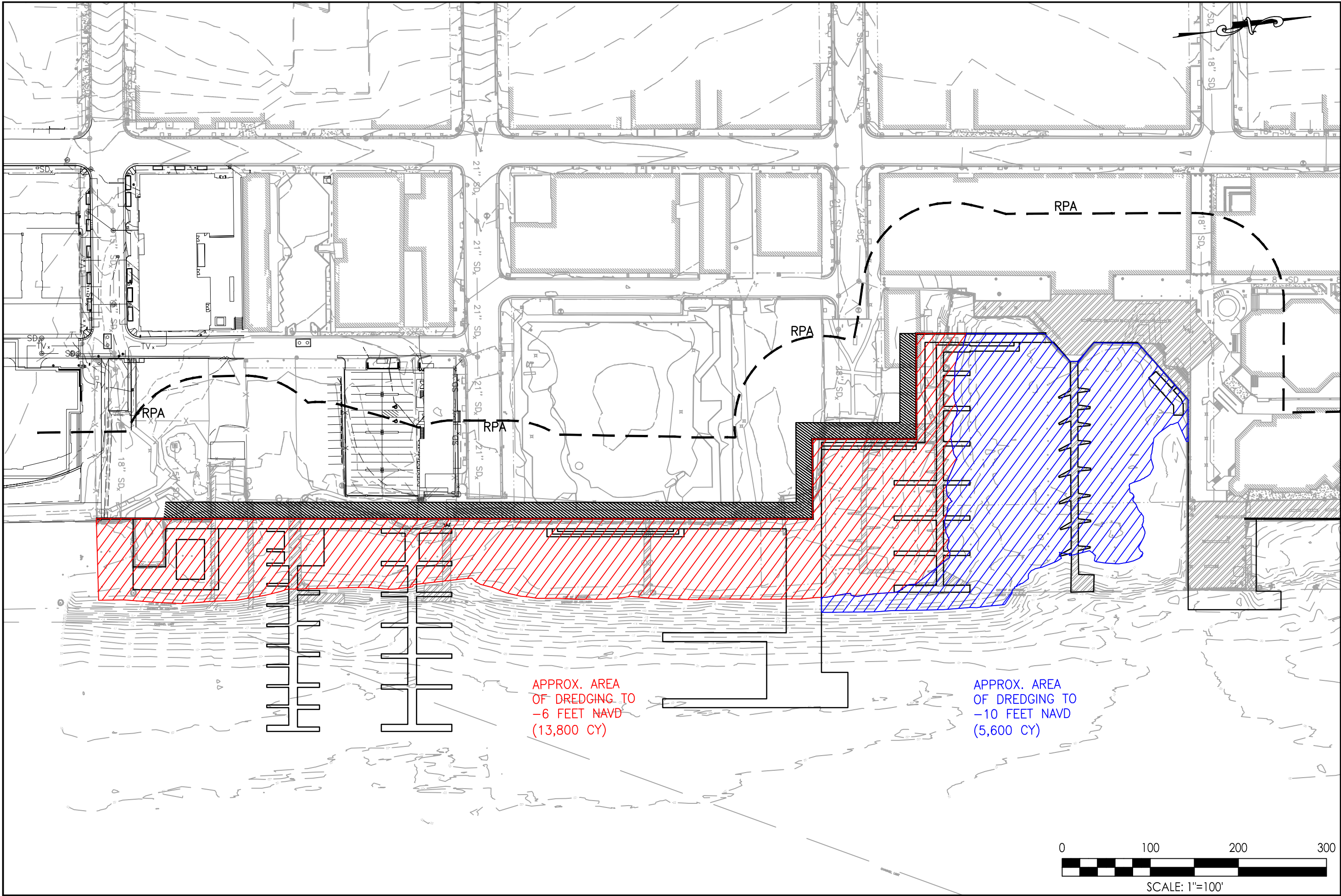
B. If specified, the manufacturer shall also make customer service available directly from the factory in addition to authorized representatives for assistance during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

OR APPROVED EQUIVALENT

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix J SOUTH BULKHEAD DREDGING EXHIBIT

Appendix J SOUTH BULKHEAD DREDGING EXHIBIT



Tel. 703.263.1220
Fax. 703.263.1221
www.stantec.com

STANTEC
4500 DALY DRIVE, SUITE 100
CHANTILLY, VA 20151

SOUTH BULKHEAD
DREDGING
WATERFRONT
FLOOD MITIGATION
IMPLEMENTATION

CITY OF ALEXANDRIA, VIRGINIA
Department of Project Implementation
P. O. Box 178
Alexandria, Virginia 22313



Date: AUGUST 2017

Scale: 1" = 100'

Project No.: 2029041842

Sheet No.

