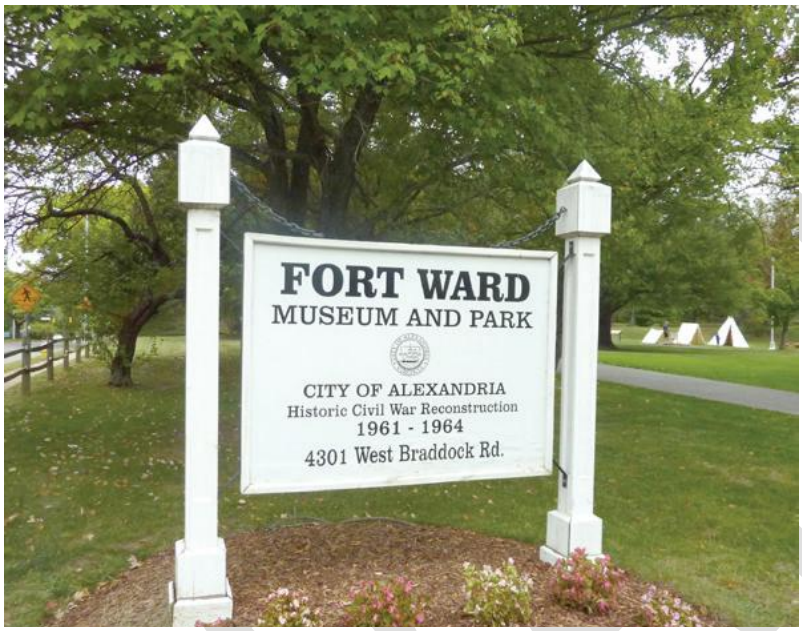
FORT WARD PARK DRAINAGE MASTER PLAN



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ACRONYMS AND ABBREVIATIONS v

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ADA	Americans with Disabilities Act
BMP	Best Management Practice
C	Rational Method Runoff Coefficient
cfs	cubic feet per second
City	City of Alexandria
CWA	Clean Water Act
DEQ	Virginia Department of Environmental Quality
EMO	Environmental Management Ordinance
ESC	Erosion and Sediment Control
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
IDF	Intensity-Duration-Frequency
in	inch
min	minute
MOT	Maintenance of Traffic
MS4	Small Municipal Separate Storm Sewer System
N/A	Not Applicable
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWP	Nationwide Permit
Park	Fort Ward Park
PVC	polyvinyl chloride
SSA	Storm and Sanitary Analysis
SWM	Stormwater Management
SWPPP	Stormwater Pollution Prevention Plan
T_c	time of concentration
T_t	calculated travel time
TMDL	Total Maximum Daily Load
URS	URS Corporation

USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VDHR	Virginia Department of Historic Resources
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
WQS	Water Quality Standards

EXECUTIVE SUMMARY

This report summarizes URS Corporation's (URS') analyses of the potential opportunities to address the drainage and erosion issues in Fort Ward Park (Park) in the City of Alexandria (City), Virginia.

Fort Ward Park covers 43.46 acres of land on the west end of Old Town Alexandria, large areas of which is forested or grassy and has limited constructed stormwater systems and few existing stormwater controls. The Park is susceptible to nuisance flooding and erosion due to overland flow concentration and flooding on properties near the southeastern boundary of the Park.

URS conducted a field reconnaissance and examined 16 sites at the Park to evaluate the existing conditions and to identify potential measures to improve the drainage and sedimentation. In addition, URS performed hydrologic and hydraulic analyses to verify the capacity of the existing stormwater system (Sections Three and Four).

URS attended two public meetings held by the Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group. During the meetings, URS presented the engineering findings of this study and addressed stakeholders' comments.

Section Five of the report summarizes the drainage improvement recommendations based on the field observations, engineering calculations, and community input. The recommendations include both structural and nonstructural measures. Further analyses are performed and described in Section Six for three recommended storm drainage system improvements to address drainage issues on targeted sites. The recommendations include retrofitting the existing stormwater system to reduce sedimentation and to improve the water quality of runoff; constructing two diversion berms and an underground drainage pipe to improve the nuisance flooding and erosion at the Oakland Baptist Cemetery; and stream stabilization to reduce erosion and improve the overall health of the stream. Section Six includes preliminary description of the recommended improvements, design consideration, feasibility, and cost estimates on planning level.

Section Seven summarizes the regulatory and permitting considerations applicable to the recommended drainage improvements.

This report compliments the Fort Ward Park and Museum Area Management Plan and can be used as supporting documentation for future drainage improvements. The recommendations in the report are consistent with the recommended best practices in the Fort Ward Park and Museum Area Management Plan.

SECTION ONE: INTRODUCTION

1.1 AUTHORIZATION

The City of Alexandria (City) signed a contract with URS Corporation (URS) on April 30, 2013 to develop a *Storm Drainage Master Plan* for Fort Ward Park. The project was funded by the City.

1.2 BACKGROUND AND PURPOSE

Fort Ward Park (Park) is a historic park located in the City of Alexandria (City), Virginia. It is regarded as the best preserved fort and battery built to protect Washington, DC during the American Civil War (1861–1865). The Park is the home of the Fort Ward Museum, which features Civil War exhibits, interpretive programs, tours, lectures, and living history activities.

The Park covers 43.46 acres of land on the west end of Old Town Alexandria. Much of the Fort has been preserved or restored. An archaeological investigation conducted in 2011 identified and documented 22 previously unmarked grave sites.

The Park is susceptible to drainage problems including erosion due to overland flow concentration and flooding, especially on properties near the southeastern boundary of the Park. The challenge is to manage the stormwater runoff and to minimize flooding and erosion while preserving the historic and archaeological resources of the Park.

The City's goals are to determine methods to improve the stormwater conveyance and minimize erosion while preserving the recreational, historic, and archaeological functions of the Park. The purpose of this study is to evaluate existing storm drainage problems and provide recommendations to the City for future storm drainage improvements in the Park while meeting the goals and expectations of the City.

URS performed the following tasks:

1. Identification of Drainage Problems: This task involves a desktop analysis using GIS, as well as field reconnaissance at the Park.
2. Hydrologic and Hydraulic Analysis: This task involves the hydraulic and hydrologic analyses within the Park drainage area.
3. General Recommendations: This task involves general recommendations for each of the drainage problems at the Park based on field investigation and hydrologic and hydraulic analysis.
4. Project Presentations to Stakeholders and the City: This task includes communicating and coordinating with the City and the stakeholder on project findings and recommendations.
5. Concept Design Plans: This task involves developing schematic concept plans for three recommended improvements.
6. Estimated Cost of Construction: This task involves developing preliminary cost estimates for construction of the recommended capital improvements.

1.3 STAKEHOLDER MEETINGS

URS attended two public meetings with the Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group. The intent of these meetings was to provide the stakeholders with information about the City's goals and the methods used in the course of this study. Stakeholders were also given an opportunity to express their thoughts and comments on existing drainage issues.

A number of public concerns were identified during these meetings, including the restoration effort necessary to correct the drainage and erosion issues in the cemetery and Marlboro Estate neighborhood.

The dates of the stakeholder meetings are presented in Table 1. The presentations for each stakeholder meeting can be found in Appendix A.

Table 1: Stakeholder Meetings

Meeting Date	Location	Attendees
June 12, 2013	Minnie Howard School	Representatives from the Advisory Group, the City, and URS
August 14, 2013	Minnie Howard School	Representatives from the Advisory Group, the City, URS, and Ladner/Klein Landscape Architects, PC

1.4 FORT WARD PARK AND MUSEUM AREA MANAGEMENT PLAN

The City has launched a long-term effort to develop the Fort Ward Park and Museum Area by documenting the historical, cultural, and recreational significance of the Park as well as risks and vulnerabilities. The ongoing effort was initiated in April 2012 by the City's Park and Recreation Commission. The Fort Ward Park and Museum Area Management Plan Management Plan synthesizes these efforts into a cohesive document that offers management recommendations to protect and enhance Park resources and benefit the public.

The Final Draft Fort Ward Park and Museum Area Management Plan (January 2014) outlines potential and anticipated improvements to the Park. These improvements include a series of Best Management Practices for the following topics:

- Park Stewardship
- Physical Changes
- Earthworks
- Land cover Establishment
- Plant Species Control

- Woodland Clearing
- Adapting Historic Road Traces as Trails.

Some of the Best Management Practices include specific recommendations relating to drainage issues on the site with respect to reducing erosion and improving stormwater conveyance such as: aerating soil and reseeding turf; redirecting stormwater away from sensitive areas; and maintaining clogged storm drain systems. The recommendations related to drainage systems contained in the Fort Ward Park and Museum Area Management Plan are consistent with and complement the information presented in this Drainage Master Plan.

SECTION TWO: STUDY AREA CHARACTERISTICS

2.1 STUDY AREA LOCATION

Fort Ward Park is at the west end of Old Town Alexandria and consists of 43.5 acres. The Park is bounded by Braddock Road to the south, Van Dorn Street to the north, and a residential community to the east. Figure 1 shows an aerial view of the Park and the existing condition on the site.

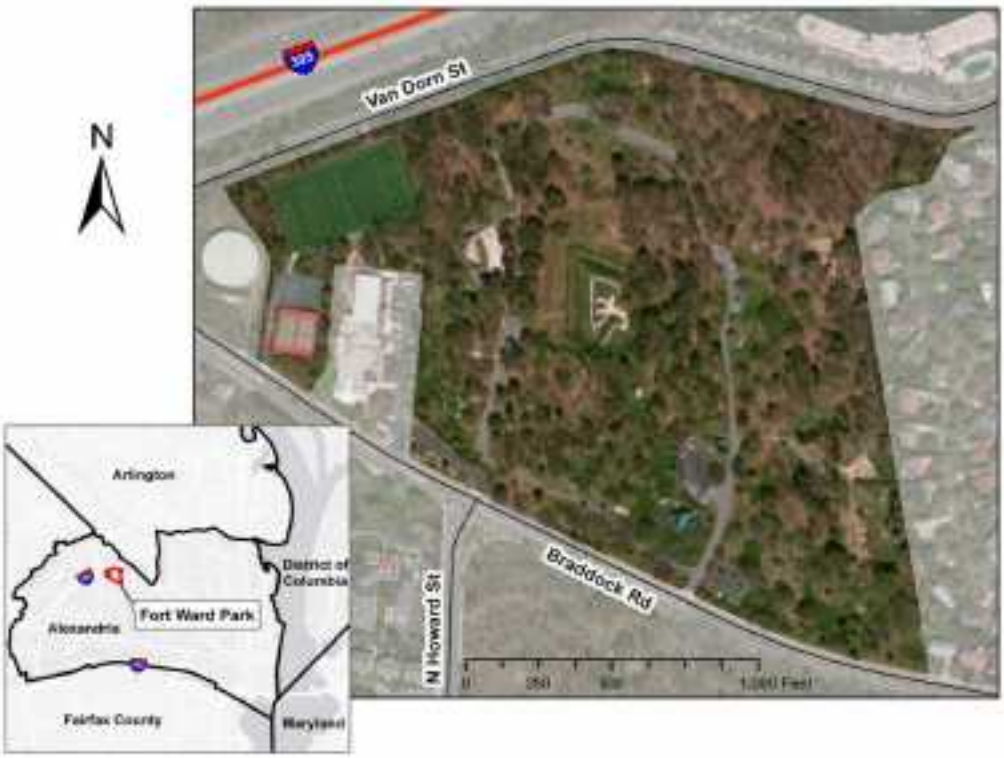

Figure 1: Fort Ward Park Vicinity Map

2.2 LAND USE

The Park land use is primarily public open space incorporating woodlands, meadows, the fort, and the cemetery. Approximately 3.5 acres of the site is developed and paved with impervious surface. The surrounding land use is made up of single-family residential zones, townhouse residential zones, and high-density apartment zones. The City of Alexandria provided 2009 zoning data that showed the current zoning of the Park is “Public Open Space.”

2.3 TOPOGRAPHY

The site has a rolling topography with moderate slopes. Topographic data were provided by the City and the vertical datum for the data is the North American Vertical Datum 1988 (NAVD 88).

The highest point is located near the center of the park and has an elevation of 290 feet. The lowest point is at the northeast corner of the Park with an elevation of 212 feet.

