TECHNICAL MEMORANDUM

TO:	Fairfax County DPWES
FROM:	KCI Technologies, Inc.
DATE:	February 23, 2010 Updated December 6, 2010
SUBJECT:	Belle Haven, Dogue Creek, and Four Mile Run Watersheds Task 3.2 Subwatershed Strategy
PROJECT:	Belle Haven, Dogue Creek and Four Mile Run Watershed Mgmt Plan
KCI PROJECT NO:	01-07-1644

INTRODUCTION

This Technical Memorandum describes the work of developing strategies for subwatershed improvements completed in Subtask 3.2, which was conducted to identify the more critical subwatersheds where improvements can have the most significant impact.

UPDATE FOLLOWING DRAFT PLAN FORUM

The most significant change in the development of the subwatershed strategy, which came out of the Draft Plan Forum and review of the plan, was to focus on restoration strategies and omit the discussion of preservation. The reasoning behind this decision was that the high quality areas in the watersheds were for the most part under preservation easements or publicly owned, and the privately-owned land was sufficiently built out that there were few large contiguous areas to preserve that would have a significant impact on watershed conditions.

In addition, a revision was made to the pollutant loading calculations which had an effect on the water quality indicator group and the overall composite score. The final subwatershed ranking was revised to include pollutant loads from stream erosion with the upland sediment, nitrogen, and phosphorus loads modeled in STEPL. Scores by subwatershed are described in more detail in a subsequent Technical Memorandum for Task 3.3, Investigation of Candidate Projects.

PROCEDURE

Watershed Advisory Group Input

This subtask required input from the Belle Haven, Dogue Creek, and Four Mile Run Watersheds Advisory Group (WAG). A facilitated discussion of restoration approaches was conducted at the second WAG meeting, held on May 5, 2009. The results of the meeting helped to shape the strategy presented below.

WAG members contributed the following approaches for subwatershed prioritization:

- Focus on restoring headwater areas.
- Identify healthy streams and focus on restoring impaired tributaries and subwatersheds

that drain to them.

The following recommendations affect the location of specific projects and project sites:

- Focus on publicly maintained land
- Projects where the cost could be shared with developers

Preservation Discussion

Preventing impairment through preservation is an effective method of maintaining healthy watersheds or sections of watersheds. The strategy for preservation is relatively simple to describe but can be difficult to execute:

- Preserve areas in good condition from development or degradation through purchase, easements, conservation agreements, education or other approaches

Restoration Discussion

The recommendations recognize the issue that improvements in headwater areas have the potential to reduce stressors downstream and improve conditions throughout the stream network. This "top down" approach ensures that projects downstream will be sustainable. A restoration strategy which summarizes the discussion is as follows:

- Restore headwater areas with healthy streams downstream
- Restore other impaired headwater areas

The word "restore" implies that the area in question is not in good condition. Headwater areas in need of restoration therefore need to meet both conditions of being impaired and of being a headwater.

Identifying Priority Subwatersheds

The subwatershed ranking procedure developed for the county's watershed planning process provides a wealth of information that can be used to help identify priority subwatersheds. Most of the information is an indicator, so that conditions in one subwatershed can be directly compared against another. More information on the indicators can be found on the county Goals and Objectives Web site at: www.fairfaxcounty.gov/dpwes/watersheds/wsgoalsobj.htm. The following discussion describes how the data were used to select the priority subwatersheds.

Preservation

Subwatersheds in this category are those that have open space or other undeveloped area which has not been converted to an urban land use. Urban land is defined as all residential, commercial, industrial, institutional and transportation areas. The ranking procedure included one indicator that measures the degree of development, "Percent Urban Land Cover." Subwatersheds flagged for preservation were those with less than 50 percent urban land cover.

Restoration

Impaired Subwatersheds Four indicator groups provide information on the general conditions of

each subwatershed. There are several measurable indicators that make up each group. These are shown in Table 1 by an "o" and discussed below.

Stormwater Runoff Impacts Runoff indicators summarize the conditions of the streams within the subwatershed and have been used primarily to assist in locating potential stream restoration sites. Best Professional Judgment (BPJ) was used with their analysis because collection of stream assessment data did not take place in every subwatershed, and as a result, several of the indicators may use values from adjacent or similar subwatershed, skewing the analysis of priorities.

Flooding Hazards. The indicators for flooding hazards have been derived from planning-level hydraulic modeling for the project. They include residential or commercial buildings that are shown within the modeled 100-year flood limit, drainage complaints related to flooding received by Fairfax County, and crossings which are modeled as flooded above the level-of-service. In practical terms, this meant crossings shown as overtopped by the 10-year event, as the only 100-year level-of-service crossings are for interstate highways.

Habitat Health. These indicators describe conditions of the natural resources that contribute to habitat quality: Forest cover, wetlands, and riparian buffers. All four are derived from GIS coverages at varied resolution and quality.

Water Quality. Four indicators are used in this objective score. Three are derived from watershed modeling, which is specific to each subwatershed and integrates GIS data on imperviousness, land use, and stormwater treatment. The fourth is based on monitoring data for E. coli collected by Virginia Department of Environmental Quality (VDEQ). Only twenty sites are monitored for the entire watershed, so data are not available for each subwatershed and surrogate data were used.

Table 1: Indicators and Indicator Groups

Impact / Source Indicator	Runoff Impacts	Flooding Hazards	Habitat Health	Water Quality
Benthic Communities	o			
Fish Communities	o			
Aquatic Habitat	o		o	
Channel Morphology	o			
Instream Sediment	o			
Hydrology	o			
Number of Road Hazards		o		
Magnitude of Road Hazards		o		
Residential Bldg Hazards		o		
Non-residential Bldg Hazards		o		
Flood Complaints		o		
RPA Riparian Habitat			o	
Headwater Riparian Habitat			o	

Impact / Source Indicator	Runoff Impacts	Flooding Hazards	Habitat Health	Water Quality
Wetland Habitat			o	
Terrestrial Forested Habitat			o	
E. Coli				o
Upland Sediment				o
Nitrogen				o
Phosphorus				o

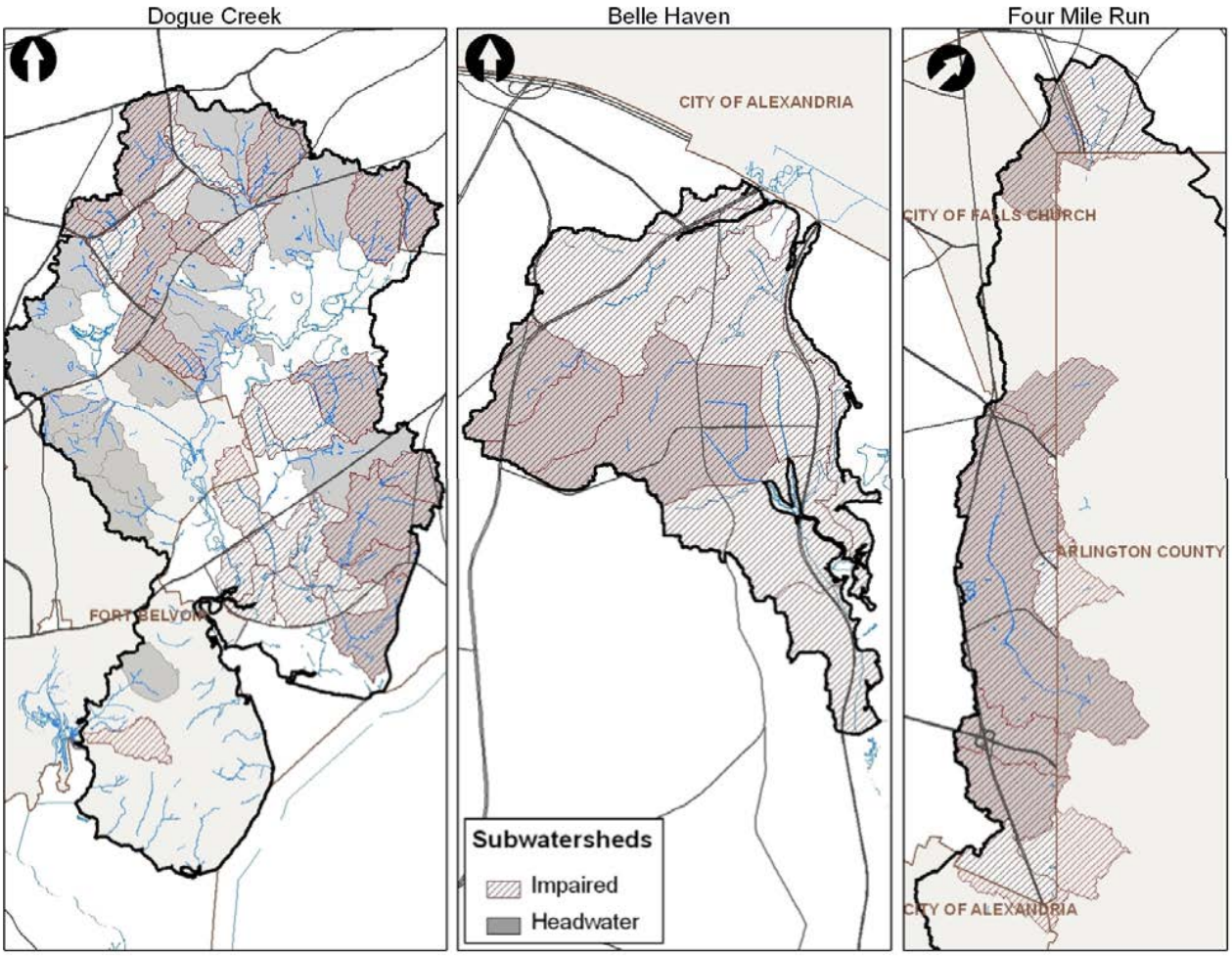
For the purpose of identifying candidate sites for restoration, subwatersheds that ranked poorly in these watershed groups were flagged. Poor ranking was defined as the worst 20 percent value for all of the subwatersheds in Dogue Creek, Belle Haven, and Four Mile Run, combined as one set of subwatersheds.

Headwaters Headwater subwatersheds are defined as the subwatersheds where a stream begins, either for the main channel, a tributary, or a small branch draining to either. Subwatersheds draining directly to tidewater were not included.

Figure 1 visually depicts subwatershed prioritization for project selection. Headwater subwatersheds are shown in grey and impaired subwatersheds are identified by the red hatch. There are some features of interest in each watershed that can be seen.

First, every subwatershed in Belle Haven and Four Mile Run met the criteria for impairment, while in Dogue Creek a majority of the subwatersheds were in better condition. Second, essentially all of the Four Mile Run subwatersheds are headwaters, either to the mainstem or to Upper Long Branch. As a result, investigations of restoration sites were made watershed-wide in this area. While impaired areas of Belle Haven occur throughout the watershed, only two subwatersheds were classified as headwater areas, so the focus on restoration investigations was concentrated to this land area. Dogue Creek has impaired headwater areas in all of its WMAs, although the largest concentration is in the upper Mainstem and North Fork WMAs

Figure 1: Subwatershed Strategy



TECHNICAL MEMORANDUM

TO:	Fairfax County DPWES
FROM:	KCI Technologies, Inc.
DATE:	February 5, 2010 Updated December 6, 2010
SUBJECT:	Belle Haven, Dogue Creek, and Four Mile Run Watersheds Task 3.3 Structural Project Selection
PROJECT:	Belle Haven, Dogue Creek and Four Mile Run Watershed Mgmt Plan
KCI PROJECT NO:	01-07-1644

INTRODUCTION

This Technical Memorandum describes the approach and results of identifying and assessing candidate sites for projects completed in Subtask 3.3.

Subtask 3.2 was conducted to identify the more critical subwatersheds improvements can have the most significant impact. In Subtask 3.3, these areas were reviewed using mapping and knowledge of retrofit approaches to identify potential sites where projects could be constructed. A field assessment of each site was conducted to identify potential constraints and better determine the feasibility of each project.

UPDATE FOLLOWING DRAFT PLAN FORUM

Pollutant loading calculations for each subwatershed were revised to include pollutant loads from stream erosion with the upland sediment, nitrogen, and phosphorus loads modeled in STEPL. The revision resulted in changes to the ranking and indicator scores for several of the subwatersheds where erosion was identified. The change is shown in the added columns for Final Rank and Final Water Quality in the subwatershed strategy tables in the WMA sections that follow.