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix K PUMP STATION ALTERNATIVES COMPARISON

Appendix K PUMP STATION ALTERNATIVES COMPARISON

ALTERNATIVE 1				
PUMP STATION 1				
Drainage Area	8.55	Ac		
10-year Storm (design)	62	cfs		
	28,000	gpm		
Forcemain	36	inch		
Exit Velocity (design)	8.8	ft/sec		
Exit Velocity (ultimate)	13.2	ft/sec		
Building Size	28' x 28'			
Wet Well	28' x 28'			
Wet Well Elevation	-12.58			
Axial/High Flow Pumps	3	each	\$	180,000.00
	16,000	gpm		
	110	HP		
Sump/Low Flow Pumps	2	each	\$	50,000.00
	5,000	gpm		
	60	HP		
Ultimate Capacity	93	cfs		
	42,000	gpm		
Diesel Generator	600	kW	\$	150,000.00
Screening Equipment			\$	200,000.00
Valves/Misc.			\$	200,000.00
			TOTAL	\$ 780,000.00
PUMP STATION 2				
Drainage Area	2.4	Ac		
10-year Storm (design)	17	cfs		
	7,600	gpm		
Forcemain	36	inch		
Exit Velocity (design)	2.39	ft/sec		
Exit Velocity (ultimate)	4.5	ft/sec		
Building Size	28' x 28'			
Wet Well	33' x 18'			
Wet Well Elevation	-13.58			
Axial/High Flow Pumps	2	each	\$	200,000.00
	6,000	gpm		
	45	HP		
Sump/Low Flow Pumps	2	each	\$	30,000.00
	1,000	gpm		
	12	HP		
Ultimate Capacity	32	cfs		
	14,500	gpm		
Diesel Generator	400	kW	\$	100,000.00
Screening Equipment			\$	100,000.00
Valves/Misc.			\$	150,000.00
			TOTAL	\$ 580,000.00
STORM SEWER SYSTEM				
			TOTAL	\$ 1,000,500.00
			SYSTEM TOTAL	\$ 2,360,500.00

ALTERNATIVE 2				
PUMP STATION 1				
Drainage Area	21.1	Ac		
10-year Storm (design)	152	cfs		
	68,000	gpm		
Forcemain	60	inch		
Exit Velocity (design)	7.77	ft/sec		
Exit Velocity (ultimate)	14.41	ft/sec		
Building Size	30' x 30'			
Wet Well	28' x 37'			
Wet Well Elevation	-17.00			
Axial/High Flow Pumps	3	each	\$	700,000.00
	26,000	gpm		
	240	HP		
Sump/Low Flow Pumps	2	each	\$	50,000.00
	5,000	gpm		
	60	HP		
Ultimate Capacity	283	cfs		
	127,000	gpm		
Diesel Generator	2,000	kW	\$	350,000.00
Screening Equipment			\$	300,000.00
Valves/Misc.			\$	400,000.00
			TOTAL	\$ 1,800,000.00
PUMP STATION 2				
Drainage Area	2.4	Ac		
10-year Storm (design)	17	cfs		
	7,600	gpm		
Forcemain	36	inch		
Exit Velocity (design)	2.39	ft/sec		
Exit Velocity (ultimate)	4.5	ft/sec		
Building Size	28' x 28'			
Wet Well	33' x 18'			
Wet Well Elevation	-13.58			
Axial/High Flow Pumps	2	each	\$	200,000.00
	6,000	gpm		
	45	HP		
Sump/Low Flow Pumps	2	each	\$	30,000.00
	1,000	gpm		
	12	HP		
Ultimate Capacity	32	cfs		
	14,500	gpm		
Diesel Generator	400	kW	\$	100,000.00
Screening Equipment			\$	100,000.00
Valves/Misc.			\$	150,000.00
			TOTAL	\$ 580,000.00
STORM SEWER SYSTEM				
			TOTAL	\$ 976,500.00
			SYSTEM TOTAL	\$ 3,356,500.00