2.4 SOILS

Most of the Park consists of the Kingstowne-Sassafras-Neabsco complex, which has poorly drained soils with low infiltration rates and high clay content. Soils have also been compacted due to recreational use, vehicle traffic, and construction activities, further reducing infiltration capacity. Less than 10 percent of the Park is made up of moderately well drained loamy soils (Sassafras-Neabsco complex) with moderate infiltration capacity. Soil data were obtained from the 2009 Soil Survey Geographic database of the Natural Resources Conservation Service (NRCS).

2.5 CHALLENGES

2.5.1 Environmental Challenges

Drainage problems in the Park include erosion due to overland flow concentration and flooding on the cemetery and properties near the southeastern boundary of the Park.

In 2012, the City implemented interim drainage improvements on the east side of the Park to divert runoff from Oakland Baptist Church Cemetery and neighboring Marlboro Estates subdivision. The measures included installation of small catch basins, drainage pipes, and infiltration trench drains (Figure 2). The improvements provide a temporary solution to prevent runoff from flowing into the cemetery.

A recent report by the Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group (2013) explains that erosion remains the critical threat to the stability and preservation of the Fort and the integrity of the bastions. Erosion is caused by natural effects of weather; poor soil quality; lack of sunlight in some areas, which prevents the growth of healthy ground cover; uprooted trees, which disturb earthen remains; and foot traffic on the wall surfaces.

2.5.2 Archaeological Activities

Contemporary interest in the historical significance of Fort Ward Park as a whole and its African-American history, as well as a desire to preserve its cultural resources, led to an archaeological investigation starting in 2009. The City carried out a ground-penetrating radar survey to identify unmarked graves and then completed fieldwork in January 2011. The survey results confirmed the presence of many burial sites. Additional research and family accounts chronicled how the Fort neighborhood was lost in the process of the City's efforts to purchase the land and create the historical park. The archaeological study documented 22 graves, 19 of which were unmarked, in the Jackson Cemetery on the west side of the Fort, the old graveyard adjoining the Oakland Baptist Cemetery, and in the eastern portion of the Park (Adams' graves). Also discovered were foundations and artifacts associated with one of the earliest households at the Fort and an African-American school. It is believed that the Park harbors many more unmarked burial sites.

The ongoing archaeological investigation expands to suspected burial areas and home sites. A shovel test survey of the entire park will be performed at 30-foot intervals to identify sensitive resource areas. This will result in an updated cultural resource inventory in preparation for planning activities for the Park.

According to a memo by Office of the City Manager (2013), the archaeological investigation has identified 43 gravesites, including 3 burials marked by a gravestone and 40 unmarked burials.

2.5.3 Recreational Significance

The Park serves as a significant recreational resource to residents and visitors. A 2013 survey conducted by the Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group suggested the Park has more than 100 visitors on average per day. Park visitors enjoy outdoor recreational opportunities such as walking, jogging, picnicking, gatherings, and cultural events, and benefit from the playground facilities and dog park.

SECTION THREE: EXISTING STORM DRAINAGE CONDITION

The evaluation of the Fort Ward Park includes an analysis of existing land use, pervious and impervious areas, soils, development, and archaeological and natural resources of the site. Geographic Information System (GIS) data available from the City in 2012 were used to characterize the existing conditions. Field assessments were conducted to evaluate the ground condition, on-site stormwater collection system, and interim drainage solutions.

3.1 DATA REVIEW AND COLLECTION

The City of Alexandria provided URS with GIS data that included:

- 2-foot contours
- Aerial photographs
- City boundary
- City parcels
- Roads
- Zoning
- Building footprints
- Storm drain networks and nodes
- Streams
- 100-year floodplain boundary
- Parks
- Impervious coverage

URS conducted an extensive review of local development plans, archaeological investigations, and Park management plans to better understand the baseline conditions and the future vision for the Park. Additionally, potential restoration opportunities were evaluated based on the benefit they would provide to the City and the Advisory Group. The City provided information to URS as AutoCAD drawings, site plans, and reports. A summary of the data reviewed is provided in Table 2.

Table 2: Data Received from the City of Alexandria

Name	Author	Format
U.S. Geological Survey (USGS) quadrangle map, Alexandria (1945)	USGS	Quadrangle map in JPG format
Marlboro Estates Site Plan (1976)	City of Alexandria	Site Plan in PDF format
Fort Ward Archaeological Investigations (2010–2012)	City of Alexandria	GIS data
Survey files for Fort Ward archaeology investigations (2010–2012)	City of Alexandria	AutoCAD files
Fort Ward Park Interim Drainage Design Solution (2011)	City of Alexandria	PowerPoint Presentation in PDF format
Fort Ward Park Temporary Drainage Improvement (2011)	City of Alexandria	Site Plan in PDF format
Recommendations for the Management of Fort Ward Historical Park (2011)	Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group	Report in PDF format
Fort Ward Park/Bastion Walkway Project (2013)	City of Alexandria	Site Plans in PDF format

Name	Author	Format
City's Responses to Fort Ward Issues (2013)	City of Alexandria	Letter to Oakland Baptist Church and The Fort Ward and Seminary African-American Descendants Society in PDF format, dated May 6, 2013
2012–2013 Advisory Group Draft Recommendations	The Ad Hoc Fort Ward Park and Museum Area Stakeholder Advisory Group	Report in PDF format
Fort Ward Park and Museum Area Management Plan: Existing Conditions (Final Draft) (January 2014)	Fort Ward Advisory Group, City of Alexandria	Final Draft report in PDF format

3.2 FIELD RECONNAISSANCE

URS performed field reconnaissance to review the existing conditions of the Park. The purpose of the field assessment was to obtain information required to conduct hydrologic and hydraulic analyses, to observe the existing ground condition, to assess existing drainage issues, and to assess the possibility of drainage improvements. Factors that affect the potential for drainage improvements include site constraints, access issues, and utility conflicts.

During the field reconnaissance trip, URS staff conducted a detailed on-site investigation, and identified existing drainage problems. Field data collected at each location included:

- Location
- Observed problems at the site
- Sketch of site
- Sketch of identified potential improvement measures

Photographs were taken as part of the field reconnaissance to record the existing condition at each site.

The detailed field reconnaissance report is included in Appendix B.

3.3 EXISTING DRAINAGE PATTERN AND CONVEYANCE SYSTEM OVERVIEW

Figure 2 shows the general drainage patterns in the Park. There are three major outfalls in the Park. Approximately 35 percent of the site drains west to the storm drainage system underneath the football field to Outfall A.

Approximately 50 percent of the Park drains northeast to the Stormwater Management (SWM) Pond before entering the City's storm drainage system at Outfall C. The SWM Pond also captures the off-site runoff from the area west of Braddock Road and the Marlboro Estate subdivision.

The rest of the Park drains north via swales before entering the storm drainage system near Van Dorn Street at Outfall B.

Approximately 3.5 acres of the Park is developed with impervious surface (e.g., buildings, parking lots, and roads), with the remaining undeveloped land consisting of open field and grassy areas.

Figure 2: Drainage Patterns in Fort Ward Park

3.4 WATERSHED AND DRAINAGE BASINS

Fort Ward Park is part of the Four Mile Run watershed, which is approximately 20 square miles in area covering the Cities of Alexandria and Falls Church and portions of Arlington and Fairfax Counties. The Four Mile Run watershed is highly urbanized and approximately 85 percent of the watershed is considered to be a developed area. Fort Ward Park drains into the lower portion of the Four Mile Run through the storm sewer system via the various outfalls (shown in Figure 2).

3.5 EXISTING STORMWATER DEFICIENCIES

Combining the observations from the field reconnaissance and the results of hydrologic and hydraulic analysis, URS identified 16 sites that have or could develop drainage deficiencies.

Deficiencies include nuisance flooding, sedimentation and erosion, flooding during more extreme events, or a combination. Figure 3 shows the locations of the 16 sites.

The following information is provided for each site:

- Ownership: the party responsible for the site improvement.
- Existing conditions: a summary of existing site conditions, including the drainage capacity of swales and culverts if applicable.

Site Number	Ownership	Existing Conditions
1	City	Shallow drop inlet near the museum and the parking lot. No major problems noted during the field reconnaissance.
2	City	15-inch culvert crossing under the entrance road near bathrooms. A small ponding area was observed at the culvert inlet.
3	City/Private	Outlet of 18-inch pipe that collects runoff from upstream forested area and Braddock Road. Sediment and debris deposition was noted at the outfall.
4	City	Swale in the natural area with "No Mowing" sign nearby. No major problems noted during the field reconnaissance.
5	City	The 36-inch culvert under the road that leads to the utility yard appeared to be partially blocked; in addition, vegetation was overgrown around the culvert. Observed sediment and debris buildup at the 6-inch PVC underdrain pipe located just upstream of the 36-inch culvert.
6	City	Old Utility Yard. Several infiltration trenches have been installed to prevent runoff from reaching the cemetery. A temporary catch basin collects runoff from the small trench along the fence line, which divides the park property from the neighborhood. The runoff from the catch basin drains toward the 36-inch culvert and downhill of the cemetery. Temporary hay bales have been set up to prevent runoff from entering the cemetery.
7	City	The main stream channel that runs through the Park is eroded and there is concrete debris in the channel. A swale has formed from backyard drainage conveyance from residential property. In addition, there is a clogged inlet at the downstream end of the natural stream channel.
8	Private	The base areas are exposed on several gravestones in the cemetery. Depressions have formed in front of several graves from ponding during rain events. There are several areas of exposed, bare ground in the cemetery. A channel is forming through the cemetery where runoff flows during rain events.
9	City	A channel has formed on the hill adjacent to the playground. Two yard inlets collect drainage from the hill before it gets to the playground. One of them is completely covered by sediment and leaves. A channel has formed through the playground. There is a rock outfall and filter fabric at the outfall of the channel through the playground. There are areas of bare ground on the hill upstream of the playground.
10	City	A clogged yard inlet was noted near the footbridge over the swale surrounding the Fort. The cross-culvert inlet upstream from the rifle trench appeared to be clogged at the time of the field visit.
11	City/Private	There appear to be water quality issues in the Pond at the northeast corner of the Park boundary. The water is cloudy from sediment and appears discolored.
12	City	Park outfalls along Van Dorn Street. Inlets collecting drainage from the Park are clogged with debris. Channels have formed downstream of cross culverts discharging runoff.

Site Number	Ownership	Existing Conditions
13	City	Bare spots were noted on the hill near the soccer field. An inlet at the base of the hill is clogged and a channel has formed upstream of the inlet.
14	City	No problems were observed near the manhole and inlets near the soccer field and amphitheater.
15	City	Areas of exposed, bare ground were seen in the open areas near the parking lot, near the amphitheater and adjacent open area. The inlet adjacent to the west side of the Fort is clogged. There is a depression at the 15-inch culvert inlet under the parking lot. Sedimentation was seen in the parking lot due to blockage from a telephone pole being used as a landscape timber.
16	Private	Runoff from the properties in Marlboro Estates is draining onto Park property and contributing to drainage issues.