The change did not affect selection of candidate sites, which was determined more by the detailed impact group scores and identification of specific indicators and causes for low ranking than by the overall composite score. In particular, the change in water quality and overall rank caused by adding increased pollutant loads from streams did not require a change in stream restoration project selection. As described below, potential stream projects were identified through detailed review of the PSA database and field photographs.

PROCEDURE

While the subwatershed strategy in Subtask 3.2 focused on two approaches, restoration and preservation, the subsequent work for developing specific projects and programs was undertaken using the County's approach from the Watershed Management Plan Development Standards, Version 3.2, (WMPDS) issued in March, 2009. This approach defined two types of projects: structural and non-structural, with a separate prioritization process for each.

The restoration strategies discussed with the WAG were included in both structural and non-structural projects, and the preservation strategies were included as one of the non-structural project types, specifically the category of Conservation Acquisition / Land Conservation Coordination projects.

There were two phases in the identification and assessment of candidate sites for restoration, defined as sites where a particular type of retrofit project could be built which would reduce the impairments identified through the analysis of subwatershed indicators described above. The first was a desktop analysis. This analysis involved the use of GIS data and orthophotography, along with field data and onsite photography from the Physical Stream Assessment (PSA), Neighborhood Source Assessment (NSA) and Hotspot Site Investigation (HSI). In some instances, maps and photography from Internet sites were also useful. These included http://maps.google.com and http://www.bing.com/maps/. The desktop analysis varied for each type of project and for each identified impairment, as discussed in the following section.

Candidate sites for stormwater retrofits and stream restoration were subsequently assessed in the field. The field assessment was designed to identify any site constraints which would prevent certain types of improvements from being implemented, or opportunities that would make others more likely to be successful. The conclusion of the field assessment was either a rough concept for the improvement, or a no-go decision that the constraints outweighed the potential benefits. Constraints included:

- Environmental constraints: impacts to wetlands and forests, suitability of soils
- Design constraints: utility relocation, construction access, topography
- Community constraints: impacts to adjacent land use, health or safety issues, opportunities for education or stewardship

The results of the assessment were compiled into the Candidate Project Investigation Database which incorporated the field assessment sheets, field maps, and pictures. The data were posted to the project ftp site in two locations:

- */KCI/BDF/7-0_Documentation/ Project_database_09_30_2009/BDF.mdb*
- */KCI/BDF/3-0_Strategies/3-3_Investigation/2009-09-15 Field Investigation*

GIS layers for the candidate sites were added to the project database and submitted to the ftp site in this location:

- */KCI/BDF/7-0_Documentation/Candidate_Site_Update/BDF2.mdb*

Specific results of the site selection and assessment for each WMA are provided in separate sections following the discussion of structural project types below.

Structural Projects

Stormwater Runoff Impacts (Objective 1A)

Candidate sites for projects to restore stormwater impacts on streams were identified first using PSA data, then by reviewing photography taken during the assessment. Best Professional Judgment was used in reviewing all the data available to determine whether the impacts were significant. The PSA data analysis included use of the following assessment data:

- Erosion Lines with Severe to Extreme impact scores (7 to 10), and Moderate to High restoration potential.
- Bank Stability recorded during the habitat assessment. Unstable and Moderately Unstable banks were flagged (40% to 100% of the bank for the reach has erosional areas).
- Channel Evolution Model assessment in categories 2 (Incising) or 3 (Widening).
- Habitat Assessment of Poor or Very Poor
- Other impacts, including obstructions, head cuts, utility impacts, or crossing impacts.
- Concrete or paved channels which could be restored to natural conditions

The following types of candidate projects were identified:

Stream Restoration Projects included stream restoration through reconstruction of cross-sections and profile, streambank stabilization, spot stabilization of specific sites such as head cuts or utilities, removal and restoration of concrete channels and daylighting of streams in storm drains.

Flooding Hazards (Objective 1B)

The modeled 100-year flood limit was the main source for identifying project sites. The flood limit mapping was used to identify structures and crossings that were affected, which was cross-checked against drainage complaints. Candidate projects included:

Flood Protection / Mitigation Reconstruction of road crossings, replacement of storm drains which appeared to be limiting flow, flood control storage upstream or onsite mitigation projects.

Habitat Health (Objective 2A)

All potential projects and programs for reforestation, restoring wetlands, or restoring riparian buffers are included as Non-Structural Projects.

Water Quality (Objective 3)

Water quality impairments were identified by stormwater runoff pollutant load modeling. Candidate sites were selected to either treat areas built before any stormwater management regulations were in place, or to retrofit existing quantity controls to add water quality treatment. The following types of candidate projects were identified:

New SWM Pond Sites in headwater areas downstream of untreated development where

the topography is suitable and sufficient open space is available to create an extended detention pond, wet pond or stormwater wetland. Public ownership of the site is an important consideration.

SWM Pond Retrofit Sites to add water quality treatment storage or features such as vegetated aquatic benches, micropools, or forebays to existing ponds designed for quantity control only.

Area-Wide Improvements Sites where water quality filters or other treatment can be installed at inlets throughout a drainage area or neighborhood.

Culvert Retrofit Sites where headwater or intermittent streams flow through roadway crossings where the topography allows storage to be created for wetlands or extended detention.

New BMP/LID These sites focused on treating paved areas, including parking lots for shopping centers, schools, and other institutions, by retrofitting medians, islands, and parking lot edges for bioretention, swales, sand filters and other onsite treatment systems. Other candidate sites included rain gardens, downspout disconnection, permeable pavers and green roofs.

Outfall Improvements Sites to add plunge pools, energy dissipaters or off-line storage to reduce impacts of high flows or add water quality treatment.

BELLE HAVEN

Subwatershed Strategy

The results of the subwatershed strategy analysis showed that all the subwatersheds in Belle Haven were impaired in some form. All except one were among the lowest ranking for the composite score of impacts and sources. In terms of overall ranking, Belle Haven had the four highest priority subwatersheds for the overall project. Flooding hazards are a significant issue in the Belle Haven WMA, which has been part of a planning process by the US Army Corps of Engineers. Four subwatersheds in this WMA were identified as headwaters and were reviewed for potential stormwater retrofit improvements. Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups.

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
BE-BH-0000	**36**	**38**	0.52	1.65	0.75	0.75	0.75	
BE-BH-0005	**13**	**12**	0.52	**1.09**	0.59	0.42	0.42	
BE-BH-0010	**2**	**2**	0.52	**0.13**	0.59	0.42	0.42	
BE-BH-0015	**1**	**1**	0.52	**0.13**	0.43	0.42	0.42	Yes
BE-HC-0000	**6**	**16**	0.52	**0.59**	0.59	0.50	0.50	
BE-HC-0005	48	47	0.52	1.45	0.59	1.08	1.08	

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
BE-HC-0010	**3**	**3**	**0.40**	**0.79**	0.53	0.42	**0.33**	
BE-HC-0015	**9**	**8**	**0.47**	**0.96**	0.48	0.42	0.42	Yes
BE-HC-0020	**4**	**4**	**0.33**	1.45	0.43	**0.33**	**0.33**	Yes
BE-HC-0025	**21**	**22**	0.52	1.72	0.59	**0.33**	**0.33**	Yes
BE-PO-0000	**35**	**37**	0.73	1.49	0.69	0.42	0.42	
BE-PO-0005	**34**	**36**	0.73	1.58	0.59	0.42	0.42	

Runoff Impacts on Streams *BE-HC-0010*

This subwatershed received a low rating because all of its streams received habitat ratings of poor or very poor. Physical condition of the streams was also impaired, with active erosion and unstable banks throughout.

BE-HC-0015

The stream in this subwatershed is a tributary to Quander Brook, draining an area that extends to West Potomac High School and Richmond Highway through a 60-inch diameter storm drain outfall. It was ranked among the lowest for runoff impacts, primarily because of surrogate estimates of biological and gemorphological indicators from adjacent streams. Aquatic habitat was rated poor. No potential stream restoration projects were identified.

BE-HC-0020

This subwatershed is the headwaters of Quander Brook. The downstream reach is incised, unstable, and has points of high erosion. One stormwater outfall discharges about 12 feet above the channel invert.

BE-BH-0015

Although not in the highest priority set of subwatersheds for stream impacts, there was one stream in the southeast flowing partly in a concrete channel through a high-density residential area which was investigated for restoration.

Flooding Hazards

BE-HC-0000, BE-BH-0000, -0005, -0010, -0015, BE-PO-0000

These subwatersheds are the focus of a planning process being undertaken by the US Army Corps of Engineers regarding flooding from both heavy rainfall and high waters from the Potomac River. Analysis by the Corps shows three crossings overtopped in the 10-year event, as well as almost 300 residential and commercial buildings affected in the four subwatersheds. The Corps planning process will result in proposed improvements. For this reason, the County is not proposing any potential flood mitigation projects in this area as part of this watershed plan.

BE-HC-0010

One residential building and two commercial buildings are within the modeled floodplain in this subwatershed.

BE-HC-0015

Four residential buildings are within the modeled floodplain in this subwatershed. They appear to be an artifact of the planning-level modeling, and no further project investigation was performed.

BE-BH-0015

One crossing at Yale Drive is modeled as overtopping for the 10-year event, and several residential structures are within the modeled floodplain.

Forest, Wetland, and Riparian Habitat

All of the subwatersheds in the Belle Haven WMA retained sufficient forest and wetland area to be above the threshold for impairment. No areas of restorable, deficient buffer were identified in the stream assessment.

Stormwater Quality BE-HC-

0020

This subwatershed is completely developed with commercial and transportation as major land use type with a small percentage of high- and medium-density residential areas. There are very few existing stormwater management facilities and a majority of the runoff is untreated.

BE-HC-0025

This subwatershed is completely developed with commercial, transportation and high-density residential as the major land uses. Most of the area is untreated by stormwater management facilities.

BE-BH-0015, BE-HC-0015

These subwatersheds were not in the highest priority category for improvements; however, they are headwater areas and were investigated for potential retrofit projects. BE-BH-0015 contains Belle View Elementary School and a part of West Potomac High School and is completely developed with commercial, transportation, single and multi-family residential land use types. There are very few stormwater management facilities in the subwatershed, so most of the runoff is untreated. BE-HC-0015 contains mainly single-family residential homes and a part of West Potomac High School. There are no stormwater management facilities in this subwatershed.