ALTERNATIVE 3				
PUMP STATION 1				
Drainage Area	27.5	Ac		
10-year Storm (design)	198	cfs		
	89,000	gpm		
Forcemain	60	inch		
Exit Velocity (design)	10.1	ft/sec		
Exit Velocity (ultimate)	14.98	ft/sec		
Building Size	30' x 30'			
Wet Well	37' x 34'			
Wet Well Elevation	-17.00			
Axial/High Flow Pumps	3	each	\$	700,000.00
	47,000	gpm		
	270	HP		
Sump/Low Flow Pumps	2	each	\$	50,000.00
	5,000	gpm		
	60	HP		
Ultimate Capacity	294	cfs		
	132,000	gpm		
Diesel Generator	1,200	kW	\$	350,000.00
Screening Equipment			\$	300,000.00
Valves/Misc.			\$	400,000.00
			TOTAL	\$ 1,800,000.00
PUMP STATION 2				
Drainage Area	18.4	Ac		
10-year Storm (design)	132.5	cfs		
	60,000	gpm		
Forcemain	60	inch		
Exit Velocity (design)	6.81	ft/sec		
Exit Velocity (ultimate)	11.92	ft/sec		
Building Size	30' x 30'			
Wet Well	37.5' x 55'			
Wet Well Elevation	-19.00			
Axial/High Flow Pumps	3	each	\$	700,000.00
	34,000	gpm		
	200	HP		
Sump/Low Flow Pumps	2	each	\$	50,000.00
	5,000	gpm		
	60	HP		
Ultimate Capacity	234	cfs		
	105,000	gpm		
Diesel Generator	1,200	kW	\$	350,000.00
Screening Equipment			\$	300,000.00
Valves/Misc.			\$	400,000.00
			TOTAL	\$ 1,800,000.00
STORM SEWER SYSTEM				
			TOTAL	\$ 1,242,000.00
			SYSTEM TOTAL	\$ 4,842,000.00

Note:
All costs are provided for preliminary engineering pupposes only to determine the magnitude of difference between each of the 3 Alternatives. Actual cost estimates to be provided with final design.

ALTERNATIVE 1				
PUMP STATION 1				
Building Size	28' x 28'	\$	392,000.00	
Wet Well	28' x 28'	\$	235,200.00	
Pumps & Equip.		\$	780,000.00	
		TOTAL	\$	1,407,200.00
PUMP STATION 2				
Building Size	28' x 28'	\$	392,000.00	
Wet Well	33' x 18'	\$	178,200.00	
Pumps & Equip.		\$	580,000.00	
		TOTAL	\$	1,150,200.00
STORM SEWER SYSTEM				
		TOTAL	\$	1,000,500.00
DREDGING \$100/CY				
-6' along South Bulkhead	13,800 CY	\$	1,380,000.00	
-10' in Marina	5,600 CY	\$	560,000.00	
		TOTAL	\$	1,940,000.00
SYSTEM TOTAL				
		\$	5,497,900.00	

ALTERNATIVE 2				
PUMP STATION 1				
Building Size	30' x 30'	\$	450,000.00	
Wet Well	28' x 37'	\$	310,800.00	
Pumps & Equip.		\$	1,800,000.00	
		TOTAL	\$	2,560,800.00
PUMP STATION 2				
Building Size	28' x 28'	\$	392,000.00	
Wet Well	33' x 18'	\$	178,200.00	
Pumps & Equip.		\$	580,000.00	
		TOTAL	\$	1,150,200.00
STORM SEWER SYSTEM				
		TOTAL	\$	976,500.00
DREDGING \$100/CY				
-6' along South Bulkhead	13,800 CY	\$	1,380,000.00	
-10' in Marina	5,600 CY	\$	560,000.00	
		TOTAL	\$	1,940,000.00
SYSTEM TOTAL				
		\$	6,627,500.00	