PVC = polyvinyl chloride

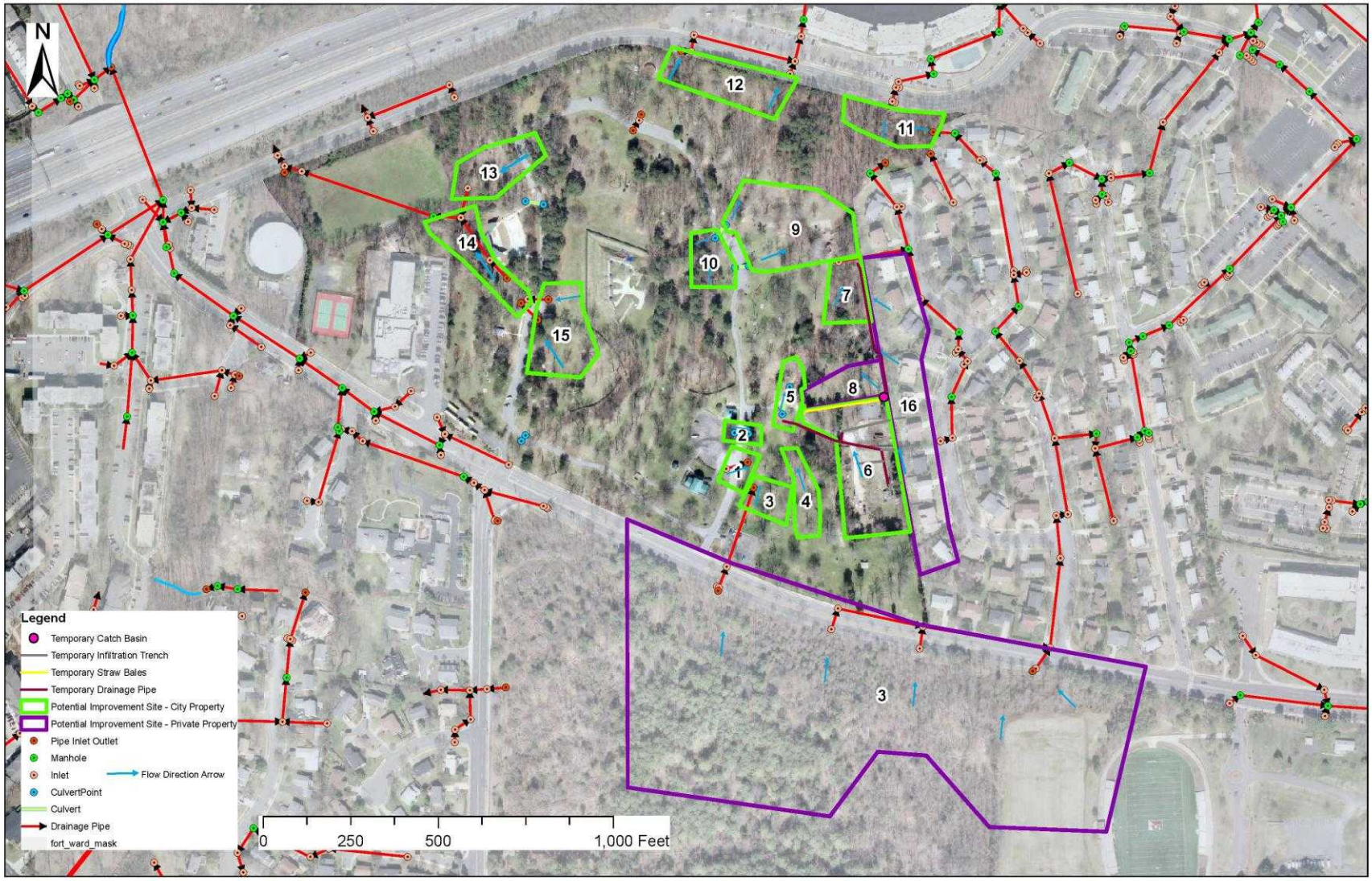

Figure 3: Fort Ward Park Sites for Potential Improvement

SECTION FOUR: ANALYSIS METHODOLOGY

4.1 HYDROLOGIC ANALYSIS

4.1.1 Modeling Development

URS performed a hydrologic analysis of the Park to develop a baseline model for the City. Results of the analysis shows the volume of water flowing through each location and can be used by the City for future Stormwater Management projects.

URS developed the hydrologic model using GIS mapping and Autodesk Storm and Sanitary Analysis (SSA) 2011 version 5.0 as requested by the City. The 2012 Zoning GIS data provided by the City were used along with data from the field reconnaissance in hydrologic modeling and calculations. URS developed the watershed delineation and attribute management using Esri ArcGIS 10. After conversations with the City on the preferred analytical method, the Rational Method was used to perform the hydrologic analysis for the Park. SSA was used to develop flows for the 1-, 2-, 10-, 25-, and 100-year storm events.

4.1.2 Modeling Input Parameters

After reviewing project specifications and recommendations, and understanding the project's objectives, specific data needs were defined and collected. The data sets used in the hydrologic modeling are described below.

The City provided 2-foot topographic data. The vertical datum used for this project is the North American Vertical Datum 1988 (NAVD 88), dated October 2012. The data were provided in a GIS shapefile format. The topographic data were used to delineate subwatersheds within the Park. The City also provided GIS zoning data. The 2009 City of Alexandria zoning data were used to represent existing land use. The GIS soil data coverage used for modeling the Park was obtained from the Soil Survey Geographic database (NRCS, 2009), which can be accessed at http://SoilDataMart.nrcs.usda.gov/.

Rainfall infiltration losses were estimated using the Rational Method Runoff Coefficient (C). The 2009 Alexandria zoning data contain five different land use types in the drainage area surrounding Fort Ward Park (Table 3). These zones were reclassified into four hydrologic soil groups based on their similarity in hydrologic responses. Each of these categories has a different C value depending on the hydrologic soil group classification of the land use. Due to the relative steepness of slopes within the park, C values were chosen based on 6 percent or greater land slope. Table 3 summarizes C values for the different zoning categories and four hydrologic soil groups. The rainfall intensity estimates were obtained from the rainfall Intensity-Duration-Frequency (IDF) curves for the City of Alexandria dated from 1941–1969.

Table 3: Land Use and C Values from Autodesk Storm and Sanitary Analysis 2011

No.	2009 Alexandria Zoning Categories	Equivalent C Category	C Value by Soil Type			
			A	B	C	D
1	Public Open Space	Open Space, less than 25 years	0.14	0.19	0.24	0.28
2	Public Open Space	Open Space, 25 years or greater	0.2	0.26	0.32	0.39
3	Residential Single Family Zone, 20,000 square-foot lot	Residential Lot Size 1/2 Acre, less than 25 years	0.24	0.28	0.32	0.37
4	Residential Single Family Zone, 20,000 square-foot lot	Residential Lot Size 1/2 Acre, 25 years or greater	0.32	0.36	0.42	0.48
5	Residential Single Family Zone, 8,000 square-foot lot	Residential Lot Size 1/4 Acre, less than 25 years	0.29	0.33	0.36	0.4
6	Residential Single Family Zone, 8,000 square-foot lot	Residential Lot Size 1/4 Acre, 25 years or greater	0.37	0.42	0.47	0.52
7	Residential Townhouse Zone	Residential Lot Size 1/8 Acre, less than 25 years	0.31	0.35	0.38	0.42
8	Residential Townhouse Zone	Residential Lot Size 1/8 Acre, 25 years or greater	0.4	0.44	0.49	0.54
9	Residential High Density Apartment Zone	Residential Lot Size 1/8 Acre, less than 25 years	0.31	0.35	0.38	0.42
10	Residential High Density Apartment	Residential Lot Size 1/8 Acre, 25 years or greater	0.4	0.44	0.49	0.54

4.1.3 Modeling Approach

URS developed the hydrologic model using Autodesk SSA 2011 (Autodesk, 2011) as requested by the City. Autodesk SSA can be used to model drainage systems using GIS shapefiles and user inputs. URS developed the terrain preprocessing, watershed delineation, and attribute management using ArcGIS 10 (Esri, 2010). The drainage map is shown in Figure 4.

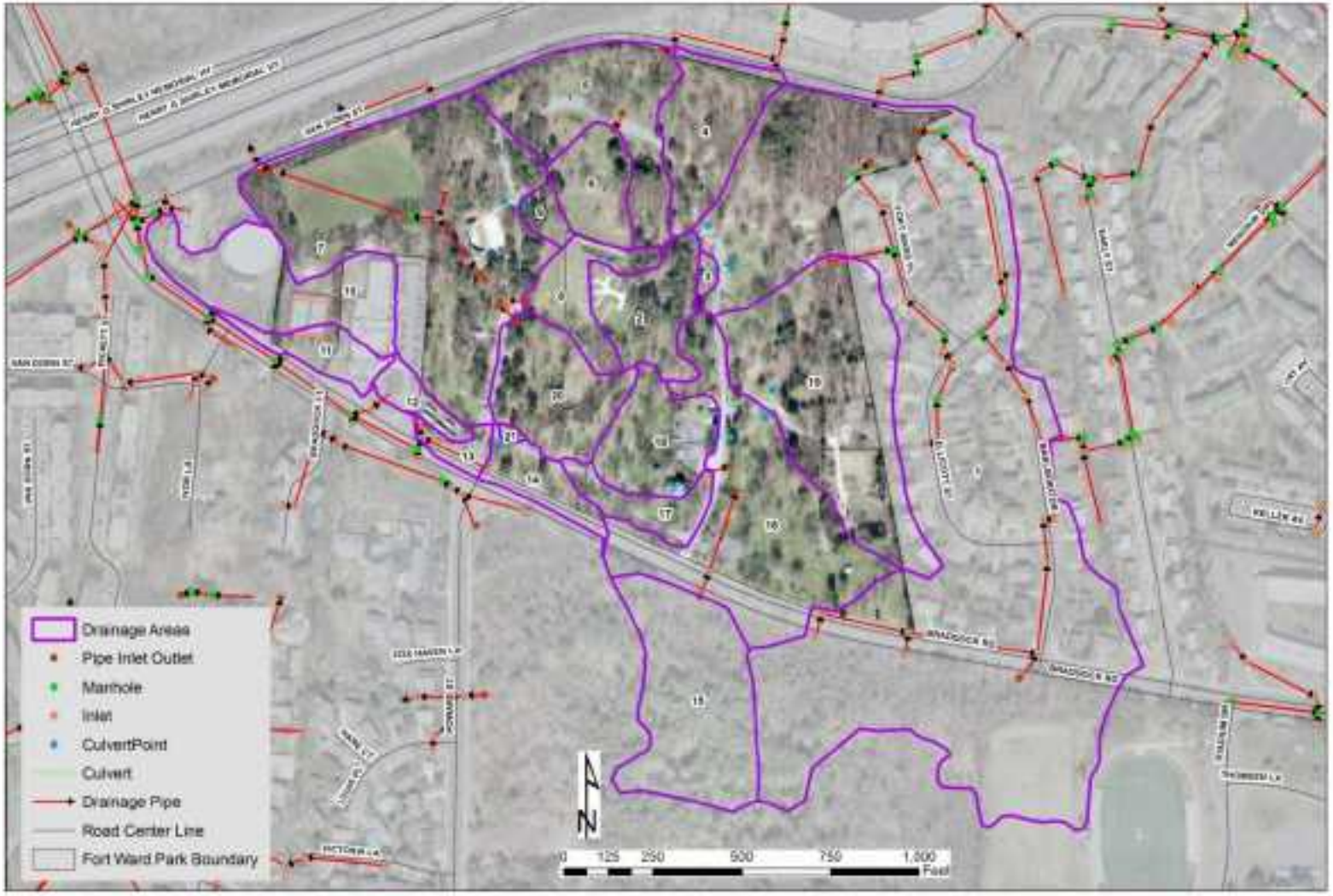

Figure 4: Fort Ward Park Drainage Divide Map

Key hydrologic parameters that are required for the SSA rainfall-runoff model include watershed-related parameters and precipitation data associated with design storms. Watershed-related input parameters needed for the SSA model include rainfall infiltration losses, drainage area, and time of concentration.

Rainfall infiltration losses were estimated using the Rational Method Runoff Coefficient, C, wherein C is the parameter used to represent drainage area properties including soil type, land use, and average slope. Composite runoff coefficients were calculated in the Subbasins tool in SSA. Table 4 shows the C values calculated for each sub-area.

Table 4: Hydrologic Parameters for Subbasins

Basin	Area (ac)	Runoff Coefficient (less than 25 years)	Runoff Coefficient (greater than 25 years)	Time of Concentration (min)
1	29.50	0.34	0.45	20.47
2	1.91	0.28	0.39	13.14
3	0.15	0.28	0.39	7.71
4	2.39	0.28	0.39	11.41
5	3.61	0.28	0.39	13.41
6	1.40	0.28	0.39	7.12
7	9.82	0.27	0.37	5.00
8	1.40	0.28	0.39	13.72
9	0.37	0.28	0.39	6.76
10	3.24	0.35	0.46	12.57
11	0.91	0.34	0.45	14.57
12	0.56	0.35	0.46	5.00
13	0.44	0.28	0.39	5.00
14	0.99	0.28	0.39	7.41
15	4.45	0.28	0.36	35.79
16	6.53	0.28	0.39	16.13
17	0.98	0.28	0.39	12.13
18	2.03	0.28	0.39	10.58
19	6.44	0.30	0.41	23.35
20	2.44	0.28	0.39	8.82
21	0.06	0.28	0.39	5.00

ac = acre
min = minute

The watershed subbasins shown in Figure 4 were delineated and the enclosed areas were calculated using 2-foot topography in ArcGIS 10. The subbasin sizes summarized in Table 4 were used as an input for the SSA model for the hydrologic simulation.