Candidate Sites and Potential Projects

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
BE-BH-0015				
BE-BH-0015-F01	#N/A	Flood Mitigation	BE9600 Flood Mitigation	The storm drain under Princeton Drive is modeled as flooding for the 100-year event, and the crossing at Yale Drive overtops for the 10-year event. The project would be reconstruction of the crossing and storm drain and adding upstream detention.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
BE-BH-0015-R01A	BE9516	Parking Lot Retrofit	BE9504 New BMP/LID	A retrofit was proposed for the inlets to treat the runoff from the parking lot behind Belle View Shopping Center.
BE-BH-0015-R01B	BE9519	Parking Lot Retrofit	BE9507 New BMP/LID	This project would treat runoff from the parking lot and roof of the Belle View Shopping center by implementing bioretention in the medians of parking lots and rainbarrels at downspouts.
BE-BH-0015-R01C	BE9515	Parking Lot Retrofit	BE9504 New BMP/LID	Inlet retrofit is proposed to treat the runoff from the north east section of the parking lot behind the Belle View shopping center for water quality.
BE-BH-0015-R01Z	BE9518	Street Retrofit	BE9506 New BMP/LID	Medians in a section of Belle View Blvd are proposed to be converted to dry swales to treat runoff for water quality.
BE-BH-0015-R02	BE9100	Pond Retrofit (NEW1031)	BE9100 Stormwater Pond Retrofit	Existing pond treating a majority of West Potomac HS would be reconstructed as a wet pond by excavating the bottom for additional water quality volume and replanting vegetation.
BE-BH-0015-R03	BE9511	Parking Lot Retrofit	No Action	A BMP was proposed to treat the runoff from parking area in West Potomac High School. Field assessment showed not enough available space.
BE-BH-0015-R04	BE9513	Parking Lot Retrofit	BE9503 New BMP/LID	Retrofit is proposed for the inlets to treat runoff from parking lots east of River Towers apartments.
BE-BH-0015-R04A	BE9101	Parking Lot Retrofit	No Action	A section of parking lot of River Towers Condominiums drains to a central open area. The proposed project is an extended detention dry pond to treat the runoff for water quality. Project taken out based on WAG recommendation
BE-BH-0015-R05	BE9520	Parking Lot Retrofit	BE9508 New BMP/LID	Parking lot runoff would be treated by installing bioretention in the medians.
BE-BH-0015-R05A	BE9102	Parking Lot Retrofit	BE9102 New Stormwater Pond	Parking lots and roof tops of Belle View ES drain to a low grassy area. The proposed project is to implement an extended detention dry pond treating to treat the runoff.
BE-BH-0015-R06	BE9510	Parking Lot Retrofit	No Action	There are potential sites for bioretention in parking lots of West Potomac High School; however the site is already being treated for water quality by an existing pond.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
BE-BH-0015-R07	BE9512	Parking Lot Retrofit	BE9510 New BMP/LID	This project consists of implementing bioretention in the medians and retrofits for inlets to treat the parking lot on the west side of West Potomac HS.
BE-BH-0015-R08	BE9802	Green Roof	No Action	Potential green roof is proposed to treat the roof runoff. Since the roof drains are already being treated by an existing pond, the project was not recommended.
BE-BH-0015-R09	BE9801	Parking Lot Retrofit	No Action	Runoff sheet flows to buffer areas, additional treatment not needed.
BE-BH-0015-R10	BE9522	Parking Lot Retrofit	No Action	Potential BMP to treat the parking lot runoff of Martha Washington Library. Site was inaccessible for assessment due to ongoing construction activity.
BE-BH-0015-R11	BE9509	Green Roof	No Action	There is no structure for green roof. It is a park (swings, slides) on the side of the road. Bioretention in small terraces may help to reduce WQ.
BE-BH-0015-R12	BE9521	Parking Lot Retrofit	BE9508 New BMP/LID	A section of parking lot of Belle View ES would be treated by implementing bioretention areas in the medians or in the low grassy spots.
BE-BH-0015-R13	BE9803	Green Roof	No Action	Depending on R05 and R12, may not be required. Potential to disconnect roof by means of rain gardens/bioretention.
BE-BH-0015-R14	BE9514	Parking Lot Retrofit	BE9503 New BMP/LID	Inlet retrofits are proposed to treat the runoff from parking lots west of River Towers.
BE-BH-0015-R15	BE9517	Street Retrofit	BE9505 New BMP/LID	Potential dry swale in the median of 14th Street to treat roof runoff from residences between H Street and Old Towne Rd.
BE-BH-0015-R16	BE9103	Dry Swale	No Action	An extended detention dry pond is proposed in the low open area to treat the runoff from the parking lots and access roads in Mt.Vernon Park Sports Complex. Project deleted based on WAG recommendation.
BE-BH-0015-R16A	BE9523	Parking Lot Retrofit	BE9509 New BMP/LID	Bioretention in medians and retrofits for inlets are proposed to treat the runoff from the parking lots in Mt.Vernon Park Sports Complex.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
BE-BH-0015-S01	BE9202	Stream Restoration	BE9201 Stream Restoration	This low-gradient reach has been channelized and straightened for its entire length. The potential project consists of removing the concrete channel and restoring natural bed and banks at the confluence near the southern end of Wakefield Drive.
BE-HC-0010				
BE-HC-0010-F01	#N/A	Flood Mitigation	BE9203 Flood Mitigation	Two buildings on either side of Quander Road appear to be affected because the pipe conveying the stream under Quander Road and downstream may not be sufficient for the modeled 100-year flow. The proposed project would replace or daylight the pipe.
BE-HC-0010-S01	BE9200	Stream Restoration	BE9200 Stream Restoration	Identified by photos BEBE003.E001 and E002; Streambanks were near vertical in areas, the streambed littered with broken concrete washed from upstream. The potential project would consist of spot stabilizing and armoring streambanks, with minor change to planform and profile.
BE-HC-0015				
BE-HC-0015-R01	BE9701	Outfall Retrofit	BE9701 Outfall Improvement	Severe erosion downstream of outfall. Concrete apron with baffle blocks.
BE-HC-0015-R02	BE9800	Green Roof	No Action	Green roof. No downspouts in view.
BE-HC-0015-R03	BE9508	Parking Lot Retrofit	BE9502 New BMP/LID	Replace inlet with WQ inlet.
BE-HC-0015-R04	BE9700	Outfall Retrofit	No Action	Outfall stable, little erosion.
BE-HC-0020				
BE-HC-0020-R01	BE9502	Large Parking Lot	BE9501 New BMP/LID	Part of parking lot used for park and ride. Remove pavement along NE side and add bioretention and/or WQ inlet.
BE-HC-0020-R02	BE9503	Parking Lot Retrofit	No Action	Majority of parking lot used. Can remove curbs on some medians to get some treatment. Low priority.
BE-HC-0020-R03	BE9505	Parking Lot Retrofit	No Action	Very little space available for retrofits. Almost no medians. Majority of parking lot used, so do not want to remove spots.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
BE-HC-0020-R07	BE9507	Parking Lot Retrofit	No Action	Little retrofit potential. No open space. Only room for a WQ inlet to treat part of parking lot.
BE-HC-0020-R08	BE9506	Bioretention	No Action	Downspout disconnection. Potential for bioretention / sand filter to treat some of the downspouts, not all.
BE-HC-0020-R09	BE9504	Parking Lot Retrofit	BE9501 New BMP/LID	Majority of parking lot not used. Can remove some pavement and put in bioretention. No grading needed.
BE-HC-0020-R10	#N/A	Wet Pond	BE9103 New Stormwater Pond	Daylight storm drain discharging to Quander Brook, create wet pond in eroded channel.
BE-HC-0020-S01	BE9202	Stream Restoration	BE9202 Stream Restoration	Reach BEBE0007. The stream reach begins at a 72" storm drain, constructed at the stream invert elevation. The restoration project would involve major regrading of the planform and stream dimensions and could be designed with project BE-HC-0020-R10..
BE-HC-0025				
BE-HC-0025-R01	BE9500	Parking Lot Retrofit	No Action	No action. No open areas, totally impervious. Green area in front could be used to do some WQv but no possible extended detention.
BE-HC-0025-R03	BE9501	Parking Lot Retrofit	BE9500 New BMP/LID	Three possible WQ inlets. Not many open areas. Possible bioretention.

DOGUE CREEK – BARNYARD RUN

Subwatershed Strategy

The results of the subwatershed strategy analysis showed that most of the subwatersheds in Barnyard Run were in good condition, primarily due to the influence of Huntley Meadows Park, which made up all or most of the land area in subwatersheds DC-BY-0000, -0005, -0010, -0015, -0020, and -0025. In addition, subwatershed DC-BY-0045 is wholly within Lee District Park. The three subwatersheds without significant park land (DC-BY-0030, -0035, and -0040) were all identified as headwaters and were reviewed for potential retrofits and improvements. Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups.

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
DC-BY-0000	69	102	0.83	1.72	0.85	1.17	1.17	
DC-BY-0005	71	104	0.83	1.98	0.85	1.08	1.08	

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
DC-BY-0010	72	103	0.83	1.98	0.75	1.17	1.17	
DC-BY-0015	44	77	0.83	1.52	0.64	0.58	0.58	Yes
DC-BY-0020	103	97	0.83	1.98	0.91	4.33	0.92	
DC-BY-0025	99	96	0.67	1.32	0.75	4.33	1.08	
DC-BY-0030	**24**	**35**	0.67	1.32	0.48	0.42	0.42	Yes
DC-BY-0035	51	**18**	0.67	**0.83**	0.53	1.67	0.42	Yes
DC-BY-0040	61	43	0.83	**1.12**	0.53	1.67	0.42	Yes
DC-BY-0045	94	88	0.67	1.98	0.43	3.33	0.83	Yes

Runoff Impacts on Streams

None of the subwatersheds in the Barnyard Run WMA were ranked among the high priority areas for stream problems.

DC-BY-0015, -0035, and -0040.

Review of the stream assessment data identified potential projects for restoration of concrete channels in these three subwatersheds.

Flooding Hazards DC-BY-

0035

Fourteen recently constructed townhouse residential buildings were within the modeled 100-year flood limit. They were adjacent to a concrete channel.

DC-BY-0040

One single-family residence was within the modeled 100-year flood limit.

Forest, Wetland, and Riparian Habitat

All of the subwatersheds in the Barnyard Run WMA retained sufficient forest and wetland area to be above the threshold for impairment. The only areas of restorable, deficient buffer identified in the stream assessment have been included with proposed stream restoration projects.

Water Quality

None of the subwatersheds in the Barnyard Run WMA were among the highest priority for SWM retrofits. The areas within Huntley Meadows Park were among the ones in the best condition of all three watersheds studied in this WMP.

DC-BY-0015, -0030, -0035, -0040, and -0045

These subwatersheds were not in the highest priority category for improvements; however, they are headwater areas and were investigated for potential retrofit projects. Land use is primarily medium-density and high-density residential, with some of the area treated by existing dry ponds.

Candidate Sites and Potential Projects

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-BY-0015				
DC-BY-0015-S01	#N/A	Stream Restoration	No Action	Concrete channel identified by photos and PSA, reach DCBY013. Wooded buffer, high construction impacts.
DC-BY-0030				
DC-BY-0030-R01	DC9722	Outfall Retrofit	DC9703 Outfall Improvement	Existing concrete apron is being undermined. All outfall retrofit projects were lower priority.
DC-BY-0030-R02	DC9724	Outfall Retrofit	DC9703 Outfall Improvement	Active erosion. Outfall retrofit projects were lower priority.
DC-BY-0030-R03	DC9723	Outfall Retrofit	DC9703 Outfall Improvement	Two foot drop from outfall to stream bed. Active erosion and undercutting banks, deposition downstream. All outfall retrofit projects were lower priority.
DC-BY-0030-R04	DC9536	WQ Treatment	DC9512 New BMP/LID	Existing curb cut, flows to grassy area. Bioretention area potential. Possible inlet treatments.
DC-BY-0030-R05	DC9116	Pond Retrofit (NEW2028)	DC9106 Stormwater Pond Retrofit	New development. Probably dry pond, no forebay.
DC-BY-0030-R06	DC9812	Dry Swale	No Action	Flows downhill to yard inlet. Some erosion/grass barren. Slope too steep for retrofits.
DC-BY-0030-R07	DC9535	Dry Swale	No Action	Downspouts already disconnected, sheet flowing to yard inlet. Additional dry swale benefits are minimal.
DC-BY-0030-R08	DC9537	Parking Lot Retrofit	DC9513 New BMP/LID	Groveton ES. Water quality inlet at corner inlet in parking area. Already CPv treatment onsite, add WQ. Education opportunity.
DC-BY-0030-R09	DC9813	Green Roof	No Action	Groveton ES. No downspouts can be seen on any building. Possibly tied into storm drain.
DC-BY-0035				
DC-BY-0035-F01	#N/A	Flood Mitigation	No Action	Buildings within the modeled 100-year flood limit. No drainage complaints, new development with open channel, modeling resolution issue.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-BY-0035-R01	DC9117	Pond Retrofit (0306DP)	No Action	Dry pond with low flow channel and baseflow. Excavation would require tree removal and disturbing wetland which has become established.
DC-BY-0035-R02	DC9118	Pond Retrofit (0554DP)	No Action	No room to expand channel (houses). Instream facility, No room to expand channel. Retrofit would impact existing wetlands. Maintenance needed.
DC-BY-0035-R03	DC9119	Pond Retrofi (0363DP)t	No Action	Pond very wet, probably existing wetlands. High impacts, retrofit not recommended. Maintenance needed.
DC-BY-0035-R04	DC9538	Parking Lot Retrofit	DC9514 New BMP/LID	Parking curbed with 3 inlets. No grassy area for swales or bioreten-tion. WQ inlets recommended.
DC-BY-0035-S01	DC9206	Stream Restoration	DC9210 Stream Restoration	Two concrete channels in turf buffer, townhouse development. Can extend good habitat upstream.
DC-BY-0040				
DC-BY-0040-F01	#N/A	Flood Mitigation	No Action	Buildings within the modeled 100-year flood limit. New development with open channel, modeling resolution issue.
DC-BY-0040-S01	DC9204	Stream Restoration	DC9211 Stream Restoration	Concrete channel above HM Park. Can extend good habitat upstream.
DC-BY-0045				
DC-BY-0045-R01	DC9725	Outfall Retrofit	No Action	Erosion downstream of outfall, endwall undercut. Outfall retrofit projects were lower priority.
DC-BY-0045-R02	DC9120	Pond Retrofit (NEW2027)	No Action	Field assessment found no existing BMP or stormdrain draining to the area. No potential for new BMP.