ALTERNATIVE 3				
PUMP STATION 1				
Building Size	30' x 30'	\$	450,000.00	
Wet Well	33' x 28'	\$	277,200.00	
Pumps & Equip.		\$	1,800,000.00	
		TOTAL	\$	2,527,200.00
PUMP STATION 2				
Building Size	30' x 30'	\$	450,000.00	
Wet Well	33' x 28'	\$	178,200.00	
Pumps & Equip.		\$	1,800,000.00	
		TOTAL	\$	2,428,200.00
STORM SEWER SYSTEM				
		TOTAL	\$	1,242,000.00
DREDGING \$100/CY				
-6' along South Bulkhead	13,800 CY	\$	1,380,000.00	
-10' in Marina	5,600 CY	\$	560,000.00	
		TOTAL	\$	1,940,000.00
SYSTEM TOTAL				
		\$	8,137,400.00	

Notes:

All costs are provided for preliminary engineering to determine the magnitude of difference between each of the 3 Alternatives. Actual cost estimates to be provided with final design.

Building and wet well costs assumed at \$500/SF for above-grade construction and \$300/SF for below-grade construction.

Dredging costs based on historical dredging costs from 2014 maintenance dredging of \$2.4M for 24,400 CY with truck haul to disposal site in Richmond, VA. Final dredging costs to be determined in final design and dependent on disposal site.

**ALEXANDRIA WATERFRONT: FLOOD MITIGATION IMPLEMENTATION
MASTER STORM WATER MANAGEMENT PLAN**

Appendix L SWM COMPLIANCE MATRIX

Appendix L SWM COMPLIANCE MATRIX

Alexandria Waterfront: Flood Mitigation Implementation SWM Compliance Feasibility Matrix	
Requirement	Mitigation
Water Quality Compliance (DEQ)	1.) Design (future phases) of SWM facilities to provide on-site treatment to the Maximum Extent Practicable (MEP). Facilities will be conducive to use in the Coastal Plain to account for shallow water tables (i.e. wetlands, wet swales, modified bioretention, grassed swales, sheetflow to conserved open space, etc.). Preliminary engineering by Olin showed early plans for SWM, but this needs more detailed review and design effort.
	2.) Typical costs (based on Fairfax County unit prices) are as follows: Bioretention - \$99.00/CY, Constructed Wetlands - \$28.66/SY, Tree box - \$4,233.71/EA, Wet Swales - \$99.00/CY, and Grassed Swales - \$11.73/SY.
	3.) Previous preliminary estimates for stormwater management BMPs were provided as approximately \$3.4M total (circa 2014), based on the initial SWM Concept plans. When factoring inflation in to update to 2017 values, the approximate cost is \$3.5M. (3.4% inflation). Note that this will vary depending upon final facility types and locations selected.
	4.) If on-site treatment design is refined, and a reduction need still exists, then off-site compliance options, including the potential for nutrient credit purchase, may need to be considered. The project appears to be located within HUC code 02070010, which contains two banks with available credits: P6 (Midland) and P11 (Owl Run). Within the Potomac watershed, nutrient credit purchase typically ranges between \$20,000 and \$40,000 per lb TP. Note that specific costs will need to be obtained from the bank once it is determined credit purchase is necessary, and tracked to ensure correct pricing is utilized.
	5.) The preliminary range of elevations associated with the improvements is between 1 ft and 18 ft (in select locations). Based on the current review, the Mean Higher High Water (MHHW) elevation is estimated as 1.65 ft. Specific facility elevation restrictions are discussed below, on a preliminary basis.
	5a.) Constructed wetlands: These facilities may intersect the groundwater table, with excavation up to 6 in below the table throughout most of the facility, and up to 3 ft below in the deep pool areas. Given this, these are a feasible BMP option, but some reduction in efficacy may be applicable due to the presence of groundwater. Maximum depth for the constructed wetlands is envisioned to be 4 ft in deep pool/forebay areas, and as such the minimum bottom elevation of these is estimated as -1.35 ft. These appear to be a feasible option.
	5b.) Wet Swale: These facilities may intersect the groundwater table, but should be constructed such that the subgrade is saturated and standing water is not a concern. Given this, it is assumed these facilities should be built at least 6 inches above MHHW, or with a minimum bottom grade of 2.15 ft. Assuming a total depth maximum of 24 inches, these could have top elevations of 4.15 ft, but is variable depending on side slopes and specific locations. These appear to be a feasible option.
	5c.) Modified Bioretention: These facilities must have a minimum of 1.0 ft between the bottom of the facility and the MHHW. As such, the minimum bottom grade can be as low as 2.65 ft. Limiting the filter bed to a depth of 24 in and the ponding depth to 9 in, and assuming 12 in diameter pipe inflows with a cover of 12 in, the depth required for construction of these is estimated at 4.75 ft. The top of the facility would need to be at 7.4 ft, which is within the range of elevations on-site, but these may not be feasible within the optimum locations for SWM facilities (i.e. receive sufficient drainage and provide enough treatment). Related to these, however, tree boxes may remain a feasible option to treat limited impervious areas in the upland portions of the overall project.
	5d.) Grassed Swale: These facilities must have a minimum of 1.0 ft between the bottom of the facility and the MHHW. As such, the minimum bottom grade can be as low as 2.65 ft. Limiting the ponding depth to 18 in, and assuming a 24 in maximum swale depth, the top of the facility would be at 4.65 ft, which is within the range of elevations on-site. These may provide good options for pre-treatment facilities and/or conveyance, but will not provide as much pollutant reductions as
	5e.) Sheetflow to Conserved Open Space or Filter Strip: These facilities do not have a minimum restriction designated between the bottom of the facility and the MHHW, but if a filter strip is used, then the incorporation depth for the soil compost amendments may be limited and efficacy affected based on the MHHW. Typical incorporation depths range between 6 and 24 inches, depending on the impervious cover/surface area of incorporation ratio. As such, the minimum bottom grade will vary, but should be no lower than 2.15 ft. These may provide good options for treatment, but may be limited in terms of depth overall.
City of Alexandria Resource Protection Area (RPA) Encroachment	1.) Completion of Buffer Equivalency Calculations using CBLAD guidance to estimate initial efficacy of buffer and possible efficacy reduction due to proposed improvements.
	2.) If a reduction in efficacy is confirmed, then use of surplus on-site stormwater treatment credit (if available) may be applied to mitigate for the reduction. No additional cost.
	3.) If no on-site excess, then additional on-site plantings of native species where possible to increase buffer efficacy or possible purchase of off-site nutrient credits. Per Fairfax County Unit Price for Reforestation (\$58,620.75/AC) and assuming 3.00 AC of Buffer Disturbance based on the draft WQIA, the cost for replanting would be approximately \$175,862.25. Within the Potomac watershed, nutrient credit purchase typically ranges between \$20,000 and \$40,000 per lb TP. Note that specific costs will need to be obtained from the bank once it is determined credit purchase is necessary, and tracked to ensure correct pricing is utilized.