Time of concentration (T_c) is defined as the time it takes for stormwater runoff to travel from the most hydraulically distant point of the watershed to a point of interest within the watershed. T_c values for each subbasin were determined using the T_c estimation method described in NRCS TR55 (1986). Runoff from each sub-area was divided into a sheet flow segment (non-concentrated runoff from the most distant point), shallow concentrated flow segment, and channel flow and storm drain flow.

T_c values for sheet and shallow concentrated flows were estimated using generalized curves that relate surface and channel conditions, slope, and flow velocity. A maximum sheet flow segment length of 100 feet was used in accordance with NRCS recommendations. Shallow concentrated flow lengths were assumed to extend from the end of the sheet flow portion of runoff to the origin of a well-defined channel segment.

The velocities for channel flows were calculated using Manning's equation assuming the bankfull discharges. Hydraulic roughness characteristics were based on aerial imagery and field reconnaissance.

The calculated travel time (T_t) values for sheet flow, shallow concentrated flow, and channel flow were summed to give the total T_c value for each sub-area. The estimated T_c values for the sub-areas are summarized in Table 4.

Rainfall intensities for the City of Alexandria were input to the SSA model. The rainfall intensities for the 1-, 2-, 10-, 25-, and 100-year rainfall events were used to calculate the discharges at the 100-, 50-, 10-, 4-, and 1-percent-annual-chance events, respectively.

4.1.4 Summary of Results

Results of the hydrologic simulations are summarized in Table 5. Results of the SSA model are reported by subbasin name. The locations of the junctions and outfalls are shown in Figure 5.

Figure 5: Fort Ward Park Drainage Divide Map with Junctions and Outfalls

Table 5: Summary of Hydrologic Analysis

Name	Drainage Area (ac)	Drainage Area within Park Limits (%)	Storm Event Flows (cfs)				
			1-yr	2-yr	10-yr	25-yr	100-yr
Subbasin 1	29.5	18.8	26.34	34.15	49.71	78.46	98.69
Subbasin 2	1.91	100	1.77	2.29	3.34	5.55	7.04
Subbasin 3	0.15	100	0.17	0.22	0.32	0.54	0.70
Subbasin 4	2.39	93.4	2.33	3.04	4.43	7.41	9.44
Subbasin 5	3.61	98	3.32	4.29	6.25	10.38	13.17
Subbasin 6	1.4	100	1.60	2.13	3.10	5.22	6.67
Subbasin 7	9.82	92.6	12.20	16.31	23.86	39.42	50.50
Subbasin 8	1.4	100	1.28	1.65	2.40	3.98	5.05
Subbasin 9	0.37	100	0.43	0.57	0.84	1.40	1.80
Subbasin 10	3.24	20.2	3.81	4.95	7.21	11.33	14.39
Subbasin 11	0.91	39.7	0.98	1.26	1.84	2.90	3.66
Subbasin 12	0.56	42.6	0.90	1.21	1.76	2.80	3.58
Subbasin 13	0.44	63	0.57	0.76	1.11	1.86	2.39
Subbasin 14	0.99	68.4	1.12	1.48	2.16	3.62	4.64
Subbasin 15	4.45	0	2.34	3.08	4.47	6.85	8.59
Subbasin 16	6.53	77.7	5.52	7.11	10.36	17.14	21.64
Subbasin 17	0.98	100	0.93	1.22	1.77	2.95	3.75
Subbasin 18	2.03	100	2.03	2.67	3.89	6.52	8.32
Subbasin 19	6.44	77.5	4.70	6.11	8.89	14.53	18.23
Subbasin 20	2.44	100	2.60	3.43	5.01	8.41	10.76
Subbasin 21	0.06	100	0.08	0.11	0.16	0.27	0.35
Junction 1	4.45	0	2.34	3.08	4.47	6.85	8.59
Junction 2	13.98	69.4	8.14	10.54	15.35	25.21	31.86
Junction 3	20.42	71	11.39	14.77	21.51	35.27	44.49
Junction 4	2.44	100	2.60	3.43	5.01	8.41	10.76
Junction 5	2.39	100	0.43	0.57	0.84	1.40	1.80
Junction 6	1.4	100	1.28	1.65	2.40	3.98	5.05
Junction 7	0.98	100	0.93	1.21	1.77	2.95	3.75
Junction 8	2.03	100	2.03	2.66	3.89	6.52	8.32
Junction 9	1.91	100	1.77	2.29	3.34	5.54	7.04
Junction 10	0.15	100	0.17	0.22	0.32	0.54	0.69
Junction 11	1.4	100	1.60	2.12	3.10	5.22	6.67
Outfall 1	65.97	71.7	37.02	48.00	69.88	111.38	140.15

Name	Drainage Area (ac)	Drainage Area within Park Limits (%)	Storm Event Flows (cfs)				
			1-yr	2-yr	10-yr	25-yr	100-yr
Outfall 2	2.39	93.4	2.33	3.04	4.43	7.41	9.44
Outfall 3	5.01	99	3.54	4.59	6.69	11.11	14.10
Outfall 4	14.02	98.2	14.45	19.27	28.19	46.67	59.76
Outfall 5	3.24	20.2	3.81	4.95	7.21	11.33	14.39
Outfall 6	0.91	39.7	0.98	1.26	1.84	2.90	3.66
Outfall 7	0.56	42.6	0.90	1.21	1.76	2.79	3.58
Outfall 8	0.99	63	0.57	0.76	1.11	1.86	2.39
Outfall 9	1.05	84.2	1.16	1.54	2.24	3.77	4.82

ac = acre
cfs = cubic feet per second
yr = year

Results from the SSA model are consistent with what was expected from field studies, which showed locations of eroded streams and the need for storm drain improvements. The results of this study can be used by the City for future stormwater management improvements or stream restoration projects. Additionally, the results of the hydrology are used to perform the hydraulic capacity analysis.

4.2 HYDRAULIC CAPACITY ANALYSIS

4.2.1 Modeling Development

URS performed a hydraulic capacity analysis for the cross culverts. The results of the hydraulic modeling will aid in future park improvement assessments and the City of Alexandria's management strategies for the park.

The hydraulic model for the Fort Ward Park Master Drainage Plan was developed using current Geographic Information System (GIS) datasets from the City and peak discharges calculated during the hydrologic analysis.

A culvert analysis program, HY-8, was used to analyze the performance of the culverts. There are 11 existing cross culverts in the Park and all of them were investigated for the conveyance capacity.

4.2.2 Modeling Input Parameters

Key parameters that are required for HY-8 include discharge data, culvert data, tailwater data, and roadway data. The discharges for the 2-year, 10-year, 25-year, and 100-year storm events were obtained from the hydrologic analysis. The culvert data required by HY-8 include:

- Culvert shape
- Material (to define Manning's n values)
- Size
- Inlet type, edge condition, and depression
- Invert data
- Embankment data

The above culvert data were obtained from the GIS data provided by the City, the field reconnaissance, aerial images, and topographic information.

The downstream tailwater channel shape and condition were defined using topographic data provided by the City and the field reconnaissance observations. The following parameters are required when defining the roadway data for the culvert:

- Roadway profile
- Roadway station
- Crest length
- Crest elevation
- Roadway surface
- Top width

The above road data were obtained from the GIS data provided by the City, the field reconnaissance, aerial images, and topographic information. The roadway surface conditions were confirmed during the field reconnaissance trip. The values entered for the crest length and top width of the roadway have no effect on the hydraulic computations unless overtopping occurs.

4.2.3 Modeling Approach

URS determined the conveyance capacity of the existing drainage systems and for the limited existing cross culverts on the site. Defined conveyance systems are not prevalent on the site, and there are no closed drainage systems other than cross culverts. The flow capacities for the existing cross culverts were determined using the discharges from the hydrologic analysis.

Culvert capacities and associated velocities were computed using the Federal Highway Administration's HY-8. HY-8 was developed by Federal Highway Administration in the 1980s

and has been continuously maintained and updated since. URS used the latest version, Version 7.2, to examine the hydraulic capacity of the cross culverts in the Fort Ward Park.

4.2.4 Summary of Results

The summary of the hydraulic capacity analysis (Table 6) shows that all the culverts, except Culverts 2, 18, and 20, are designed to convey 25-year storm events, provided routine maintenance is performed. For example, sedimentation in the culvert under West Braddock Road (Culvert 15) will cause the water to overtop the crossing road during the 25-year storm event. However, the conveyance can be restored by cleanup and routine maintenance. The detailed model output for each culvert is available in Appendix C.

Table 6: Summary of Culvert Capacity Analysis

Culvert ID	Subbasin ID	Site ID	Storm Event Flows (cfs)			Flows that would cause overtopping (cfs)	Will it be overtopped during a 25-year storm event?	Will it be overtopped during a 100-year storm event?
			10-yr	25-yr	100-yr			
Culvert 15	Subbasin 15	Site 3	4.47	6.85	8.59	8.25	No	Yes
Culvert 15*	Subbasin 15	Site 3	4.47	6.85	8.59	6.04	Yes	Yes
Culvert 17	Subbasin 17	Site 1	1.77	2.95	3.75	5.30	No	No
Culvert 18	Subbasin 18	Site 2	3.89	6.52	8.32	5.17	Yes	Yes
Culvert 16	Junction 2	Site 5	15.35	25.21	31.86	40.27	No	No
Culvert 3	Subbasin 3	Site 10	0.32	0.54	0.70	4.0	No	No
Culvert 2	Subbasin 2	Site 10	3.34	5.55	7.04	5.06	Yes	Yes
Culvert 6	Subbasin 6	N/A	3.10	5.22	6.67	7.55	No	No
Culvert 9	Subbasin 9	N/A	0.84	1.40	1.80	4.05	No	No
Culvert 8	Subbasin 8	Site 15	2.40	3.98	5.05	4.04	No	Yes
Culvert 20	Subbasin 20	Site 15	5.01	8.41	10.76	7.35	Yes	Yes
Culvert 21	Subbasin 21	Site 21	0.16	0.27	0.35	2.6	No	No

*with 1/3 of the culvert blocked by sedimentation

SECTION FIVE: RECOMMENDATIONS

5.1 GENERAL RECOMMENDATIONS

Over the course of the study, URS identified potential improvements to address nuisance flooding and erosion issues at the Park. These improvements are based on field observations, engineering analysis, and community input. The improvements include both structural and nonstructural measures. Nonstructural measures are defined as not requiring design and generally involving lower-cost activities that can be integrated into the maintenance already occurring at the Park. Structural measures, also referred to as capital projects, typically require additional analyses such as design development, geotechnical analysis, field surveying, archaeological investigation, and permitting. These measures typically involve greater effort and higher costs.

Nonstructural improvement options recommended for general implementation at the Park are listed below:

- Aeration and Turf Seeding: This alternative consists of aerating the soil to increase infiltration capacity and seeding turf. Aerated soil has a higher infiltration capacity (decreasing runoff) and is also more suitable for plant growth. Healthy turf reduces erosion while greatly improving park aesthetics. The Fort Ward Park and Museum Area Management Plan provides additional information on aeration of soils at the park
- Conveyance Improvements: This alternative includes cleanup and maintenance of the existing system, swales, closed systems, etc. This includes removing sediment and debris that decrease flow in existing conveyance systems, or avoiding cutting grass in infiltration trenches. These practices increase flow conveyance and decrease flooding frequency.
- Redirect Drainage from Homes: This alternative requires redirecting residential drainage away from erodible areas and sensitive resources by redirecting roof downspouts or sump pumps to storm drain systems. This option decreases runoff on to the Park by redirecting residential runoff.
- Mowing Maintenance Plan: This alternative requires a maintenance plan to clearly identify areas to be mowed and areas to avoid mowing. “No Mow” areas should also be established for drainage practices that use plant growth for retention, and where undesired pedestrian traffic is causing erosion.