DOGUE CREEK – MAINSTEM

Subwatershed Strategy

The results of the subwatershed strategy analysis showed that a significant number of the subwatersheds in the Mainstem of Dogue Creek were in good condition, primarily due to the influence of undeveloped areas of four parcels: Huntley Meadows Park (DC-DC-0055, -0065), Woodlawn Plantation (DC-DC-0005, -0010) Greendale Golf Course (DC-DC-0090, DC-DC-0100), and Fort Belvoir (DC-DC-0015, -0020, -0025, -0030, -0035, -0040). Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups. Because of its long, narrow topography, many of the subwatersheds in this WMA were identified as headwaters.

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
DC-DC-0000	66	**22**	0.68	**0.43**	0.59	2.33	0.50	
DC-DC-0005	76	64	0.67	1.72	0.59	2.33	0.58	
DC-DC-0010	77	51	0.68	1.52	0.53	2.33	0.50	
DC-DC-0015	82	**32**	0.68	**0.99**	0.59	3.00	0.50	
DC-DC-0020	101	99	0.67	1.98	0.59	4.67	1.17	Yes
DC-DC-0025	93	60	0.67	1.98	0.59	3.33	0.50	Yes
DC-DC-0030	101	98	0.67	1.98	0.59	4.67	1.17	
DC-DC-0035	100	100	0.77	1.98	0.64	4.33	1.08	
DC-DC-0040	97	85	0.77	1.98	0.53	3.33	0.83	Yes
DC-DC-0045	45	71	0.77	1.58	0.64	0.58	0.58	Yes
DC-DC-0050	**29**	**38**	0.77	1.32	0.59	0.42	0.42	Yes
DC-DC-0055	70	101	0.77	1.98	0.85	1.08	1.08	
DC-DC-0060	53	81	0.77	1.98	0.64	0.58	0.58	Yes
DC-DC-0065	68	95	0.77	1.98	0.75	0.92	0.92	
DC-DC-0070	75	65	0.77	1.32	0.64	2.33	0.58	Yes
DC-DC-0075	58	**31**	0.67	1.32	**0.37**	1.67	0.42	Yes
DC-DC-0080	59	**30**	0.77	**0.96**	0.64	1.67	0.58	
DC-DC-0085	65	45	0.67	1.58	0.48	1.67	0.42	Yes
DC-DC-0090	**27**	37	0.67	1.45	0.48	0.42	0.42	Yes
DC-DC-0095	86	62	0.67	1.98	0.53	2.67	0.50	Yes
DC-DC-0100	89	44	0.55	1.85	0.59	3.33	0.50	Yes
DC-DC-0105	**38**	59	0.67	1.98	0.59	0.42	0.42	
DC-DC-0110	**33**	57	0.73	1.58	0.53	0.42	0.42	Yes

Runoff Impacts on Streams

None of the subwatersheds in the Dogue Creek Mainstem WMA were ranked with a high priority for stream impairments.

DC-DC-0000, -0010, -0015, -0095, and -0100.

Review of the stream assessment data identified erosion and stability issues in these subwatersheds with a potential for restoration projects.

DC-DC -0065, and -0090.

Stream assessment and storm drain records identified concrete channels in these subwatersheds with a potential to be restored to more natural conditions.

Flooding Hazards DC-DC-

0000

Five single-family residences and three commercial structures were within the modeled 100-year flood limit.

DC-DC-0015

One commercial and ten residential structures were within the modeled 100-year flood limit.

DC-DC-0080

Twenty residential buildings were within the modeled 100-year flood limit.

Forest, Wetland, and Riparian Habitat

DC-DC-0075

This subwatershed received a low ranking for terrestrial habitat, primarily for the lack of wetlands and riparian habitat. All drainage is in storm drains and there are no natural streams or wetlands remaining. No projects are proposed.

DC-DC-0000, -0010, -0080

These subwatersheds were not ranked among the worst for habitat health. The stream assessment showed one buffer site in each; however, that was rated with moderate impact and moderate restoration potential. (Photos DCDC001.B001, DCDC002.B001/B002, and DCDC509.B001)

Water Quality

None of the subwatersheds in the Dogue Creek Mainstem WMA were among the highest priority for SWM retrofits among the three watersheds.

DC-DC-0020, -0025,-0030, -0040, -0050, -0060, -0070, -0075, -0085, -0090, -0095, -0100, and -0110

These subwatersheds were not in the highest priority category for improvements; however, they are headwater areas and were investigated for potential retrofit projects. DC-DC-0020, -0025, -0030, and -0040 are entirely within Fort Belvoir and were not assessed. The remaining areas have a diversity of land use, encompassing medium- and high-density residential, commercial, institutional, and open space.

Candidate Sites and Potential Projects

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-DC-0000				
DC-DC-0000-B01	#N/A	Buffer Restoration	DC9800 Buffer Restoration	Buffer restoration adjacent to commercial / industrial site, photo DCDC001.B001. Moderate impact and moderate restoration potential.
DC-DC-0000-F01	#N/A	Flood Mitigation	No Action	No feasible mitigation project for the buildings within the floodplain.
DC-DC-0000-S01	#N/A	Stream Restoration	DC9217 Stream	Site was assessed for erosion at WAG request. Construction impacts were high

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
			Restoration	in relation to benefits.
DC-DC-0010				
DC-DC-0010-S01	DC9203	Stream Restoration	DC9208 Stream Restoration	Exposed sewer manhole and vertical banks were identified in photo DCDC002.U001.
DC-DC-0015				
DC-DC-0015-F01	#N/A	Flood Mitigation	No Action	Buildings within the modeled 100-year flood limit. Modeling done on section of stream which has been piped, no project needed.
DC-DC-0015-S01	#N/A	Stream Restoration	DC9209 Stream Restoration	Bank erosion identified by photo DCDC011.TOP.
DC-DC-0045				
DC-DC-0045-R02	DC9534	Bioretention	No Action	Used as playground/meeting/picnic area. Everything curbed, inlets draining away. Would need to reroute stormdrains.
DC-DC-0050				
DC-DC-0050-R01	DC9532	Parking Lot Retrofit	DC9510 New BMP/LID	Hayfield HS. Bioretention in medians and parking islands.
DC-DC-0050-R02	DC9529	Parking Lot Retrofit	DC9510 New BMP/LID	Bioretention or WQ inlets in turf area on downstream side of parking lot.
DC-DC-0050-R03	DC9533	Parking Lot Retrofit	DC9511 New BMP/LID	Hayfield Plaza, Very few islands. Drains toward vegetated strip with several inlets. Potential bioretention and WQ inlets.
DC-DC-0050-R04	DC9531	Parking Lot Retrofit	DC9510 New BMP/LID	Hayfield HS. Bioretention in medians and parking islands.
DC-DC-0050-R05	DC9811	Green Roof	No Action	No downspouts visible on Hayfield HS buildings. Green roofs recommended. Implementation costs much higher compared to benefits.
DC-DC-0050-R06	DC9528	Bioretention	No Action	Bioretention not recommended. Grassy area steep, road crowned, slopes in wrong direction.
DC-DC-0050-R07	DC9530	Bioretention	No Action	Small grassy area, Hayfield HS. Drainage slopes away from site.
DC-DC-0050-R08	DC9810	Parking Lot Retrofit	No Action	Hayfield Swim Club parking lot is currently graveled. All open section, very flat, flowing into grass ditch. Effectively disconnected.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-DC-0065				
DC-DC-0065-S01	#N/A	Stream Restoration	DC9212 Stream Restoration	Concrete channel, grass buffer; photo DCDC505.B001. Restore to natural channel.
DC-DC-0075				
DC-DC-0075-R91	#N/A	Culvert Retrofit	DC9400 Culvert Retrofit	Culvert retrofit proposed by WAG
DC-DC-0080				
DC-DC-0080-B01	#N/A	Buffer Restoration	DC9801 Buffer Restoration	Buffer through LDR area with moderate impact and moderate restoration potential, photo DCDC506.B001.
DC-DC-0080-F01	#N/A	Flood Mitigation	No Action	Buildings within the modeled 100-year flood limit. No feasible mitigation
DC-DC-0085				
DC-DC-0085-R01	DC9121	Pond Retrofit (0226DP)	DC9107 Stormwater Pond Retrofit	Remove concrete channels, change stormdrains to discharge at top of open area, grade out high and low marshes with long flow path and add riser to treat WQv and CPv.
DC-DC-0085-R02	DC9401	Culvert Retrofit	No Action	Stream appears stable. No sediment accumulation, riprap already stabilized banks and created riffle.
DC-DC-0085-R03	DC9541	Parking Lot Retrofit	DC9516 New BMP/LID	Dry swales, bioretention, and WQ inlets for WQ treatment. Some utility and tree removal constraints.
DC-DC-0085-R04	DC9123	Dry Pond (0936DP)	DC9108 Stormwater Pond Retrofit	Existing pond with clogged inflow has developed into wet pond / wetland. Reconstruct to enhance WQ treatment and prevent embankment failure.
DC-DC-0085-R05	DC9540	Manufactured BMP (0937MB)	No Action	Could not obtain field access for assessment.
DC-DC-0085-R06	DC9122	Dry Pond (1306DP)	No Action	Remove concrete channels. Excavate for WQv. Currently mowed, plant aquatic plants after creating high and low marshes. Design analysis indicates less room for improvement.
DC-DC-0085-R07	DC9539	Parking Lot Retrofit	DC9515 BMP/LID Retrofit	Some medians converted to bioretention areas will catch approximately half the runoff from parking lot and building. Storage in existing UG0146.
DC-DC-0090				

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-DC-0090-R01	DC9124	Wet Pond (WP0275)	No Action	Greendale GC. Create aquatic bench, more plantings. Remove concrete channel outlet and restore to more natural conditions. Design analysis indicates less potential for improvement.
DC-DC-0090-R02	DC9125	Wet Pond (WP0276)	No Action	Greendale GC. Remove concrete channel inflow. Create aquatic bench. Design analysis indicates less potential for improvement.
DC-DC-0090-R03	DC9126	Wet Pond (WP0277)	No Action	Greendale GC. Create aquatic bench and revegetate. Design analysis indicates less potential for improvement.
DC-DC-0090-S01	#N/A	Stream Restoration	DC9213 Stream Restoration	Remove concrete channel and restore stream; see photo DCDC012.BOT and DCDC509.TOP
DC-DC-0095				
DC-DC-0095-S01	#N/A	Stream Restoration	No Action	Reach DCDC015. Already restored.
DC-DC-0100				
DC-DC-0100-R01	DC9542	Parking Lot Retrofit	DC9517 New BMP/LID	Most of parking lot drains to grass area down to yard inlet. Create rain garden yard inlet.
DC-DC-0100-R02	DC9127	Wet Pond (WP0213)	No Action	Sediment deposited within facility. Excavate, create aquatic bench, revegetate. Replace missing trash racks. Design analysis indicates less potential for improvement.
DC-DC-0100-R03	DC9128	Wet Pond (WP0278)	No Action	Sediment deposited within facility. Excavate, create aquatic bench, revegetate. Replace missing trash racks. Design analysis indicates less potential for improvement.
DC-DC-0100-S01	DC9209	Stream Restoration	DC9214 Stream Restoration	Greendale GC. (DCDC014) Erosion on reach between pond retrofits R02 and R03. Moderate restoration potential
DC-DC-0110				
DC-DC-0110-R01	DC9545	Parking Lot Retrofit	No Action	Parking areas already draining to open grassy area. No erosion, so already treating WQ. Can put in swale, but not necessary. Effectively disconnected.
DC-DC-0110-R02	DC9549	Street Retrofit	DC9522 New BMP/LID	Some places along roadway have enough right-of-way for dry swales to treat the road. May need to work with residents if have existing driveway culverts.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-DC-0110-R03	DC9546	Parking Lot Retrofit	DC9520 New BMP/LID	Water quality inlets can be added near building. Medians on west side can be removed for bioretention areas. Would require tree removal and replanting at each median.
DC-DC-0110-R04	DC9129	Pond Retrofit (Not shown in KCI BMP DB)	DC9109 Stormwater Pond Retrofit	Remove concrete channels, some excavation for WQv. Add aquatic vegetation. Maintenance at riser, clear debris.
DC-DC-0110-R05	DC9814	Parking Lot Retrofit	No Action	Parking lot in back of church does not seem to get much use based on amount of grass growing between cracks. Potential for permeable pavers.
DC-DC-0110-R06	DC9550	Parking Lot Retrofit	DC9523 New BMP/LID	Roof treated by dry pond on east side. On west side, disconnect roof drains onto grassy area, possible bioretention area. All of parking treated by dry pond.
DC-DC-0110-R07	DC9130	Pond Retrofit (DP0104)	DC9110 Stormwater Pond Retrofit	Remove concrete channels, excavate. Plant aquatic vegetation. Treating most of parking lot.
DC-DC-0110-R08	DC9548	Dry Pond (0661DP)	Stormwater Pond Retrofit	Grass channel with riser structure. Inlet almost completely buried. Very little room to expand. Add micropools for WQ and CPv.
DC-DC-0110-R09	DC9547	Dry Pond (0662DP)	DC9521 Stormwater Pond Retrofit	Side along houses already very steep. Functioning as grass channel with a riser. Add micropools.
DC-DC-0110-R10	DC9543	Manufactured BMP (MB0058)	DC9518 BMP/LID Retrofit	VDOT manhole with underground storage behind inlet. Add Filterra type inlet to treat WQv also.
DC-DC-0110-R11	DC9544	Manufactured BMP (MB0059)	DC9519 BMP/LID Retrofit	Add Filterra-type inlet to existing inlet to treat parking. Disconnect roof drains to treat more area.