City of Alexandria Chesapeake Bay Tree Removal	1.) Detailed review of trees proposed for removal as a result of the proposed improvements with City of Alexandria Urban Foresters.
	2.) Development of landscape plans for the SWM facilities and overall project to enhance canopy cover and promote growth of native species within the RPA. This design would be embedded into the overall project design cost, and reforestation cost would be approximately \$58,620.75/AC based on Fairfax County Unit prices. Individual plantings would range between \$49.50/EA and \$1,172.41/EA, depending upon the species of tree. Total costs would depend upon field evaluation and final number of trees that would need to be removed that fall under this category.
Dredging/USACE Impacts	1.) Draft graphic provided to illustrate the impact shape of dredging to "-10" as opposed to "-6" per City requests. Mitigation (if required) will require approval by the National Park Service (NPS). Associated costs will be determined at a later date once more detailed information is available.
	2.) Dredge locations to be identified (if applicable and once known) once the USACE permit is submitted.
Erosion and Sediment Control	3.) Source location and description of any fill material (if applicable and once known) to be provided once the USACE permit is submitted.
	4.) Location of and impacts to any adjacent shellfish beds, submerged aquatic vegetation, and fish spawning areas (if applicable) to be provided once the USACE permit is submitted.
	1.) Controls for detailed plans to be designed in accordance with Virginia Erosion and Sediment Control Law. Special care to be taken given shoreline proximity.
	2.) Trench runs for storm and utilities will be handed through the practice of setting spoils on the upstream side of the trenches.
	3.) Sediment traps may be feasible if built at/above existing grade, but sediment basins will be a challenge due to shallow groundwater.
Hydrologic Conditions	4.) Installation of BMPs, especially any bioretention or facilities with subsurface filter capabilities (i.e. wet swales), will require additional measures such as use of filter fabric, plastic tarps, and/or supplemental silt fence to provide additional protection while the facility vegetation is establishing. These additional measures are not anticipated to substantially increase the overall cost.
	5.) BMPs will not be installed to their final configuration until upstream contributing drainage areas are stabilized. Any sediments deposited within BMP footprint areas will be removed prior to finalization of facilities.
Hydrologic Conditions	1.) SWM to be designed in such a manner as to prevent adverse impacts to site hydrology. Attenuation, floodplain, and energy-balance all to be reviewed as part of advanced SWM design. No additional cost required in this regard.