General structural improvement options considered are as follows:

- Increase Culvert Capacity: This alternative involves increasing the size of culverts to accommodate the 25-year storm. This will lead to culverts surcharging less frequently, potentially avoiding nuisance flooding.
- Redirect Surface Flow: This alternative requires creating or upgrading an existing conveyance system. This can include swales, berms, culverts, etc. depending on the site requirements. Directly altering surface flow should be used where sheet flow is eroding sensitive areas.

- Level Spreader: This alternative involves implementation of gravel or riprap downstream of a culvert outlet to reduce erosion. Level spreaders reduce energy, converting high-velocity flow into sheet flow.
- Stream Restoration/Stabilization: This alternative consists of modifying an existing stream so it is more stable under existing and future flow conditions. This can decrease stream erosion, improve stream aesthetics, and decrease sediment loading downstream.
- Install Underground Best Management Practices (BMPs): This alternative involves adding water quality BMPs to an existing or proposed culvert. The BMPs are designed to trap sediment, debris, and other contaminants to improve water quality downstream.

5.2 GENERAL MAINTENANCE BEST PRACTICES FOR CEMETERY AREAS

The following summarizes best practices for grounds and headstone maintenance at cemeteries, but is focused on the Oakland Baptist Church Cemetery (Site 8), although the cemetery is not under City jurisdiction. The parties responsible for maintenance of the cemetery should view this document as general guidance and refer specifically to the Additional References and Resources at the end of this document to help determine the most appropriate methods and means of implementation.

5.2.1 Virginia Cemetery Regulations

The State of Virginia has a number of laws and regulations related to marked and unmarked cemeteries including ones that address impacts to graves and access to gravesites, among others (see Code of Virginia Titles 18 and 57). Questions regarding cemetery regulations in Virginia can be directed to the Virginia Department of Historic Resources (VDHR) at 804-367-2323 / http://www.dhr.virginia.gov/.

5.2.2 Maintenance Recommendations

Maintenance issues at cemeteries typically revolve around two often interconnected themes: vegetation and drainage. Vegetative issues include poor turf quality resulting from soil compaction and excessive shade and trees growing in and around graves, displacing headstones. Drainage issues at cemeteries are often related to sheet flow of water due to impervious surfaces upslope from the cemetery, compaction of soil around and within the cemetery proper, and poor soil drainage characteristics, such as impermeable clay layers; a high, or perched, water table can be another contributing factor. There are a number of mitigation measures that can be implemented by parties responsible for cemetery maintenance to address vegetative and drainage issues both outside a cemetery and within the boundary of a cemetery.

Turf Maintenance: Within the boundaries of a cemetery, poor drainage and erosion is most commonly related to soil compaction, which prevents water from infiltrating into the ground and instead contributing to surficial erosion or subsidence of head stones or pooling in depressions. Soil compaction issues can be addressed through a turf maintenance program, whereby the soil is aerated and appropriate grassy vegetation is planted as an erosion prevention technique. Such an

activity may involve the removal or pruning of trees that are contributing to excessive shade or could be diverting water flow, but care must be taken to ensure that the trees removed do not contribute to the character and feeling of the cemetery and do not cause additional damage during the removal process. Mowing, edging, and related turf maintenance activities are major contributors to headstone damage. Any turf management program must include damage prevention measures.

Water Diversion: There are three main methods that can be used around a cemetery to redirect water flowing from upslope sources: berms (see Section 6.2 for example), ditches, and subsurface installations such as French drains or drainage tiles. Construction of any of these features can have adverse impacts to a cemetery due to either compaction of burials (e.g., berms) or physical disturbance of a burial (e.g., ditches and French drains). As such, it is important that an accurate map of the limits of burials, marked and unmarked, within the cemetery be prepared to ensure that such features will not be constructed through any burials.

Grave Depressions: While water can pool in grave depressions caused by casket and soil subsidence, it is recommended that these not be filled unless they pose a safety hazard, especially if an accurate map of the cemetery and all marked and unmarked burials has not been developed (Chicora Foundation, Inc. (CFI) N.D.a). Grave depressions are an important indicator of unmarked graves and filling of the depression can remove any sign of a burial if it is not properly mapped and/or marked. Issues with grave depressions collecting water can be mitigated by instituting a turf management program.

Conservation and Repair of Damaged Headstones: Trees and tree roots as well as drainage issues can cause subsidence of and damage to headstones. If resetting of headstones is feasible, care should be taken when identifying which headstones should be reset and the manner in which the resetting is undertaken. It is recommended that only headstones with a severe amount of tilting be reset. Headstones can contain internal cracking that is not visible to the naked eye and the process of resetting can result in failure of the stone, thus causing a more severe impact to the headstone and more costly repair. There are numerous methods for repairing cracked or broken headstones, but improper repair techniques can cause additional damage or minimally result in disfigurement. Additionally, it should be noted that mowing and other turf maintenance can be the most damaging activities to headstones, and proper guidance is critical to preventing damage from these activities.

5.2.3 Potential Funding Sources

A number of different options may exist for procuring funding to support cemetery maintenance activities. Within the City of Alexandria, it is recommended that the Alexandria Archaeology Museum be contacted at 703-746-4399 / http://alexandriava.gov/Archaeology. The VDHR is a resource that can be used to identify potential state and federal funding sources, and can be contacted at 804-367-2323 / http://www.dhr.virginia.gov/. The State, Tribal, and Local Plans & Grants Division of the National Park Service (http://www.nps.gov/history/hpg/) often works with State Historic Preservation Offices such as the VDHR. While cemeteries are not typically

considered eligible for listing in the National Register of Historic Places (NRHP), there are a number of "Criteria Considerations" under which a cemetery may be considered eligible. VDHR may be able to provide guidance on the NRHP nomination process and possible funding sources.

A list of organizations that would provide additional funding sources is included in Additional References and Resources at the end of this document.

5.3 DESIGN STANDARDS FOR PROPOSED IMPROVEMENTS

Several design standards were used when considering proposed improvements to Fort Ward Park, including the following:

- The Four Mile Run Design Guidelines (2009)
- The Amendments to City of Alexandria Article XIII Environmental Management Ordinance (2006)
- The Virginia Stream Restoration & Stabilization Best Management Practices Guide (2004) – used when considering stream restoration improvements
- The Virginia Department of Transportation Drainage Manual (2002)
- The Virginia Erosion and Sediment Control Handbook (1992)

5.4 SITE-SPECIFIC RECOMMENDATIONS

Specific recommendations are summarized below for each of the sites shown in Figure 3. Section Six includes additional information for the recommended capital projects that were analyzed in detail.

5.4.1 Site 1

Two nonstructural measures are recommended for Site 1:

- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from culverts is recommended.

5.4.2 Site 2

Two nonstructural measures and one structural measure are recommended for Site 2:

- Increase culvert capacity: Increase the capacity of the 15-inch culvert under the entrance road near the bathrooms
- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from culverts is recommended. Re-grading to avoid ponding is also recommended.

5.4.3 Site 3

Two nonstructural measures and one structural measure are recommended for Site 3:

- BMP implementation: this alternative requires the installation of a BMP at the site or upstream of the outfall to remove sediment, trash, and debris. (See Section Six for concept design.)
- Level spreader: this alternative requires the implementation of a level spreader at the culvert outlet.
- Conveyance improvements: periodic removal of sediment and debris from culverts is recommended.

5.4.4 Site 4

One nonstructural measure is recommended for Site 4:

- Aeration and turf seeding

5.4.5 Site 5

Two nonstructural measures are recommended for Site 5:

- Aeration and turf seeding: seeding is recommended at the sloped area upstream of the 36-inch culvert.
- Conveyance improvements: periodic removal of sediment and debris from the 36-inch culvert and the 6-inch PVC pipes is recommended.

5.4.6 Site 6

One nonstructural measure and one structural measure are recommended for Site 6 (Old Utility Yard).

- Redirect surface flow: this alternative requires the construction of berms to direct runoff and to replace temporary hay bales. (See Section Six for concept design.)
- Mowing maintenance plan: reduce mowing due to the existing infiltration basins and graves.

5.4.7 Site 7

Two nonstructural measures and two structural measures are recommended for Site 7:

- Stream restoration/stabilization: this alternative involves implementing stream restoration measures for eroded stream banks. (See Section Six for concept design.)
- Redirect surface flow: this alternative requires developing a solution to effectively handle concentrated flow from the nearby residential property.
- Aeration and turf seeding

- Conveyance improvements: periodic removal of debris from the stream and yard inlets is recommended.

5.4.8 Site 8

Recommendations for the Oakland Baptist Cemetery property are discussed in Section 5.3.

5.4.9 Site 9

Two nonstructural measures and two structural measures are recommended for Site 9:

- Level spreader: this alternative requires the implementation of a level spreader at the culvert outlet to prevent concentrated flow.
- Redirect surface flow: this alternative requires the construction of a berm to direct runoff around playground area before the playground is relocated to a different location.
- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris at yard inlets is recommended.

5.4.10 Site 10

One nonstructural measure and one structural measure are recommended for Site 10:

- Increase culvert capacity: Increase the capacity of the 15 inch culvert.
- Aeration and turf seeding

5.4.11 Site 11

One nonstructural measure is recommended for Site 11:

- Community outreach: Conduct outreach activities with residents to prevent pollutants from entering the storm drain system.

5.4.12 Site 12

One nonstructural measure and two structural measures are recommended for Site 12:

- Level spreader: this alternative requires the implementation of a level spreader at the culvert outlet to prevent concentrated flow.
- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from inlets is recommended.

5.4.13 Site 13

Two nonstructural measures and one structural measure are recommended for Site 13:

- Level spreader: this alternative requires the implementation of a level spreader at the culvert outlet to prevent concentrated flow.
- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from inlets is recommended.

5.4.14 Site 14

Two nonstructural measures are recommended for Site 14:

- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from inlets is recommended.

5.4.15 Site 15

Two nonstructural measures and one structural measure are recommended for Site 15:

- Increase culvert capacity: Increase the capacity of the 15 inch culvert.
- Aeration and turf seeding
- Conveyance improvements: periodic removal of sediment and debris from inlets is recommended. A slight re-grading and the removal of the telephone pole at the upstream culvert are also recommended.

5.4.16 Site 16

One nonstructural measure is recommended for Site 16:

- Redirect surface flow: this alternative requires developing a solution to effectively handle concentrated flow from the nearby residential property.

SECTION SIX: RECOMMENDED CAPITAL IMPROVEMENT PROJECTS AND COST ESTIMATES

This section provides the concept design for the recommended capital improvement projects to address the flooding and erosion issues and improve the drainage on selected sites. The specific recommendations set forth in this section should be considered as conceptual only. Additional details and potential alternatives should be investigated and analyzed in the preliminary engineering phase of final project designs.

6.1 STORMWATER FILTER (SITE 3)

6.1.1 Existing Site Description

Sedimentation is occurring at the outfall 150 feet east of the Fort Ward Park Museum (Site 3). The flow at the outfall is made up of runoff from the 5-acre forested area south of Braddock Road and approximately 1 acre of Braddock Road. An 18-inch reinforced concrete pipe conveys water from Braddock Road to the outfall. The pipe was found to be adequate to convey the 25-year flood event as long as the pipe was not blocked by sediment. This site is the only area in the Park where offsite runoff enters and flows through the Park. The outfall is close to two parking lots and the museum, so it is considered a medium- to high-visibility area. The soils from the pipe inlet to the outfall are composed of hydrologic soil group D soils, which are poorly drained with low infiltration rates and high clay content.

6.1.2 Proposed Design

The primary goal for the proposed design is to improve the water quality of runoff at the Park. The secondary goal is to provide a solution that the community will accept while not detracting from the aesthetics of the Park. It is recommended that the existing sediment and debris within the outfall be removed prior to the implementation of any structural improvements at this location.

Existing Site 3 Outfall

The proposed retrofit to the Site 3 outfall is to install an underground stormwater filter beneath the parking lot southeast of the museum (Figure 6). Excavation of a portion of the parking lot is necessary and excess soil needs to be hauled offsite. The existing 18-inch reinforced concrete pipe would be cut in place and reconfigured and connected to the underground stormwater filter unit.

A filter such as the Contech StormFilter is recommended for adequate removal of sediment and other stormwater pollutants (including Phosphorous). Figure 7 shows a standard detail of this model. Within the StormFilter unit there is a bypass structure for overflow, pre-treatment to capture sediment, and filters to treat stormwater. Following installation, the excavated area of the

parking lot would need to be resurfaced and regraded. More detailed calculations are needed for final design. Preliminary calculations used for conceptual design are provided in Appendix D.