DOGUE CREEK – NORTH FORK

Subwatershed Strategy

The results of the subwatershed strategy analysis showed that all but two of the subwatersheds in North Fork were impaired in some form and the majority were among the lowest ranking for the composite score of impacts and sources. Of the subwatersheds in this WMA, nine were identified as headwaters and were reviewed for potential stormwater retrofit improvements. Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups.

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
DC-NE-0000	**20**	**11**	**0.44**	**1.16**	0.48	0.58	0.42	
DC-NE-0003	41	63	**0.51**	1.72	0.53	0.75	0.75	
DC-NE-0005	63	**21**	0.63	**0.66**	0.43	2.33	0.58	Yes
DC-NE-0010	**23**	26	0.56	**1.22**	0.59	0.58	0.50	
DC-NE-0015	**40**	56	0.68	1.98	0.59	0.50	0.50	
DC-NE-0020	**11**	**6**	0.56	**0.92**	0.43	0.42	0.42	Yes
DC-NE-0025	**16**	**14**	**0.51**	1.25	0.43	0.42	0.42	Yes
DC-NE-0030	49	**23**	0.63	**0.96**	0.53	1.67	0.42	Yes
DC-NE-0035	**25**	**40**	0.61	1.45	0.43	0.58	0.58	Yes
DC-NW-0000	**12**	**8**	0.56	**0.73**	0.53	0.50	0.50	
DC-NW-0005	**10**	**16**	0.56	**0.99**	**0.32**	0.42	0.42	Yes
DC-NW-0010	47	**13**	0.56	1.35	0.43	1.67	0.42	
DC-NW-0015	52	**15**	0.56	1.35	0.53	1.67	0.42	Yes
DC-NW-0020	**31**	46	0.56	1.85	**0.32**	0.67	0.67	Yes
DC-NW-0025	**19**	**17**	0.56	1.25	0.43	0.42	0.42	
DC-NW-0030	**15**	**12**	0.56	**1.09**	0.53	0.42	0.42	Yes

Runoff Impacts on Streams

Low runoff impact scores for DC-NE-0000, -0003, and -0025 were caused by several low ratings in the SPA assessment discussed below. Potential sites were identified in these and other lower priority subwatersheds from desktop analysis of SPA data and photos.

DC-NE-0000

This subwatershed received a low rating because the mainstem of the North Fork tributary, which flows through it, was ranked poor for aquatic habitat, and for most of its length it was assessed as severely eroded with good potential for restoration. The same reach was identified as unstable and widening for most of its length as well.

DC-NE-0003

The reach through this subwatershed was ranked poor for aquatic habitat, with deficient buffer for most of its length, but without significant erosion or stability problems. Its location within a golf course precludes buffer restoration. No potential projects were identified.

DC-NE-0005, -0020, DC-NW-0005, -0015, -0020

Stream conditions in these subwatersheds were not among the worst in the watershed group. In each of them a portion of the streams has been channelized with a concrete channel with the potential for removal and restoration of more natural conditions.

DC-NE-0020, -0025, -0030, -0035,

Several of the stream reaches in these subwatersheds were identified as unstable and actively eroding, with either good or moderate restoration potential.

Flooding Hazards DC-NE-

0000

Two structures were within the modeled 100-year flood limits under future development conditions. No complaints of flooding have been recorded and no crossings were flooded beyond the design level-of-service. No projects were proposed.

DC-NE-0005

Approximately 25 residential buildings were within the modeled 100-year flood limits under future development conditions. Drainage complaints for these areas were generally for maintenance issues, with no repeated flooding issues. No crossings were shown as flooded and no projects were proposed.

DC-NE-0010

One residential building was within the modeled 100-year flood limits under future conditions; however, there were no drainage complaints related to flooding. The crossing on Union Farm Road (DCNF005.C001) overtopped for the 10-year event. The roadway is a gated entrance to a single parcel adjacent to Grist Mill Park and Mount Vernon Country Club.

DC-NE-0020

Several residential buildings were within the modeled 100-year flood limits under future development conditions. No long-term complaints of flooding have been recorded in the area. Three crossings, at Robertson Blvd (C005), Heather Glen Drive (C004), and Craig Avenue (C003) were modeled as overtopping for the 10-year event. Assessment of maps, photos, and a field visit showed significant constraints for enlarging the openings. Alternate routes for emergency traffic exist.

The subwatershed is built out and there are no suitable sites for stormwater detention upstream. The channel through the area is proposed for restoration to natural conditions with project Site DC-NE-0020-S02. If possible, flooding of the crossings will be included as part of this project; however, given the constraints and the availability of alternate routes if flooding occurs, no specific projects are proposed.

DC-NE-0030

Several residential buildings were shown partially impacted by the modeled 100-year flood limit. No crossings were overtopped. There were no drainage complaints associated with these areas to indicate a significant flooding problem, so no projects were proposed.

DC-NW-0000

Several residential and commercial structures were shown partially impacted by the modeled 100-year flood limit. No crossings were overtopped beyond the level-of service. There were no drainage complaints associated with these areas to indicate a significant flooding problem, so no projects were proposed.

DC-NW-0005

One commercial and several residential buildings were shown partially impacted by the modeled 100-year flood limit. No crossings were overtopped beyond the level-of service. There were no

drainage complaints associated with these areas to indicate a significant flooding problem, so no projects were proposed.

DC-NW-0030

Several residential structures are shown partially within the modeled 100-year flood limit. In addition, the crossing at Ashboro Drive immediately below this area overtops for the same event. (DCNF017.C003).

Water Quality

None of the subwatersheds in the North Fork WMA were among the highest priority for SWM retrofits, although several were on the threshold. Of these, all but one were identified as headwaters and assessed for potential stormwater improvements.

DC-NE-0005, --0020, -0025, -0030, -0035, DC-NW-0005, -0015, -0020, -0030

These subwatersheds were not in the highest priority category for improvements; however, they are headwater areas and were investigated for potential retrofit projects.

Candidate Sites and Potential Projects

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NE-0000				
DC-NE-0000-S01	#N/A	Stream Restoration	No Action	Erosion identified by photo DCNE001.C004. Further assessment showed that one reach upstream of Old Mill Road had been restored and another was waiting for funding. The downstream reach had areas of moderate erosion, but poor access.
DC-NE-0005				
DC-NE-0005-S01	#N/A	Stream Restoration	DC9205 Stream Restoration	The reach (DCNF004) was investigated to determine the feasibility of removing the concrete channel and restoring the stream to natural conditions. Site constraints precluded the project.
DC-NE-0010				
DC-NE-0010-F01	#N/A	Flood Mitigation	No Action	The crossing on Union Farm Road (DCNF005.C001) overtopped for the 10-year event. The roadway is a gated entrance to a single parcel adjacent to Grist Mill Park and Mount Vernon Country Club.
DC-NE-0020				
DC-NE-0020-F01	#N/A	Flood Mitigation	No Action	Three crossings were modeled as overtopping for the 10-year event. No suitable sites for stormwater detention upstream. Alternate routes exist for access.
DC-NE-0020-R01	DC9700	Outfall Retrofit	No Action	Field assessment showed no erosion, and no open space for storage.
DC-NE-0020-R02	DC9701	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.
DC-NE-0020-R03	DC9703	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.
DC-NE-0020-R04	DC9704	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.
DC-NE-0020-R05	DC9706	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.
DC-NE-0020-R06	DC9705	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.
DC-NE-0020-R07	DC9702	Outfall Retrofit	No Action	Field investigation showed direct discharge from pipe to concrete channel. No space for storage, no need for stabilization.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NE-0020-R09	DC9707	Outfall Retrofit	No Action	Plunge pool armored with rip rap. Concrete apron higher than stream. Fish blockage. No upstream culvert retrofit possible.
DC-NE-0020-R10	DC9708	Outfall Retrofit	No Action	Potential stream site, low potential. Outfall retrofits all rated low priority.
DC-NE-0020-R11	DC9709	Outfall Retrofit	No Action	Potential stream site, low potential. Outfall retrofits all rated low priority.
DC-NE-0020-S01	#N/A	Stream Restoration	DC9201 Stream Restoration	Reach DCNF014. This severe erosion site is along a reach with high restoration potential. A number of other issues would be addressed with the restoration, including a head cut, utility crossing, and obstruction.
DC-NE-0020-S02	#N/A	Stream Restoration	DC9200 Stream Restoration	This project is intended to remove the concrete channel and restore the stream to more natural conditions. Reconstruction will connect the habitat from the headwaters of this tributary to the tidal portion of Dogue Creek. See photo DCNF013.B001
DC-NE-0025				
DC-NE-0025-B01	#N/A	Buffer Restoration	No Action	Review of GIS and site photography indicated that the stream flows through an area where forest is re-establishing itself.
DC-NE-0025-R01	DC9500	Parking Lot Retrofit	No Action	Impervious area is already essentially disconnected. Drains to lawns.
DC-NE-0025-R02	DC9711	Storage in Conveyance - stream	No Action	Stream is incised, no significant storage opportunity.
DC-NE-0025-R03	DC9710	Outfall Retrofit	No Action	Outfall to concrete channel in good shape. No active erosion. No storage opportunity.
DC-NE-0025-S01	DC9200	Stream Restoration	DC9202 Stream Restoration	Reach DCNF011. The proposed project consists of spot stream stabilization using both hard armoring and natural practices, with only minor changes in channel dimension.
DC-NE-0030				
DC-NE-0030-B01	#N/A	Buffer Restoration	No Action	Reach DCNF010. The buffer consists of lawns, shrubs and trees that provide partial shade. Because of the hard channel boundaries, benefits of the buffer would be minimal.
DC-NE-0030-S01	#N/A	Stream Restoration	DC9203 Stream Restoration	Reach DCNF009. Severe erosion along the left bank (facing downstream) and moderate erosion along the right bank. The project would involve regrading the cross-section and planform to a stable configuration