Nonpoint Source Nutrient Trading

December 6, 2016



Chesapeake Bay Watersheds

- Chesapeake Bay
- Locality
- HUC-8
- Potomac
- Rappahannock
- York
- James
- Eastern Shore/Chesapeake Bay

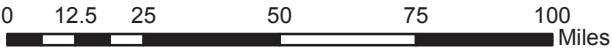
Southern Rivers Watersheds

- Atlantic Ocean
- Albemarle
- Chowan
- Roanoke
- Yadkin
- New
- Holston
- Clinch/Powell
- Big Sandy



Nutrient Banks by Watershed

POTOMAC:				
P1 - Buena Vista	P13 - Red Hill Farms	JAMES:	J13 - Greyfields	ROANOKE:
P2 - Swinging Bridge	P14 - Kinsale	J1 - Wildwood Farm	J14 - Gold Hill	Rn1 - Hawkins Forest
P3 - Elk Run	P15 - Edgecliff	J2 - Malvern	J15 - Farmville	Rn2 - Glade Hill
P4 - Wampler Road	P16 - Montross	J3 - Cranston Millpond	J16 - Namozine	NEW:
P5 - Holy Cross Abbey	RAPPAHANNOCK:	J4 - Swiss Dixie	J17 - Millboro	N1 - Stallone Farms
P6 - Midland	Rp1 - Rappahannock	J5 - Eastern Henrico	J18 - Willis River	N2 - Hiwassee
P7 - South River	Rp2 - Culpeper	J6 - Layne	ALBEMARLE:	
P8 - Autumn Lane	Rp4 - Pristine Waters	J7 - Leinster	A1 - Pigeon Hill	
P9 - Wentworth Road	YORK:	J8 - Stone Tavern	CHOWAN:	
P10 - Bowen	Y1 - Pamunkey Farms	J9 - Dungeness	C1 - Dillon Grove	
P11 - Owl Run	Y2 - Healy's Pond	J10 - Shaefer		
P12 - Cross Junction	Y3 - York	J11 - Buckingham		
	Y4 - Clover Creek	J12 - Prince Edward		