Figure 6: Proposed Stormwater Filter Concept Design

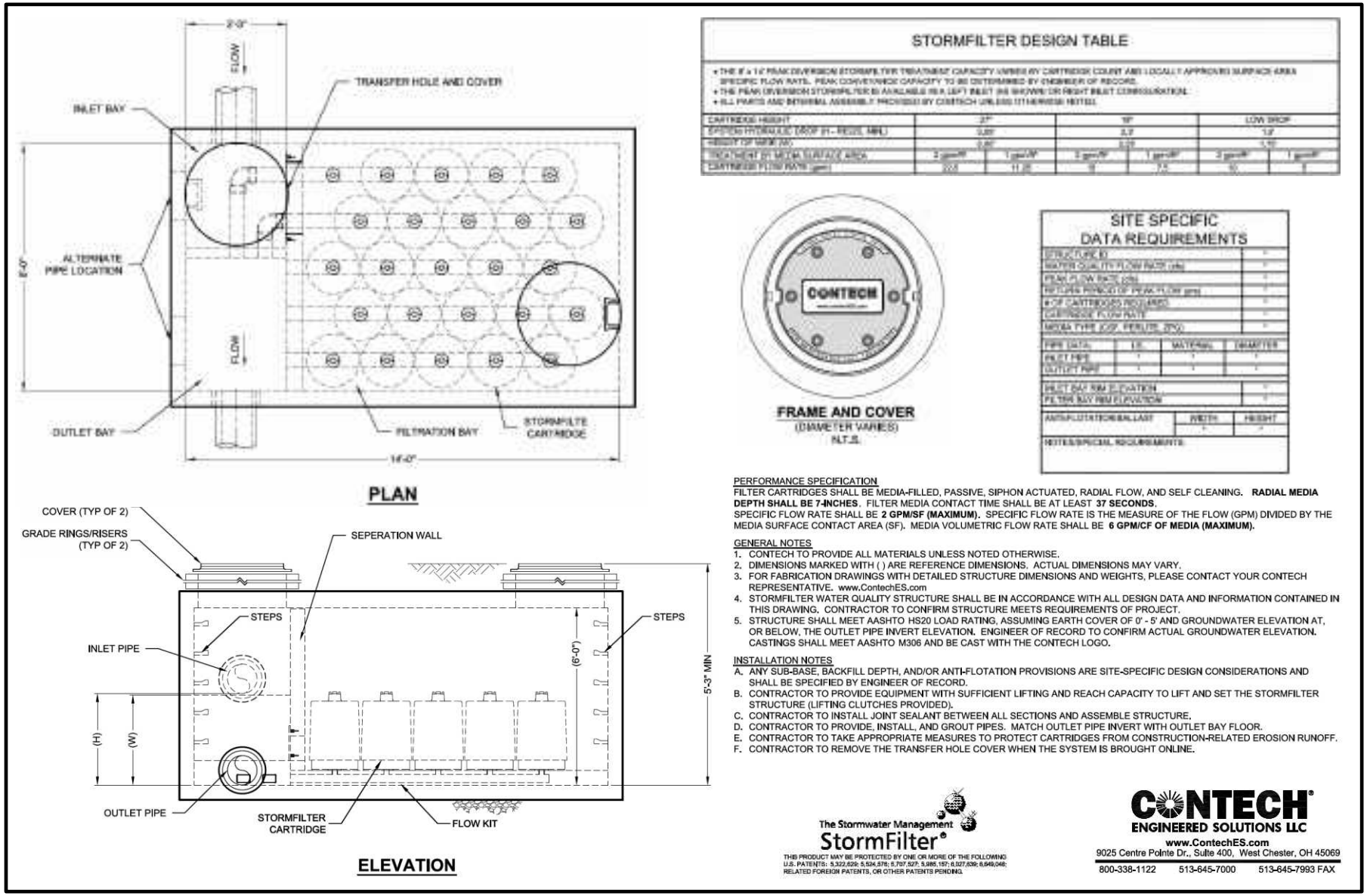

Figure 7: Stormwater Filter Example Standard Detail: Peak Diversion StormFilter

6.1.3 Improvements and Benefits

The current drainage system is adequate for water conveyance, but not water quality. A stormwater filter would intercept fine sediment, oil, floating debris, sinking debris, and nutrients. A StormFilter with twenty filter cartridges is rated to treat up to 1 cfs, which is sufficient to meet Virginia requirements for stormwater filters. Stormwater filters have emergency spillways allowing safe conveyance of up to the 100-year storm, although excess water would not be treated. The proposed retrofit would improve aesthetics by reducing sediment, debris, and pollutant loading into the Park.

6.1.4 Project Design Considerations

The proposed design is consistent with the Four Mile Watershed design guidelines, as well as the Amendment to the City of Alexandria Article XIII Environmental Management Ordinance. The design would involve the installation of a stormwater filter. In order for maintenance access the stormwater filter needs to be installed in or adjacent to the parking lot. Several trees would have to be removed if the filter were installed to the north or south of the parking lot. Construction in the proposed location would require excavation within the existing parking lot and would not impact existing trees. The amount of parking at the Park would be temporarily impacted during construction.

The proposed stormwater filter would detract from the Park aesthetically during construction, but would neither be visible nor take up valuable park space following completion. This is one of the benefits compared to a retention pond or bio-swale, for which more space would be needed.

6.1.5 Feasibility

Construction access to the parking lot will be available through the main entrance on Braddock Road. The parking lot is located near the entrance, so the Park Loop Road would not be impacted. No utilities are expected to be impacted, although further coordination with the City will be needed during detailed design for confirmation.

The environmental impacts of the proposed design would not be substantial as long as construction occurred in the parking lot. The trees on either side of the parking lot would be impacted if the stormwater filter were installed in the grass areas north or south of the proposed location. There would be a temporary loss of public parking during construction at the proposed location. Temporary fences and barriers would be required for safety.

The site is located within a High Cultural Resource Protection area as specified by the Alexandria Archeology Office of Historic Alexandria. Therefore, an archeological investigation at the site is required prior to or in conjunction with construction. The proposed concept design could occur concurrently or prior to installation of pervious pavement for the parking lot if desired by the City.

Routine inspection and maintenance would be required for the proposed stormwater filter. Cleaning would be required during dry periods to remove the sediment and debris that were retained. To clean the cartridges workers must enter the vault and remove cartridges for cleaning above ground. A

maintenance plan is recommended to ensure that the unit would continue to function as it was designed. Permitting and regulations are discussed in Section Seven.

6.2 DIVERSION BERM AROUND CEMETERY (SITE 6)

6.2.1 Existing Site Description

Runoff from the utility yard (Site 6) to the Oakland Baptist Cemetery (Site 8) is eroding the cemetery site. Temporary practices including hay bales, trenches, culverts, and a catch basin are in place to control runoff (Figure 3). The drainage area includes 0.2 acre of developed area (driveways and buildings) and 1.5 acres of grass or bare earth. The utility yard and the cemetery are composed of hydrologic soil group D soils, which are poorly drained with low infiltration rates and high clay content.

Existing Site 6 Hay Bales

6.2.2 Proposed Design

The primary goal for the proposed design is to limit erosion and nuisance flooding at the Oakland Baptist Cemetery. The secondary goal is to provide a permanent solution that will have community acceptance and look more aesthetically appealing than the current hay bale practice.

The proposed site improvements are two permanent earthen diversion berms to direct runoff from the utility yard to a catch basin. Figure 8 displays the proposed location of the two diversion berms. The northern berm keeps runoff from entering the cemetery while the southern berm keeps runoff from the road off the site. The berm would follow the natural slope (4 percent) south of the Oakland Baptist Cemetery. The proposed berm would be approximately 1.5 feet tall, with a minimum 2:1 side slopes (depending on obstructions), and would be 1 foot wide at the top (Figure 9). Erosion protection matting would extend from the base of the berm to the existing grade, and the upstream face would be protected using erosion protection matting or other erosion prevention measures (see Figure 9). The remainder of the berm would be made up of fill. The entire berm can be seeded with grass unless an impervious material is required to protect the berm slope instead of erosion protection matting. There are several potential options for the protected slope including erosion control matting, porous pavers, or riprap.

For the proposed design, both diversion berms lead to a catch basin (yard inlet) that is connected to a 12-inch reinforced concrete pipe (Figure 8). The pipe would extend from the catch basin to the stream with outlet protection to reduce flow velocity. Outlet protection options include stone (e.g., riprap), a level spreader, and a concrete structure. Preliminary calculations are available in Appendix D.

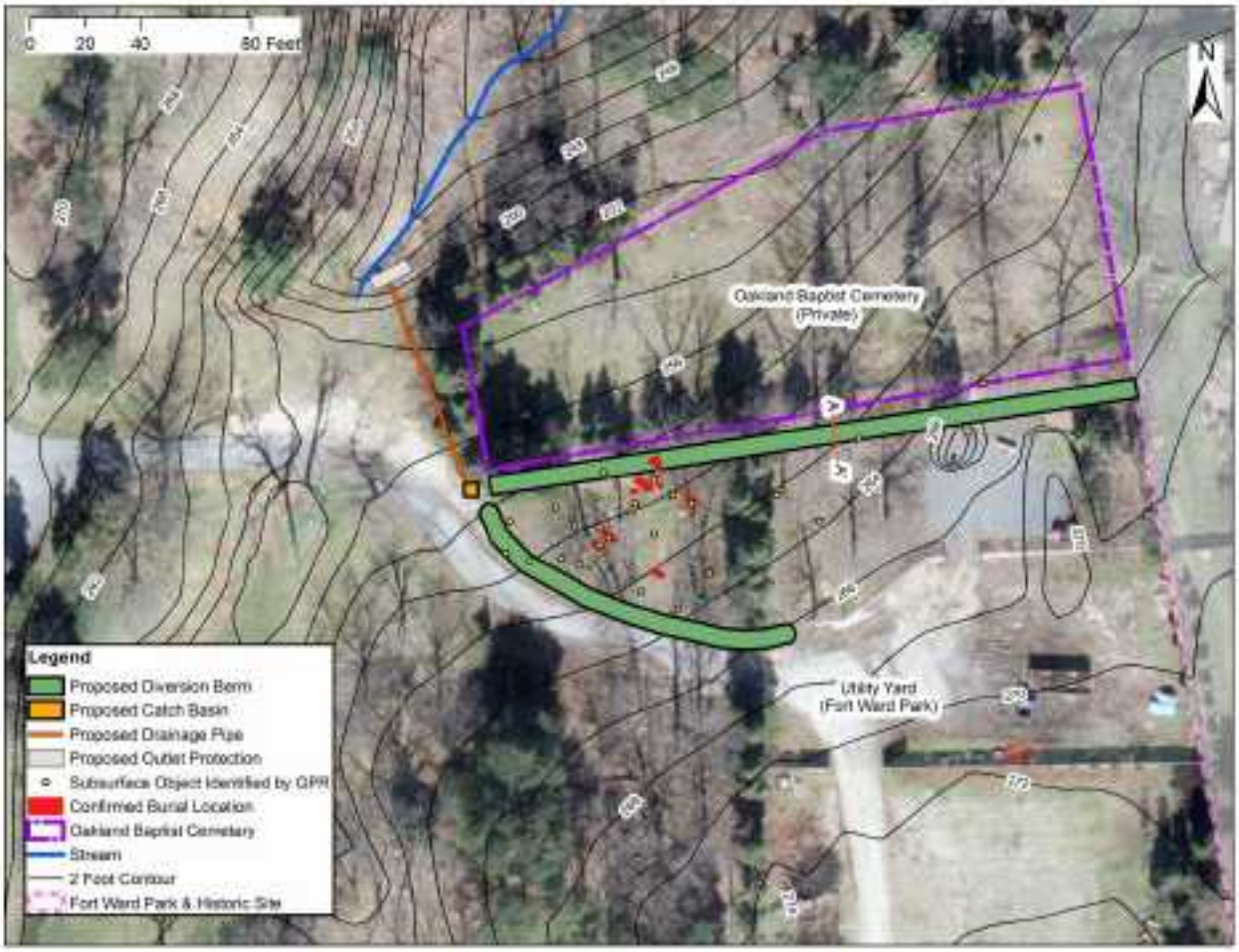

Figure 8: Proposed Diversion Berm Concept Design

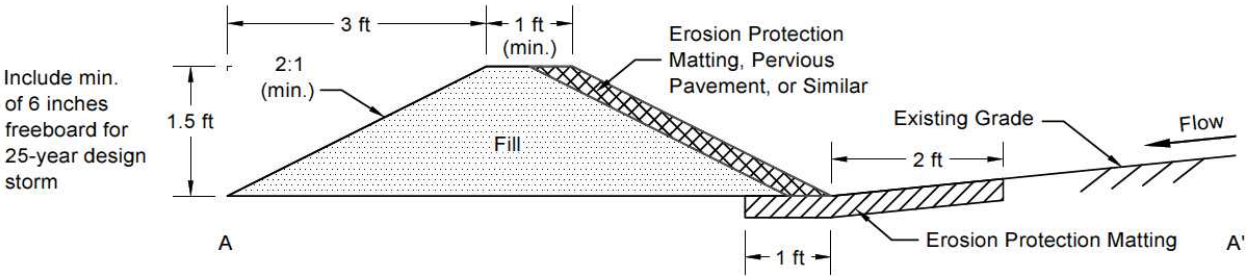

Figure 9: Proposed Diversion Berm Concept Design Cross-Section A – A'