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NE-0030-S02	#N/A	Stream Restoration	No Action	Reach DCNF010. Deficient buffer and concrete channelization were the primary reasons for this potential project site. Site constraints outweighed the benefits expected from restoration.
DC-NE-0035				
DC-NE-0035-R01	DC9512	Parking Lot Retrofit	DC9505 New BMP/LID	Parking lot drains to one inlet. There is an open area that could be used as bioretention or WQ could be installed or a combination of both.
DC-NE-0035-R02	DC9801	Pond Retrofit (1130DP)	DC9101 Stormwater Pond Retrofit	Convert to Shallow Marsh. Spoke to adjacent land owner. Pond fills to top in heavy rain, drains in a few hours, usually dry.
DC-NE-0035-R03	DC9510	Parking Lot Retrofit	DC9504 New BMP/LID	No space for bioretention. WQ inlet would be suitable.
DC-NE-0035-R04	DC9513	Parking Lot Retrofit	DC9505 New BMP/LID	All parking drains to an inlet. There is an open area that could be used as bioretention or WQ could be installed or a combination of both. Parking lot is large.
DC-NE-0035-R05	DC9514	Parking Lot Retrofit	DC9505 New BMP/LID	All parking drains to an inlet. There is an open area that could be used as bioretention or WQ could be installed or a combination of both. Parking lot is large.
DC-NE-0035-R06	DC9804	Green Roof	No Action	Reconstruct roof of Mt. Vernon HS as green roof. Project cost outweigh benefits
DC-NE-0035-R07	DC9103	Pond Retrofit	No Action	No existing pond, but open space feasible for new ponds. Daylighting NSA. Critical constraint is the depth of storm drains. If shallow this is a good location. Duplicate project with DC-NE-0035-R13
DC-NE-0035-R08	DC9102	Pond Retrofit	No Action	No pond found at site.
DC-NE-0035-R09	DC9509	Parking Lot Retrofit	DC9505 New BMP/LID	Median can be used as bioretention for parking areas.
DC-NE-0035-R10	DC9508	Parking Lot Retrofit	DC9503 New BMP/LID	Filterra of two inlets on the side
DC-NE-0035-R11	DC9802	Green Roof	No Action	Reconstruct roof of Riverside ES as green roof. Project cost outweigh benefits
DC-NE-0035-R12	DC9511	Bioretention	DC9503 New BMP/LID	Bioretention in open area between school entrance and Old Mt. Vernon Rd.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NE-0035-R13	DC9803	Wetland	DC9100-New Stormwater Pond	Open space feasible for new ponds. Could daylight storm drain. Critical constraint is the depth of storm drains. If shallow this is a good location.
DC-NE-0035-R14	DC9800	Wetland	No Action	Open area, not clear about treatment, minor incidence.
DC-NE-0035-S01	DC9208	Stream Restoration	DC9204 Stream Restoration	Reach DCNF008. This project is intended to stabilize the incision and head cuts, by adjusting the profile, stabilizing the head cuts with rock ramps or similar practices, and regarding the cross-section
DC-NW-0000				
DC-NW-0000-B01	#N/A	Buffer Restoration	No Action	Reach DCNF018. Property ownership constraints. Could conduct outreach to property owners to fill in the missing buffer where there are gaps.
DC-NW-0005				
DC-NW-0005-B01	#N/A	Buffer Restoration	No Action	Reach DCNF019. The deficient buffer in this subwatershed is adjacent to a concrete channel. Restoration would be done as part of a stream restoration project.
DC-NW-0005-S02	#N/A	Stream Restoration	DC9206 Stream Restoration	Reach DCNF019. This project is intended to remove the concrete channel and restore the stream to more natural conditions. Open space would be replanted as riparian buffer.
DC-NW-0010				
DC-NW-0010-B01	#N/A	Buffer Restoration	No Action	Reach DCNF015. Property ownership constraints. Could conduct outreach to property owners to fill in the missing buffer where there are gaps.
DC-NW-0010-B02	#N/A	Buffer Restoration	No Action	Reach DCNF018. Property ownership constraints. Could conduct outreach to property owners to fill in the missing buffer where there are gaps.
DC-NW-0015				
DC-NW-0015-B01	#N/A	Buffer Restoration	No Action	Reach DCNF021. Restoration is feasible if the channel is reconstructed and would be done as part of stream restoration project DC-NW-0015-S01.
DC-NW-0015-B02	#N/A	Buffer Restoration	No Action	Reach DCNF022. Review of project data showed that a majority of the stream buffer is forested.

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NW-0015-R01	DC9101	Pond Retrofit (1351DP)	No Action	Pond and concrete channel dry after rains. Ground solid, probably insufficient flow for wet pond or wetland. Revise riser for WQ or CPV if needed in this area, regrade the bottom. Design analysis indicates less potential for improvement.
DC-NW-0015-R02	DC9501	Parking Lot Retrofit	DC9500 New BMP/LID	Retrofit with Filterra or other WQ device. Retrofit area by bus shelter with bioretention. Inlets at entrances can't be retrofit.
DC-NW-0015-R03	DC9100	Pond Retrofit (DP0091)	No Action	Convert to wet pond and create habitat and a community amenity. Design analysis indicates less potential for improvement.
DC-NW-0015-R04	DC9502	Parking Lot Retrofit	DC9501 New BMP/LID	Bioretention or rain garden at low corner of parking lot would catch all runoff. No curbs. Good volunteer opportunity.
DC-NW-0015-R05	DC9503	Parking Lot Retrofit	DC9502 New BMP/LID	Filterra or Bioretention at all curb inlets
DC-NW-0015-R06	DC9805	Green Roof	No Action	Green roof. Roof drains not visible. Project cost outweigh benefits
DC-NW-0015-R07	DC9505	Parking Lot Retrofit	DC9501 New BMP/LID	Take up lawn of downstream edge of parking lot. No curbs - appears to be easy retrofit, potentially by volunteers.
DC-NW-0015-R08	DC9507	Parking Lot Retrofit	DC9501 New BMP/LID	66" storm drain below site. Build depressed berm with bioretention at border of street and lot.
DC-NW-0015-R09	DC9504	Bioretention	DC9501 New BMP/LID	Flows go downslope to bottom of parking lot. Site would require removal of either play area or parking (2 spaces)
DC-NW-0015-R10	DC9506	Parking Lot Retrofit	DC9501 New BMP/LID	Curb cuts and bioretention /rain garden at low points.
DC-NW-0015-S01	#N/A	Stream Restoration	No Action	Reach DCNF021. The concrete channel was investigated for removal and restoration. Constraints outweighed benefits.
DC-NW-0015-S02	DC9202	Stream Restoration	DC9207 Stream Restoration	Reach DCNF024. Field investigation showed active downcutting and erosion. Restoration would involve change in cross-sections and stabilization with hard armoring practices, and minor habitat improvement.
DC-NW-0020				
DC-NW-0020-S01	#N/A	Stream Restoration	No Action	Reach DCNF016. Very narrow concrete channel, insufficient space to restore to natural conditions.
DC-NW-0025				

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-NW-0025-B01	#N/A	Buffer Restoration	No Action	Reach DCNF015. Property ownership constraints. Could conduct outreach to property owners to fill in the missing buffer where there are gaps.
DC-NW-0030				
DC-NW-0030-F01	#N/A	Flood Mitigation	DC9600 -Flood Mitigation	Crossing at Ashboro Drive overtops and several upstream buildings are within the modeled 100-year flood limit. Culvert reconstruction could reduce backwater effects.
DC-NW-0030-R01	DC9516	Parking Lot Retrofit	No Action	2 Filterra systems already installed on property. Other inlets are VDOT, set to catch most parking and driveway runoff before VDOT inlet
DC-NW-0030-R02	DC9806	Green Roof	No Action	Roof drains not visible, may be internal to building.
DC-NW-0030-R03	DC9515	Dry Swale	No Action	Outfall adjacent to concrete channel. No erosion, limited opportunity to daylight pipe. Inflow too low for pond. Slope is a part of channel. Any storage would be flooded.
DC-NW-0030-R04	DC9400	Culvert Retrofit	DC9401 Culvert Retrofit	Culvert Retrofit for WQ ED. Would flood trapezoidal grass channel. Regrading channel and revegetation needed. Safety impacts from adjacent MFR could be significant.

DOGUE CREEK – PINEY RUN

Subwatershed Strategy

The lower reaches and subwatersheds of Piney Run are within the boundaries of Ft. Belvoir and were not assessed for retrofits or improvements. These include all or most of the area for subwatersheds DC-PY-0000, -0005, -0010, and -0015. The majority of the remaining subwatersheds met the definition of headwater areas and the assessment was focused on these areas. Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups.

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
DC-PY-0000	104	80	0.79	1.98	0.59	4.67	0.83	
DC-PY-0005	55	50	0.72	1.98	0.43	0.83	0.50	
DC-PY-0010	98	78	0.79	1.98	0.59	3.33	0.67	
DC-PY-0015	85	67	0.79	1.98	0.48	2.67	0.50	
DC-PY-0020	95	76	0.63	1.98	0.43	3.33	0.75	Yes
DC-PY-0025	92	47	0.79	1.98	0.59	3.00	0.58	

Subwatershed	Initial Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
DC-PY-0030	78	53	0.68	1.72	0.48	2.33	0.50	Yes
DC-PY-0035	90	66	0.79	1.98	0.53	3.00	0.50	Yes
DC-PY-0040	**26**	**36**	0.56	1.72	0.48	0.42	0.42	Yes
DC-PY-0045	**37**	**33**	0.68	1.52	0.53	0.58	0.50	
DC-PY-0050	**30**	**34**	0.56	1.98	**0.37**	0.42	0.42	Yes
DC-PY-0055	**28**	**39**	0.56	1.85	**0.37**	0.42	0.50	Yes

Runoff Impacts on Streams

None of the subwatersheds in the Piney Run WMA were ranked among the high priority areas for stream problems.

DC-PY-0025 -0035, -0040, and -0045.

Review of the stream assessment data identified potential projects in these subwatersheds

Flooding Hazards

None of the subwatersheds within Piney Run were a high priority for flood mitigation. No crossings were overtopped beyond the level-of-service frequency. Only one building was affected by the modeled 100-year flood limit. Recent aerial photography shows that the building, while still in the GIS database, has been demolished, and no longer exists.

Forest, Wetland, and Riparian Habitat DC-PY-

0050, -0055

These watersheds received a low ranking for habitat health. They are completely developed and there is no wetland or forest cover mapped. All natural streams have been replaced with storm drains. No feasible sites for restoration were identified and no projects have been proposed.

DC-PY-0020

This subwatershed was ranked very near the break point for poor habitat condition. One potential buffer site was identified from PSA data and assessed for improvements.

Water Quality

None of the subwatersheds in the Piney Run WMA were among the highest priority for SWM retrofits.

DC-PY-0020, -0030,-0035, -0040, and -0050

These subwatersheds were not in the highest priority category for improvements; however, they are headwater areas and were investigated for potential retrofit projects. They have a diversity of land use, primarily high-density residential and commercial areas, along with open space, most notably Hilltop Country Club.

Candidate Sites and Potential Projects

Site ID	Candidate Project Database	Proposed Action	Final Action	Notes
DC-PY-0020				
DC-PY-0020-B01	#N/A	Buffer Restoration	DC9802 Buffer Restoration	Reach DCPY006. Grassy area with scrub adjacent to the channel. The project would consist of reforestation of a 25 ft buffer to either side of the channel
DC-PY-0020-R01	DC9808	Green Roof	No Action	No downspouts were visible on building. Not known where roof drains.
DC-PY-0020-R02	DC9519	Parking Lot Retrofit	No Action	All of back parking lot draining to grass, including pavilion. Effectively disconnected.
DC-PY-0020-R03	DC9104	Pond Retrofit (1459DP)	DC9102 Stormwater Pond Retrofit	Remove concrete channels, flatten bottom, and add aquatic plants. Bottom is mowed grass - stop maintaining.
DC-PY-0020-R04	DC9518	Pond Retrofit (TBD)	DC9506 New BMP/LID	Cannot find existing pond. Could put in dry swale along houses. Would treat roofs and some driveways.
DC-PY-0020-R05	DC9807	New Pond	No Action	Large aerated existing wet pond draining to this channel. No additional retrofit needed.
DC-PY-0020-R06	DC9517	New Wetland	No Action	Existing stream channel, deep with riprap, no space for improvements. Recommend buffer restoration (DC-PY-0020-B01)
DC-PY-0025				
DC-PY-0025-R01	DC9108	Pond Retrofit (DP0238)	DC9104 Stormwater Pond Retrofit	Deposition in pond, sinuous low flow channels and wetland already developed. Add and maintain vegetation, create micropool at riser.
DC-PY-0025-S01	#N/A	Stream Restoration	No Action	Streambank erosion; (DCPY008.E001) Low restoration potential, difficult access.
DC-PY-0030				
DC-PY-0030-R01	DC9716	Outfall Retrofit	No Action	Outfall looks stable. No erosion downstream. Outfall retrofit projects were lower priority.
DC-PY-0030-R02	DC9712	Outfall Retrofit	DC9701 Outfall Improvement	Channel is eroding and undercutting banks. Outfall is 2'-3' above channel bottom. Existing riprap is stabilizing that slope. Outfall retrofit projects were lower priority.
DC-PY-0030-R03	DC9715	New Wetland	DC9701 Outfall Improvement	Blockage downstream of DC-PY-0030-R01 forces stream underground for long stretch. High impacts outweigh benefits.
DC-PY-0030-R04	DC9714	Outfall Retrofit	No Action	Outfall looks stable. No erosion, downstream channel not eroded. Outfall retrofit projects were lower priority.