Virginia Nonpoint Source Nutrient Credit Registry

Nutrient Bank	Urban/ Ag BMPs	Bank Sponsor	Broker	Broker Contact	Phone No.		County	HUC Code	Certification No.	Credits Released		Credits Used/Retired		Credits Available	
						Email				Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen
Buena Vista	Ag land conversion	Falling Springs, LLC	Falling Springs, LLC	James Parker	(804) 330-8092	jparker@fallingspringsllc.com	King George	02070011	Potomac-001	67.55	1057.14	51.60	808.79	15.95	248.35
Swinging Bridge	Ag land conversion	Paul J. Wright	P. J. Wright	P. J. Wright	Credits not for sale	0	Augusta	02070005	Potomac-002	8.61	54.25	01	0	0	0
Elk Run	Ag land conversion	CBAY-VA LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Fauquier	02070010	Potomac-003	115.15	1550.97	115.15	1550.97	0.00	0.00
Wampler Road	Ag land conversion	NERD Farms, LLC	Virginia Nutrient Bank, LLC	Nathan Blackwell	(540) 908-1679	nathan@virginianutrientbank.com	Rockingham	02070006	Potomac-004	33.51	341.83	33.40	340.71	0.11	1.12
Holy Cross Abbey	Ag land conversion	CBAY-VA LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Clarke	02070007	Potomac-005	87.56	558.65	81.23	512.56	6.33	46.09
Midland	Ag land conversion	CBAY-VA LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Fauquier	02070010	Potomac-006	167.96	2244.97	167.11	2233.61	0.85	11.36
South River	Ag land conversion	EBCO, LLC	EBCO, LLC	Eddie Burkholder	(540) 490-4001	draftelect@comcast.net	Augusta	02070005	Potomac-007	17.37	148.10	9.55	81.43	7.82	66.67
Autumn Lane	Ag land conversion	TROBUDD, Inc.	Virginia Nutrient Bank, LLC	Nathan Blackwell	(540) 908-1679	nathan@virginianutrientbank.com	Rockingham	02070005	Potomac-008	27.69	356.63	26.77	344.78	0.92	11.85
Wentworth Road	Ag land conversion	Randy Cosner	Virginia Nutrient Bank, LLC	Nathan Blackwell	(540) 908-1679	nathan@virginianutrientbank.com	Rockingham	02070006	Potomac-009	33.61	249.56	20.13	149.47	13.48	100.09
Bowen	Ag land conversion	Wilton Acquisitions, LLC	Wilton Family Investment Trust	Henry Wilton	(804) 285-2191	hwilton@wiltondevcorp.com	Westmoreland	02070011	Potomac-010	21.26	337.05	0.11	1.70	21.15	335.35
Owl Run	Ag land conversion	CBAY-VA LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Fauquier	02070010	Potomac-011	50.99	556.99	38.27	417.91	12.72	139.08
Cross Junction	Ag land conversion	Winchester Management, LLC	Winchester Management, LLC	Cassy Sargent	(540) 662-4185	jtweedie@greenwayeng.com	Frederick	02070004	Potomac-012	72.20	536.18	26.78	209.94	45.42	326.24
Redhill Farm	Ag land conversion	Gary M. & Debra H. Callen	Gary M. & Debra H. Callen	Gary Callen	(703) 346-8206	gary.callen@daston.com	Loudoun	02070008	Potomac-013	58.83	585.25	44.38	443.53	14.45	141.72
Kinsale	Ag land conversion	RLP Investments, LC	RLP Investments, LC	Ron Green	(804) 908-4171	rongreen116@gmail.com	Westmoreland	02070011	Potomac-014	56.35	881.82	0.15	2.35	56.20	879.47
Edgecliff	Ag land conversion	CBAY-VA LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Fauquier	02070008	Potomac-015	323.98	2405.96	242.13	1799.07	81.85	606.89
Montross	Ag land conversion	Montross Properties, LLC	Old Dominion Nutural Resources, LLC	Jeremy Tweedie	(540) 974-0343	jtweedie@greenwayeng.com	Westmoreland	02070010	Potomac-016	21.85	351.36	0.00	0.00	21.85	351.36
Sandy	AG Landuse Conversion	Riverbanks VA, LLC	Riverbanks VA, LLC Ecocap, LLC	Jackie Morris	(804) 445-5337	jh-morris@verizon.net	Westmoreland	02070011	Potomac-017	33.45	523.42	0.19	2.97	33.26	520.45
Antonio	AG Landuse Conversion	Wilton Acquisitions, LLC	Wilton Family Investment Trust	Henry Wilton	(804) 285-2191	hwilton@wiltondevcorp.com	Northumberland	02070010	Potomac-018	0.00	0.00	0.00	0.00	0.00	0.00
Windright Run	AG Landuse Conversion	Old Dominion Natural Resources Partners, LLC	Old Dominion Natural Resources, LLC	Jeremy Tweedie	(540) 662-4185	jtweedie@greenwayeng.com	Fauquier	02070010	Potomac-019	81.71	1100.60	0.04	0.53	81.67	1100.07
Stone Bridge	AG Landuse Conversion	CBAY-VA, LLC	Resource Environmental Solutions, LLC	Claire Wolanski	(804) 591-4060	cwolanski@res.us	Clarke / Warren	02070007	Potomac-020	244.44	1815.26	7.79	57.87	236.65	1757.39
Boones Run Farm	Ag land conversion	Boones Run Farm, LLC	Environmental Services, LLC	Jon Roller	(540) 578-4298	jon@ecosystems-services.us	Rockingham	02070005	Potomac-022	65.65	487.52	0.00	0.00	65.65	487.52

Totals	1589.72	16143.51	864.78	8958.19	716.33	7131.07
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Red Cells Indicate Zero Available Credits at This time

Yellow Cells Indicate Less Than One Pound of Phosphorus Credit Remains Available for Sale at This Time

Notes: ¹ Credits have not been transferred but are reserved per 9/20/13 letter from bank sponsor