6.2.3 Improvements and Benefits

The temporary drainage solutions at the utility yard require a more permanent upgrade to direct runoff away from sensitive areas. The berms would direct sheet flow into concentrated flow with erosion preventative measures (e.g., the erosion protection matting). Runoff from the Park would no

longer have access to Oakland Baptist Cemetery. The catch basin and drainage pipe would direct runoff from the site directly into the stream, alleviating some of the sedimentation concerns at the road (Site 5).

6.2.4 Project Design Consideration

The proposed design involves bringing fill and erosion protection matting onsite and creating two diversion berm segments. The proposed design also requires the installation of a catch basin, drainage pipe, and outlet protection. The site would need to be cleared of debris and some vegetation would need to be trimmed or removed. The design is flexible so most trees should be avoidable, although it is possible that some trees may need to be removed and replaced. Construction of the berm would require compaction, as well as seeding with grass or other vegetation. Installation of the underground drainage solution would require excavation, placement of the drainage structures, backfill, and seeding grass. Construction of the proposed concept design would affect the public when construction was occurring near the unpaved road, and when trucks were hauling soil into the area.

The site is located within a Maximum Cultural Resource Protection area as specified by the Alexandria Archeology Office of Historic Alexandria. There are several confirmed burial sites and potential burial sites that have been identified in the area surrounding the proposed berms (Figure 8). Due to the confirmed and potential burial sites, digging south of Oakland Baptist Cemetery is not considered to be an option. Due to this constraint, below-ground techniques that otherwise may have been suitable for the site (e.g., wet swales, infiltration trenches, and stormwater pipes) were not considered to replace the hay bales. These below-ground techniques also would have been complicated by the large numbers of trees in the area. There are no confirmed burial sites west of the Oakland Baptist Cemetery where the drainage pipe has been proposed. Careful archeological study will need to occur prior to construction to verify that no historical artifacts or burials would be impacted by the design. Above ground techniques were not suitable for this area because they would interfere with public access to the Oakland Baptist Cemetery.

6.2.5 Feasibility

Construction access to the proposed site will be available through Fort Ward Park Loop Road via Braddock Road. The proposed construction site would be located near the southeastern Fort Ward Park entrance so the Park Loop Road would not be significantly impacted by construction traffic. No utilities are expected to be impacted, although further coordination with the City would be needed during detailed design for confirmation.

The environmental impacts of the proposed design primarily involve potential impacts to trees north of the berm. These impacts will need to be considered during final design, and most of the trees should be avoidable. The public would temporarily lose access to a small portion of the Park, and temporary fences or barriers could be necessary to keep the public out of construction areas. An archeological investigation will be required prior to or in conjunction with construction.

Routine maintenance would be required for the proposed berms. This maintenance would include seeding grass, clearing of debris, and occasional visual inspections. The catch basin would also need to be cleaned periodically. Permitting and regulations are discussed in Section Seven.

6.3 STREAM STABILIZATION (SITE 7)

6.3.1 Existing Site Description

Bank erosion is occurring along the intermittent stream (Site 7) northeast of the Oakland Baptist Cemetery. The banks are incised, and a significant amount of sediment is accumulating at the northern segment of the stream prior to entering the closed storm drain system. The drainage area consists of 2 acres of developed area (roads and buildings) and 18 acres of undeveloped area (grass and brush). The area surrounding the stream is composed of hydrologic soil group D soils, which are poorly drained with low infiltration rates and high clay content, as noted previously. The material within the stream is coarser, but the grain size distribution has not been determined. The existing stream slope is approximately 6 percent on average and is greater than 7 percent at some locations.

6.3.2 Proposed Design

The primary goal for the proposed design is to limit erosion and sedimentation along the intermittent stream northeast of Oakland Baptist Cemetery. The secondary goal is to provide a solution that will have community acceptance and look more aesthetically appealing than the current incised channel.

The proposed site improvement is a stream stabilization, including the replacement of the two yard inlets at the downstream boundary of the stream reach. The proposed stream stabilization strategy is to connect the channel to its floodplain and add a step-pool configuration for improved channel stability and function. The Virginia Stream Restoration & Stabilization Best Management Practices Guide (2004) was used to estimate the geometry and spacing of the step-pool configuration. Based on the estimated channel conditions (without survey), seven steps are expected at approximately 50-foot intervals. The steps would have heights varying from 0.5 to 1.5 feet and would be preceded by pools that are approximately 10 feet long. The proposed stream slope would be approximately 4 percent as a result of the elevation drops from step-pool geometry. The step-pools would require Class II rip-rap or equivalent, and fill would be required for most of the stabilization reach. For this application, it is recommended that more aesthetic rocks, such as river rocks, be utilized. Figure 10 show the layout of the improvements and Figure 11 shows a conceptual cross-section of the nonstructural locations for the concept design. Figure 12 shows a conceptual cross-section for the steps and pools for the concept design. The final stabilization design is not expected to be trapezoidal; however, it was assumed for concept-level design purposes. The two damaged yard inlets north of the restoration reach will be replaced with standard yard inlets.

Both stream restoration and stream stabilization are complex because of the dynamic nature of streams. Detailed survey and analysis will be necessary prior to detailed design. Preliminary calculations that were used to estimate the appropriate stabilization design are available in Appendix D.

Figure 10: Proposed Stream Stabilization Concept Design

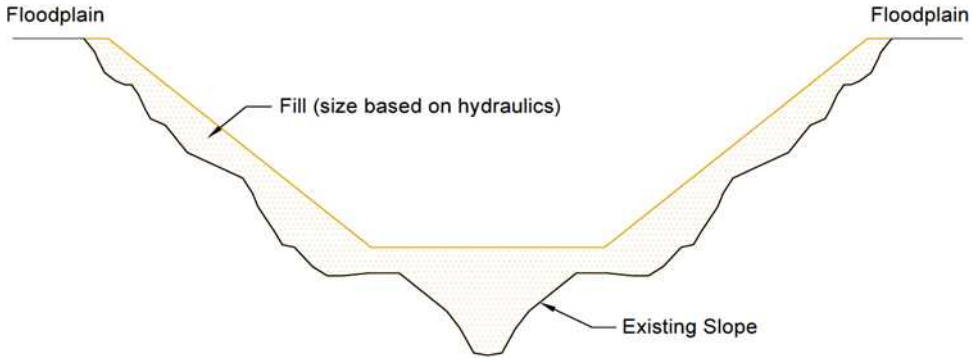

Figure 11: Typical Cross-Section Concept Design (Not to Scale)

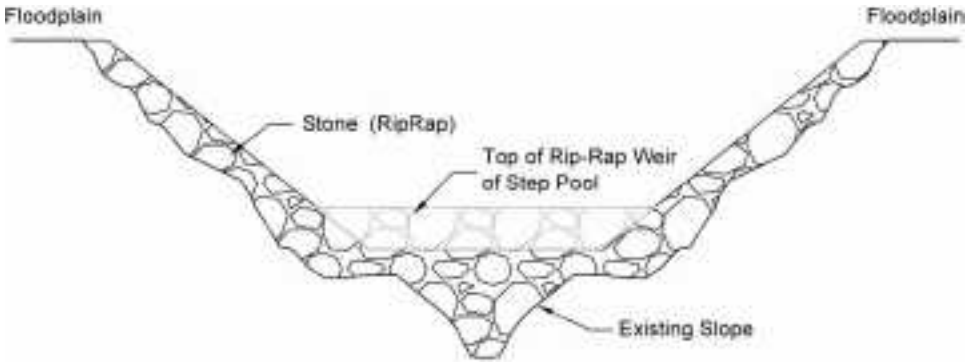

Figure 12: Step-Pool Cross-Section Concept Design (Not to Scale)

6.3.3 Improvements and Benefits

Incised stream banks indicate that a stream is not in a stable state. Without intervention, the stream condition is expected to continue to degrade with time. If the proposed stream stabilization occurs, the banks would be stabilized due to the addition of stone structures, lower channel slope, and an increase in channel roughness (due to the steps and pools). Pools would also allow for settling of fine particles, as well as providing potential habitat. Replacing the yard inlets would improve conveyance from the stream to the existing stormwater network.

Stream stabilization substantially improves the aesthetics of urban streams, and is often well received by the public. An educational sign is recommended to explain why stabilization occurred, as well as the benefits to a healthy stream.

6.3.4 Project Design Considerations

The proposed stream stabilization requires stone and sediment to be brought onsite. The installation of the elevated step-pool configuration would occur in the stream followed by the addition of fill to connect the channel to its floodplain. Pump-around diversion will be required to temporarily pump base flow around segments of the stream channel that are under construction.

Several other options were considered for stabilization design. These include connecting the bank to the channel by creating inset floodplains (cutting into the bank instead of raising the channel). The site is located within a Maximum Cultural Resource Protection area as specified by the Alexandria Archeology Office of Historic Alexandria due to potential burial sites in the area. Because of its location in the Maximum Cultural Resource Protection area, stream or bank excavation is not an option. Other stream structures including cross-vanes and log drops were also considered, but they generally require more excavation than step-pools.

Replacing the existing yard inlets would require excavation of the current inlets and hauling of the excess material offsite. The new yard inlets would also need to be installed and connected to the existing stormwater network.

6.3.5 Feasibility

Construction access to the proposed stream stabilization site would be available through Fort Ward Park Loop Road via Braddock Road. It will be necessary to drive on grass from the Park Loop Road. No utilities are expected to be impacted, although further coordination with the City would be needed during detailed design for confirmation.

Ideally, no trees would be removed during the stabilization process, but it is possible that some may need to be removed or relocated. It is also possible that trees could be damaged as a result of equipment. Trees may be planted following the stream restoration to help meet the City of Alexandria's Urban Forestry Plan goal of 40 percent tree cover over the City. Sediment control practices will have to be implemented during construction to avoid negatively impacting downstream waters.

The area surrounding the stream stabilization site will need to be temporarily closed off to the public. Fencing and signs may be necessary to keep park visitors from accessing the construction areas. Once the stabilization is complete, periodic inspection would be required to verify that there was not substantial movement of channel aggregate. In the two years following stream stabilization, some steps and pools typically require slight adjustments to function efficiently in the long term. Permitting and regulations are discussed in Section Seven.

6.4 COST ESTIMATE

Costs have been estimated for each of the proposed improvements described in sections 6.1-6.3.

The cost estimate described below should be considered as planning level only, and should be updated and refined with preliminary engineering and final project design.

The estimated costs for the proposed stormwater filter are shown in Table 7. The unit cost for the stormwater filter unit and installation was based on correspondence with Contech for the StormFilter. The remaining unit costs are from the Fairfax County Land Development Services 2013 Comprehensive Unit Price document as requested by the City of Alexandria.