DC-PY-0030-R05	DC9713	Outfall Retrofit	DC9701 Outfall Improvement	Outfall stabilization. Past erosion evident downstream. 4' from outfall to channel bottom. Outfall retrofit projects were lower priority.
DC-PY-0030-R06	DC9105	Pond Retrofit (0841DP)	No Action	Many trees within facility, including wetland plants. Functioning as wetland. Impacts outweigh benefits.
DC-PY-0035				
DC-PY-0035-S01	DC9204	Stream Restoration	DC9215 Stream Restoration	Reach DCPY010. Bank erosion, moderate impact; moderate restoration potential.
DC-PY-0040				
DC-PY-0040-R01	DC9107	Pond Retrofit (0859DP)	No Action	Dry pond, currently wet and functioning as a wetland area. Trees in and around facility. Riser functioning well. Add micropool and forebays at storm drain outfalls into pond. Design analysis indicates less potential for improvement.
DC-PY-0040-R02	DC9809	Pond Retrofit (DP0239)	No Action	Missed site. Pond is further downstream at Summer Ridge Rd from the area assessed. Design analysis indicates less potential for improvement.
DC-PY-0040-R03	DC9520	Parking Lot Retrofit	DC9507 New BMP/LID	Entire parking lot drains to two inlets. May be able to put in WQ inlets or bioretention at those locations.
DC-PY-0040-R04	DC9106	Wet Pond	DC9218 Stream Restoration	Stream channel has lots of riprap -daylight stream - create more natural sinuosity. Could possibly put in step pools for WQ. (WAG SITE)
DC-PY-0040-S01	#N/A	Stream Restoration	No Action	Identified by photos; outfall repairs; field assessment was that it was stable, no project necessary.
DC-PY-0045				
DC-PY-0045-R01	DC9110	Outfall Retrofit	No Action	Existing pond DP0237, not outfall. Functioning well as wet pond, except no vegetation within facility. Add plants for WQ. Design analysis indicates less potential for improvement.
DC-PY-0045-R02	DC9521	Parking Lot Retrofit	No Action	Parking lot and rooftop are draining to steep grass hill. No room for treatment, all open section. Essentially disconnected.
DC-PY-0045-R03	DC9109	Pond Retrofit	No Action	No pond found. No outfall besides road culvert. Would need to reroute SD to treat runoff. No project.
DC-PY-0045-R04	DC9717	Outfall Retrofit	No Action	Outfall seems stable. Erosion starts approximately 100' downstream of outfall. No project.

DC-PY-0045-R05	DC9721	Outfall Retrofit	DC9702 Outfall Improvement	Concrete pipe is crushed. Flow is coming from under concrete pieces. Maintenance needed.
DC-PY-0045-R06	DC9720	Outfall Retrofit	No Action	Outfall looks to be stabilized after previous erosion. No project.
DC-PY-0045-R07	DC9718	Outfall Retrofit	DC9702-Outfall Improvement	Concrete headwall and PVC pipe discharge into stream channel. 3' headcut just downstream of this outfall, undercutting left bank. Has previously been stabilized. Outfall projects received low priority.
DC-PY-0045-R08	DC9719	Outfall Retrofit	No Action	Plunge pool at bottom of concrete emergency spillway. Channel seems stable below. No project.
DC-PY-0045-S01	#N/A	Stream Restoration	DC9216 Stream Restoration	Identified by photos; bank erosion and heavy deposition. DCPY013.H001
DC-PY-0050				
DC-PY-0050-R0	DC9524	Bioretention	No Action	Roof drains into parking lot/driveway. Many constraints: Would need to remove curb and grade edge; however, there are utilities (electric and water) in the immediate area, as well as mature pine trees.
DC-PY-0050-R01	DC9527	Parking Lot Retrofit	DC9509 New BMP/LID	Replant medians with bioretention plants and soils. Parking lot very flat and drains to existing dry pond. Add rain gardens at downspouts.
DC-PY-0050-R02	DC9526	Parking Lot Retrofit	DC9509 New BMP/LID	Replant medians with bioretention plants and soils.
DC-PY-0050-R03	DC9115	Dry Pond (DP0311)	No Action	Small drainage area, not much room to excavate. Could replant vegetation. May need fence from parking area due to proximity of school. Constraints outweigh benefits.
DC-PY-0050-R04	DC9525	Large Parking Lot	DC9508 New BMP/LID	Most of parking lot drains to single inlet. If attached to a median, can remove curb and replace with bioretention and connect to existing stormdrain.
DC-PY-0055				
DC-PY-0055-R01	DC9112	Dry Pond (1478DP)	DC9105 Stormwater Pond Retrofit	Remove concrete channel. Currently grass (mowed), create landscaping around edge. Minor grading needed.
DC-PY-0055-R02	DC9114	Wetland (WP0107)	No Action	Some cattails present, but little other vegetation in facility. Riser performs WQv and CPv. Good existing treatment. Could add more vegetation for uptake, improve buffer.

DC-PY-0055-R03	DC9113	Wet Pond (WP0105)	No Action	Pond is maintained up to edge of water, little to no buffer. Could plant some aquatic vegetation. Outfall structure working (WQv and CPv). Good existing treatment.
DC-PY-0055-R04	DC9111	Wet Pond (WP0108)	No Action	Cattails in inlet/forebay area. Receives drainage from R03. More buffer present. Still algae in facility. Good existing treatment.
DC-PY-0055-R05	DC9523	Dry Swale	No Action	Grassy area between Manchester Lakes and parking lot is higher than road. Cannot remove sidewalk; hill too steep for swales. Topographic constraints to treatment.
DC-PY-0055-R06	DC9522	Wetland	No Action	Downspouts currently go underground, presumably into wet pond (R04). Open space area used for recreation and utilities. Utility constraints.

FOUR MILE RUN

Subwatershed Strategy

The results of the subwatershed strategy analysis showed that all the subwatersheds in Four Mile Run were impaired in some form. All but one were among the lowest ranking for the composite score of impacts and sources. All the subwatersheds in this WMA are headwaters and all were reviewed for potential improvements.
Table entries in **bold** indicate values that meet the definition of impairment for the indicator groups.

Subwatershed	Inital Rank	Final Rank	Runoff Impacts	Flooding Hazards	Habitat Health	Initial WQ	Final WQ	Head-water
Threshold	43		0.52	1.25	0.43	0.42		
FM-FM-0000	**18**	**19**	**0.51**	1.85	**0.32**	**0.33**	**0.33**	Yes
FM-FM-0005	**42**	54	**0.51**	1.98	**0.32**	0.83	0.83	Yes
FM-FM-0010	**5**	**9**	**0.51**	1.45	**0.32**	**0.25**	**0.25**	Yes
FM-FM-0015	**14**	**19**	**0.51**	1.85	**0.32**	**0.25**	**0.33**	Yes
FM-FM-0020	**32**	48	**0.51**	1.98	0.43	0.67	0.67	Yes
FM-FM-0025	50	73	**0.51**	1.98	**0.32**	1.08	1.08	Yes
FM-FM-0030	**22**	**29**	0.52	1.58	**0.37**	0.50	0.50	Yes
FM-FM-0035	**17**	**25**	0.52	1.45	0.48	**0.33**	**0.33**	Yes
FM-LO-0000	**7**	**5**	**0.51**	**1.22**	0.48	**0.33**	**0.33**	Yes

Runoff Impacts on Streams

Low runoff impact scores for FM-LO-0000 were caused by several low ratings in the SPS and SPA assessments as discussed below. The other low-ranked subwatersheds have no natural streams and were scored based on surrogate values from adjacent areas.
Potential sites were identified from desktop analysis of SPA data and photos.

FM-LO-0000

This subwatershed received a low rating because of poor habitat, due to a considerable length of Upper Long Branch (tributary to Four Mile Run), which has been channelized with concrete (Photo FMLO002.B001). In general, because of the channelization, the streambanks are stable; however, there is a severely eroded stream downstream of the culvert under Patrick Henry Drive and upstream of the concrete channel, and several specific points of impairment including an exposed utility (Photo FMLO001.U001).

Flooding Hazards FM-LO-

0000

Ten residential structures were within the modeled 100-year flood limits under future development conditions. Nine are adjacent to the concrete channel above and below Olin Drive, while the tenth is upstream of the crossing at Glen Carlyn Road. No complaints of flooding have been recorded. No crossings were flooded beyond the design level-of-service. Field assessments showed only one project was feasible – reconstruction of the crossing at Glen Carlyn Road. Because of potential downstream effects, and because the crossing is currently passing the 100-year flow, no projects were proposed.

Forest, Wetland, and Riparian Habitat FM-FM-

0000, -0005, -0010, -0015, -0025

These watersheds are completely developed and there is no wetland or forest cover mapped. No feasible sites for restoration were identified and no projects were proposed.

FM-LO-0030

Only small amounts of forest were mapped within this subwatershed. No feasible sites for restoration were identified and no projects were proposed.

FM-LO-0000

FM-LO-0000 was not ranked among the worst for habitat health, as this subwatershed contains small areas of mapped forest and wetlands. No feasible sites for restoration were identified and no projects were proposed. One potential buffer restoration site was identified and assessed.

Stormwater Quality FM-FM-

0000

The subwatershed contains part of Bailey's Crossroads and is completely developed with commercial, transportation, and medium or high-density residential land uses. Most of the area was developed prior to regulations requiring stormwater management facilities.

FM-FM-0010

This area drains part of Bailey's Crossroads and is completely developed. Development predated stormwater management regulations so there is very little treatment of runoff.

FM-FM-0015

This subwatershed drains the intersection of Columbia Pike and Leesburg Pike and the commercial and residential areas to the north. Approximately one-third of the subwatershed is treated by SWM facilities, primarily underground detention for quantity but not quality.

FM-FM-0020

While not among the high priority subwatersheds, the Fairfax County portion of this subwatershed is a headwater which drains high-density residential development, most of which is untreated. Two areas are treated by quantity control facilities proposed for retrofits.

FM-FM-0035

Land use in this subwatershed consists of medium-density residential areas and I-66. There are no existing stormwater management facilities.

FM-LO-0000

This subwatershed consists of older medium- and high-density residential development and commercial areas developed prior to stormwater management, so most of the runoff is untreated.

Candidate Sites and Potential Projects

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
FM-FM-0000				
FM-FM-0000-R01	FM9111	Dry Pond (DP0319)	FM9104 Stormwater Pond Retrofit	Remove concrete channels, dig down for WQ, and flatten out bottom for additional storage. Already fenced off.
FM-FM-0010				
FM-FM-0010-R02	FM9113	Wet Pond	No Action	Site is too small, on slope, no detention system feasible.
FM-FM-0010-R04	FM9112	Parking Lot Retrofit	FM9105 New Stormwater Pond	Dry pond for detention of 36" stormdrain. Could take up unused area of parking lot.
FM-FM-0015				
FM-FM-0015-R01	FM9114	Dry Pond	FM9106 Stormwater Pond Retrofit	Remove concrete channels, dig down for WQ.
FM-FM-0020				
FM-FM-0020-R01	FM9104	Dry Pond (1406DP)	FM9101 Stormwater Pond Retrofit	Remove concrete, dig out concrete for WQ. Receives water from rooftops and possibly parking area. Keep as grassy swale. Very shallow and flat.
FM-FM-0020-R02	FM9103	Dry Pond (1109DP)	FM9100 Stormwater Pond Retrofit	Remove concrete channel. Currently filled with weedy vegetation, so can be removed to dig out bottom for WQ.
FM-FM-0035				