Table 7: Stormwater Filter Concept Design Estimated Costs (Site 3)

Item	Quantity	Units	Unit Cost	Total
Excavation	70	CY	$23.36	$1,635.20
StormFilter Filtration System	1	EA	$60,000.00	$60,000.00
StormFilter Installation	1	EA	$15,000.00	$15,000.00
Restore Parking Area	30	SY	$35.04	$1,051.20
Mobilization	1	EA	$10,000.00	$10,000.00
CY = Cubic Yard		Initial Project Costs		$87,686.40
EA = Each		Maintenance	25%	$21,921.60
SY = Square Yard		Erosion and Sediment Control	20%	$17,537.28
		Subtotal 1		$127,145.28
		Contingency	25%	$31,786.32
		Subtotal 2		$158,931.60
		Engineering		$40,000.00
		Total		**$198,931.60**

The estimated costs for the proposed diversion berm concept design are shown in Table 8. The unit costs are from the Fairfax County Land Development Services 2013 Comprehensive Unit Price document as requested by the City of Alexandria.

Table 8: Diversion Berm Concept Design Estimated Project Costs (Site 6)

Item	Quantity	Units	Unit Cost	Total
Fill	100	CY	$23.36	$2,336.00
Excavation	30	CY	$29.20	$876.00
Erosion Control Matting	400	SY	$1.87	$748.00
Grading	700	SY	$0.90	$630.00
Clearing / Grubbing	1	AC	$7,006.50	$7,006.50
Tree Planting	5	EA	$525.49	$2,627.45
Catch Basin (Yard Inlet)	1	EA	$5,464.37	$5,464.37
12" Reinforced Concrete Pipe	80	LF	$47.88	$3,830.40
Outlet Protection (RipRap)	5	SY	$56.05	$280.25
Grass Seeding and Fertilizer	1000	SY	$2.34	$2,340.00
Mobilization	1	EA	$10,000.00	$10,000.00
AC = Acres		Initial Project Costs		$36,138.97
CY = Cubic Yard		Berm Maintenance	25%	$9,034.74
EA = Each		Erosion and Sediment Control	20%	$7,227.79
LF = Linear Feet		Subtotal 1		$52,401.51
SY = Square Yard		Contingency	25%	$13,100.38
		Subtotal 2		$65,501.88
		Engineering		$50,000.00
		Total		**$115,501.88**

The estimated costs for the proposed stream stabilization are shown in Table 9. The unit cost for step-pools is from the Virginia Stream Restoration & Stabilization Best Management Practices Guide (2004). The remaining unit costs are from the Fairfax County Land Development Services 2013 Comprehensive Unit Price document as requested by the City of Alexandria.

Table 9: Stream Stabilization Concept Design Estimated Project Costs (Site 7)

Item	Quantity	Units	Unit Cost	Total
Step Pools (Stone and Labor)	410	Ton	$50.00	$20,500.00
Fill	350	CY	$23.36	$8,176.00
Grading	1000	SY	$0.90	$900.00
Clearing / Grubbing	1	AC	$7,006.50	$7,006.50
Tree Planting	5	EA	$525.49	$2,627.45
Yard Inlet	2	EA	$5,736.69	$11,473.38
Dispose of Existing Yard Inlet	10	CY	$40.88	$408.80
Temporary Pump Around	2	Month	$11,677.00	$23,354.00
Mobilization	1	EA	$10,000	$10,000.00
AC = Acres		Initial Project Costs		$84,446.13
CY = Cubic Yard		Step-Pool Maintenance	25%	$21,111.53
EA = Each		Erosion and Sediment Control	20%	$16,889.23
SY = Square Yard		Subtotal 1		$122,446.89
		Contingency	25%	$30,611.72
		Subtotal 2		$153,058.61
		Engineering		$50,000.00
		Total		**$203,058.61**

SECTION SEVEN: PERMITTING REQUIREMENTS AND FUTURE REGULATIONS

7.1 FEDERAL REGULATIONS

7.1.1 General

The Clean Water Act (CWA) of 1972 and its amendments are the primary federal law that protects "navigable waters" of the U.S. from water pollution. Titles III and IV of CWA discuss EPA's Water Quality Standards (WQS) program and the National Pollutant Discharge Elimination System (NPDES) program.

CWA gives individual states the authority to implement CWA on all lands including federal property. In Virginia, the Virginia Department of Environmental Quality (DEQ) is responsible for issuing NPDES construction activity permits and NPDES Small Municipal Separate Storm Sewer System (MS4) permits. The terminology in Virginia is slightly different: the NPDES program is called the Virginia Pollutant Discharge Elimination System (VPDES) program and the NPDES permits are called Virginia Stormwater Management Program (VSMP) permits.

When activities require discharge of dredged or fill material into Waters of the U.S., a permit authorized by the U.S. Army Corps of Engineers (USACE) pursuant to section 404 of the Clean Water Act (CWA) (33 U.S.C. 1344) and a Virginia Water Protection permit Section 401 Certification must be obtained prior to conducting work.

7.1.2 Total Maximum Daily Loads (TMDLs) and Waste Load Allocations

Title III of the CWA discusses the federal WQS program. States are responsible for setting WQS by designating uses for each water body (e.g., drinking water use, primary contact/swimming use, fishing use, shell-fishing use, and aquatic life use) and applying water quality criteria to protect the designated uses.

TMDLs, which are the maximum amounts of pollutants that a water body can receive and still meet WQS, are developed for impaired waters listed in the 2012 Virginia 305(b)/303(d) Waster Quality Assessment Integrated Report. The TMDL applicable to Fort Ward Park is shown in Table 10.

Table 10: Impairments of Nearby Waterbodies from the 2012 Virginia 305(b)/303(d) List

Associated Waterbody	Pollution Status	Cause for Impairment	Source
Four Mile Run	Impaired	E. Coli	Illicit connections/hook-ups to storm sewers Wastes from pets Waterfowl

Source: Virginia Environmental GIS dataset "2012 Draft Water Quality Assessment GIS Applications" available at: *http://www.deq.virginia.gov/ConnectWithDEQ/VEGIS/2012DraftWQMAssessmentGISApplications.aspx*

A bacteria TMDL for the Four Mile Run watershed was completed and approved in 2002.

The TMDL implementation plan was approved in 2004, which called for "proper pet waste disposal." The Park is in compliance with the implementation plan since it has a pet waste station at the dog exercise area. This is the only dog exercise area within the non-tidal Four Mile Run watershed.

7.1.3 Approvals for Bank Stabilization Projects

USACE issued Nationwide Permit 13 (NWP 13) for bank stabilization projects on February 21 2012. NWP (13) authorizes bank stabilization up to 500 feet in length and up to 1 cubic yard of material per running foot placed along the bank below the plane of the ordinary high water mark. The recommended bank stabilization project in Section Six is less than 500 feet long. Therefore, no additional permitting is required from USACE.

A Virginia Water Protection Permit is required for bank stabilization projects, and the City needs to submit the Virginia Joint Permit Application to the Virginia Marine Resources Commission, which serves as the clearinghouse for Federal and State wetland and waterway permits.

7.2 STATE REGULATIONS

Legislation passed by the 2012 General Assembly integrated and consolidated components of the Erosion and Sediment Control (ESC) Act, the Stormwater Management Act, and the Chesapeake Bay Preservation Act so that these regulatory programs could be implemented in a consolidated and more consistent and efficient manner. The new regulations were approved by the Board of Conservation and Recreation on September 28, 2012, and became effective on November 21, 2012.

During construction, a land disturbance permit may be required for ESC. These permits are issued by localities as part of their ESC program. A stormwater permit may be required to discharge stormwater from a construction activity. Such a permit may also be required to discharge stormwater through a stormwater conveyance system owned or operated by a government entity. DEQ administers these stormwater permits under the VSMP Permit Regulations, authorized by the Virginia Stormwater Management Act. As mandated by CWA and the Code of Federal Regulations, federal permitting requirements have been incorporated into the VSMP permit regulations.

7.2.1 General Permit for Discharge of Stormwater from Small Municipal Separate Storm Sewer System (MS4)

Under the VSMP permit regulations, the City is required to control stormwater pollution to the maximum extent practicable and to develop a pollution prevention plan – known as a Municipal Separate Storm Sewer System (MS4) Program Plan. The current MS4 permit for the City is valid from July 1, 2013 to June 30 2017.

7.2.2 General Permit for Discharge of Stormwater from Construction Activities (VAR10)

The Virginia DEQ administers VSMP's General Permit for Discharges of Stormwater from Construction Activities. The General VSMP Permit authorizes stormwater discharges from the following types of land-disturbing activities at Fort Ward Park:

- Operators of construction activities resulting in land disturbance equal to or greater than one acre;
- Construction activities with land disturbance less than one acre that are part of a larger common plan of development or sale that disturb one or more acres. A larger common plan of development or sale is a contiguous area where separate and distinct construction may be taking place at different times on different schedules.

To be in compliance with the general permit, it is necessary to follow the steps listed below. In most cases, construction projects at the Park will be contracted out; however, the City of Alexandria is ultimately responsible for ensuring that a Stormwater Pollution Prevention Plan (SWPPP) is written and implemented for all regulated construction activities, and that construction activities are properly registered.

- Prepare a Registration Statement
- Prepare a site-specific SWPPP
- Apply for permit coverage
- Conduct construction in accordance with the permit and SWPPP
- Submit a notice of termination after construction is complete

A registration statement (Form DEQ199-146) and fee form (DEQ199-213) must be completed and submitted to the State along with the appropriate fee payment.

The SWPPP must be prepared prior to submitting a registration statement for permit coverage. The SWPPP is to be retained at the construction site along with a copy of the permit and permit coverage letter.

7.3 CITY OF ALEXANDRIA PERMIT REQUIREMENTS

Currently, the City plans to amend the Environmental Management Ordinance (EMO) and the Erosion and Sediment Control Ordinance to comply with several new regulatory requirements. The proposed EMO is available on the City website (http://www.alexandriava.gov/tes/oeq/info/default.aspx?id=3844) and the first hearing is scheduled for March 11, 2014.

No land-disturbing activities may commence until the final site plan is approved by the City and a state construction general permit has been issued.

7.3.1 Floodplain

The Park does not have lands designated as Federal Emergency Management Agency (FEMA) floodplains.

7.3.2 Chesapeake Bay Preservation

The Park does not have lands designated as a Chesapeake Bay Preservation Area.

7.3.3 Maintenance of Traffic (MOT) Permit

The City requires a permit on any work in the public right-of-way (street, grass strip [area between the sidewalk and the street], sidewalk, public alleys). Types of work that require a permit includes: placing a ladder and/or scaffolding on the sidewalk; closing the sidewalk; crossing the curb, gutter, and sidewalk with heavy equipment, a dumpster, or a crane; lane closure; stockpiling materials in the public right-of-way; trailer in the public right-of-way; temporary fence in the public right-of-way; hauling construction debris, materials, or equipment; excavation in the public right-of-way; and special events such as a block party, foot race/walk-a-thon, or parade/procession.

City code definition of "street" [see code section 1-1-5(13)] - The word "street" shall include avenues, boulevards, highways, roads, alleys, lanes, viaducts, bridges and the approaches thereto and all other public thoroughfares in the city and shall mean the entire width thereof between abutting property lines; it shall be construed to include a sidewalk or footpath, unless the contrary is expressed or unless such construction would be inconsistent with the manifest intent of the council.

A permit for work in/use of the public right-of-way should be applied for 5 business days prior to the start of the work. A drawing will be required showing the location of the work/use and equipment, together with a maintenance of traffic plan.

SECTION EIGHT: CONCLUSIONS

Fort Ward Park is susceptible to nuisance flooding and erosion due to overland flow and flooding. URS conducted a field reconnaissance and examined 16 sites at the Park to evaluate the existing conditions and identify potential measures to improve drainage and reduce sedimentation. URS also performed hydrologic and hydraulic analyses to verify the capacity of the existing stormwater systems. Most culverts are designed to convey 25-year storm events, provided routine maintenance is performed.

This report summarizes the drainage improvement recommendations based on the field observations, engineering calculations, and community input. The most frequent recommendations for the 16 sites evaluated by URS were for nonstructural improvements. These include turf seeding, soil aeration, and routine maintenance. Structural improvements were also recommended at some of the sites, including at the locations of the three proposed concept designs. The concept designs include a stormwater filter, stream stabilization, and a diversion berm.

SECTION NINE: REFERENCES

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