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
FM-FM-0035-R01	#N/A	WQ Treatment	FM9300 Area-wide Drainage	WQ inlets throughout the area
FM-LO-0000				
FM-LO-0000-B01	#N/A	Buffer Restoration	No Action	Reach FMLO001. The right bank south of Merritt Place consists of a 1,100 foot disturbance. Field investigation showed much of the buffer was vegetated.
FM-LO-0000-F01	#N/A	Flood Mitigation	No Action	Ten residential structures were within the modeled 100-year flood limits upstream of Glen Carlyn Rd along concrete channel. No feasible improvements.
FM-LO-0000-R01	FM9108	Outfall Retrofit	No Action	Downstream banks are eroded. Upstream stream incising. Good potential for extended detention. Stream restoration. Minor bank stabilization and revegetation. Outfalls into wing walls. No project needed.
FM-LO-0000-R02	FM9702	Outfall Retrofit	No Action	12" outfall adjacent to house flows through paved channel. At flatter slope, sediments deposit. Steep slope to stream, no erosion.
FM-LO-0000-R03	FM9701	Outfall Retrofit	No Action	Potential Stream site, low potential.
FM-LO-0000-R04	FM9101	Wet Pond (DP0544)	No Action	Drainage area to pond is locked. Insufficient DA to maintain wet pond. Keep as-is. No project
FM-LO-0000-R05	FM9700	Outfall Retrofit	No Action	Concrete pipe directly to concrete channel.
FM-LO-0000-R07	FM9109	Outfall Retrofit	FM9102 New Stormwater Pond	Downstream banks are eroded. Upstream stream incising. Good potential for extended detention. Culvert retrofit for either WQ or CPv detention. Perennial flow, fish passage would have to be maintained. Apartments with children adjacent.
FM-LO-0000-R08	FM9505	Dry Swale	No Action	Potential Stream site, low potential.
FM-LO-0000-R09	FM9506	Dry Swale	No Action	Site under development.
FM-LO-0000-R10	FM9110	Dry Pond (DP0432)	FM9103 Stormwater Pond Retrofit	Remove concrete channel, dig bottom down to create WQ area, and add plantings. Add forebay for sediment settling.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
FM-LO-0000-R11	FM9508	Bioretention	FM9503 New BMP/LID	Some concrete can be removed immediately around buildings. Place pervious pavers and small gardens. Replace storm inlet next to playground with rain garden (photo). Rain barrels at roof top drains adjacent parking lot, add open section.
FM-LO-0000-R12	FM9507	Bioretention	FM9502 BMP/LID Retrofit	Remove curb at bottom of parking lot and create bioretention area. Possibly have to remove trees. Turn some of the medians into rain gardens. Might already have underground storage.
FM-LO-0000-R13	FM9107	Dry Pond (0540DP)	No Action	Remove concrete channel and dig down for WQ. A little regrading of side slopes to increase footprint. Wetland plantings.
FM-LO-0000-R14	FM9106	Dry Pond (DP0120)	No Action	Place riprap at curb opening inlets to pond to reduce erosion. Plant more vegetation for uptake. Design analysis indicates less potential for improvement.
FM-LO-0000-R15	FM9105	Dry Pond (0318DP)	No Action	Very small, very close to houses. No room for increasing depth or width. Residential backyard. Nothing recommended.
FM-LO-0000-R16	FM9102	Dry Pond (0253DP)	No Action	No retrofit. Used as community area. Very well landscaped
FM-LO-0000-R18	FM9502	Bioretention	No Action	Take out curb at back of parking lot and add infiltration strip. Add bioretention at roof top downspouts.
FM-LO-0000-R19	FM9504	Bioretention	FM9501 BMP/LID Retrofit	Limited area for rain gardens/bioretention. Possibly open section at back of parking lot for infiltration.
FM-LO-0000-R20	FM9500	Bioretention	No Action	Several seeps around edge of property. Put several rain gardens and/or bioretention areas. Grass swales. School very interested, but is in Arlington County.
FM-LO-0000-R21	FM9100	Dry Pond (1405DP	No Action	Remove concrete channel. Dig down for WQ.
FM-LO-0000-R22	FM9501	Bioretention	No Action	Grass/Dry swale in place of concrete channel.
FM-LO-0000-R22A	FM9800	Dry Swale	No Action	Rain barrels on portables, downspouts.

Site_ID	Candidate Project Database	Proposed Action	Final Action	Notes
FM-LO-0000-R23	FM9503	Bioretention	FM9500 New BMP/LID	Bioretention areas at church front.
FM-LO-0000-R23A	FM9802	Parking Lot Retrofit	No Action	Remove pavement in parking spaces and replace with pervious pavers.
FM-LO-0000-R23B	FM9801	Parking Lot Retrofit	No Action	Parking area too small. Potential for rain barrels on school downspouts.
FM-LO-0000-S01	#N/A	Stream Restoration	No action	Reach FMLO002. This potential project consists of removal of the concrete channel and reconstruction with natural stream bed and banks. The field assessment showed that there was not sufficient area to realign the channel without significant encroachment on private property.
FM-LO-0000-S02	#N/A	Stream Restoration	No action	Reach FMLO001. This stream reach contains an exposed utility. Field investigation showed that the site of the exposed utility has been repaired with a stream restoration project subsequent to the SPA assessment.
FM-LO-0000-S03	BE9201	Stream Restoration	FM9200 Stream Restoration	Reach FMLO002. Field investigation confirmed the unstable bank conditions of the reach downstream of Patrick Henry Drive. Stream stabilization through grading and either natural or hard armoring is proposed. Only minor changes in channel dimension are recommended. A narrow riparian buffer would be established on the left bank.

TECHNICAL MEMORANDUM

TO:	Fairfax County DPWES
FROM:	KCI Technologies, Inc.
DATE:	February 26, 2010 Updated December 7, 2010
SUBJECT:	Belle Haven, Dogue Creek, and Four Mile Run Watersheds Task 3.4 Structural Project Selection and Prioritization Update: Revised Projects and Pollutant Loading
PROJECT:	Belle Haven, Dogue Creek and Four Mile Run Watershed Mgmt Plan
KCI PROJECT NO:	01-07-1644

INTRODUCTION

This Technical Memorandum describes the approach and results of the project prioritization process defined in Subtask 3.4. It is based on the work of developing strategies for subwatershed improvements completed in Subtask 3.2 and identifying and assessing candidate sites for projects completed in Subtask 3.3.

The purpose of prioritizing is to focus limited resources in the most effective way. Subtask 3.2 was conducted to identify the more critical subwatersheds improvements that will have the most significant positive impact. In Subtask 3.3, these areas were reviewed using mapping and knowledge of retrofit approaches to identify potential sites where projects could be constructed. A field assessment of each site was conducted to identify potential constraints and the feasibility of each project. The information collected during the field exercise can be found in the Candidate Project Investigation database.

In Subtask 3.4, the water quality benefits of the structural projects were modeled using STEPL and a spreadsheet technique for estimating pollutant loads from stream erosion. A prioritization procedure was used to help select the most effective projects to carry forward for concept design.

This revised Technical Memorandum describes the changes to the project prioritization which resulted from a change in the project mix from input by County staff, WAG members and the public, along with revisions to pollutant loading calculations that incorporated stream erosion estimates.

STAFF AND STAKEHOLDER INPUT

One category of BMP/LID projects was eliminated from consideration after review of preliminary cost/benefit analysis. Green roofs were determined to be much less cost effective than other approaches to pollutant removal.

Two meetings were held to provide an opportunity for discussion of the potential projects. The first was WAG meeting #3, on March 4, 2010, where maps of project sites were presented.

Several comments were received, but only one resulted in a change to the project list:

Table 1: Changes from WAG Meeting

Project	Project Type	Action	Location	Issue	Recommendation
DC9400	Culvert Retrofit	Add	Telegraph Road	Potential site could be used to provide detention for upstream area.	Culvert retrofit project added with 10-yr priority.

As a result of the Draft Plan Forum on August 5, 2010 and subsequent review, a number of changes were made to the proposed structural projects, as follows:

Table 2: Changes from Draft Plan Forum

Project	Project Type	Action	Location	Issue	Recommendation
BE9101	New Pond	Delete	River Towers	Pond site is at entrance to River Towers on open space used by residents.	Pond was deleted, no alternatives were feasible.
BE9102B	New Pond	Delete	Mt Vernon Dist Park	Proposed pond is at the site of existing bioswale / rain garden.	Both ponds in front of the Mt Vernon Rec Center will be deleted.
BE9201	Stream Restora-tion	Revised design	Belle View Condos	Removal of concrete channel may cause erosion in tidal section.	Project limits to be revised for fact sheet and cost estimates.
BE9503	BMP/LID	Revised design	River Towers	Proposed bioretention filter will require removing mature trees. Tree box filters do not appear to be located at inlets.	Field investigation showed there was sufficient area for bioretention without disturbing mature trees. Tree box filters can treat remaining area at inlets.
BE9509	BMP/LID	Revised design	Mt Vernon Dist Park	Proposed bioretention filters would require removing mature trees from parking islands.	Field assessment showed that tree box filters at the inlets in the parking lot were feasible.
DC9217	Stream Restora-tion	Add project	Dogue Creek Mainstem from Rte 1 to tidewater	Stream erosion and sediment deposition.	Field assessment identified two bank patch areas, outfall stabilization, and 400 LF of restoration.

Project	Project Type	Action	Location	Issue	Recommendation
DC9218	Stream Restora-tion	Delete DC 9103, add stream project	Banks Park	Pond footprint too large, takes up open space needed for park.	Design revised as stream restoration: daylight existing pipe, repair erosion and headcut downstream.

REGIONAL POND ALTERNATIVES

There were no unbuilt regional ponds in the three watersheds. There were two existing regional ponds. Results of the site investigations were as follows:

Pond MV-1A No retrofits were proposed for this regional pond. However, there are seven projects proposed in the drainage area of the pond: one stormwater management pond, five BMP/LIDs and one stream restoration site.

Pond DC-106 No retrofits were recommended for this pond nor were there any projects proposed within the pond drainage area.

PROJECT CONSTRAINTS

The TM for Task 3.3 describes in detail the results of the field investigation at all the candidate project sites. Each project dropped from consideration is labeled “No Action” and a brief description of the reason is provided.

The higher-priority 10-year projects have been written up with a Project Fact Sheet that describes the constraints that will have to be considered during the design process. These include:

- Environmental constraints: impacts to wetlands and forests, suitability of soils
- Design constraints: utility relocation, construction access, topography
- Community constraints: impacts to adjacent land use, health or safety issues, opportunities for education or stewardship

APPROACH

The work in Subtask 3.4 was intended to provide a quantitative assessment of each of the structural projects and stream buffer projects. It has been conducted using the same impact and source indicator metrics that were used to identify priority subwatersheds, following procedural guidance provided by Fairfax County. The following steps have been carried out:

1. Determine effect of each project on watershed impact and source indicators by subwatershed
    a. Define predictive indicators for each type of project
    b. Perform STEPL modeling for pollutant load indicators
    c. Use BPJ to determine changes in other indicators

   d. Calculate overall scores for each project
2. Determine project score for location within priority subwatersheds
3. Determine project score for sequencing in upstream-downstream order
4. Determine project score for implementability

PREDICTIVE INDICATORS

Attachment 1 of WMPDS, version 3.2, provided a list of indicators to be evaluated in Subtask 3.4. There are two sets of indicators. Impact indicators measure the extent that reversal or prevention of a particular watershed impact has been achieved by a proposed project. Source indicators quantify the reduction of potential stressors or pollutant sources. A subset of these indicators have been described as "predictive", meaning that they can be used to estimate the effects of proposed projects. The impact and source indicators which have been selected for the analysis differ based on the proposed project type, shown in Tables 3 and 12 below. The method used for developing project scores using the subwatershed ranking for each indicator is based on the Subtask 5.1E procedures, as follows:

- Link the project ID to the three model / subwatershed ranking runs (existing, future w/o, and future w/) which included it.
- For each indicator applicable to the project type, link the subwatershed ranking results to a new table.
- Develop a quintile table for each indicator which assigns a project score based on the following approach:
  - E: Scores from existing condition ranking table
  - F: Percent difference between existing and future w/o project ranking
  - P: Percent difference between future w/o and future w/ project ranking

Table 3: Impact Indicators

Project Type Code:	1	2	3	4	5	6	7	8	
	New / Retrofit SWM Pond	Stream Restoration	Area Wide Improvement	Culvert Retrofit	New / Retrofit BMP/ LID	Flood Protection / Mitigation	Outfall Improvement	Buffer Restoration	Predictive Indicator
Benthic Communities	--	--	--	--	--	--	--	--	--
Fish Communities	--	--	--	--	--	--	--	--	--
Aquatic Habitat	--	E	--	E	--	--	--	E	
Channel Morphology (ICEM)	E	E	--	--	--	E	--	--	Yes
Instream Sediment	E	E	--	--	--	--	--	E	--
Hydrology	F	F	F	F	F	F	--	--	Yes
Number of Road Hazards	--	--	--	F	--	F	--	--	Yes
Magnitude of Road Hazards	--	--	--	F	--	F	--	--	Yes
Residential Building Hazards	--	--	--	F	--	F	--	--	Yes

Project Type Code:	1	2	3	4	5	6	7	8	
	New / Retrofit SWM Pond	Stream Restoration	Area Wide Improvement	Culvert Retrofit	New / Retrofit BMP/ LID	Flood Protection / Mitigation	Outfall Improvement	Buffer Restoration	Predictive Indicator
Non-Residential Bldg Hazards	--	--	--	F	--	F	--	--	Yes
Flood Complaints	--	--	--	--	--	--	--	--	--
RPA Riparian Habitat	--	E	E	--	F	--	--	E	Yes
Headwater Riparian Habitat	--	E	E	--	F	--	--	E	Yes
Wetland Habitat	--	E	E	--	F	--	--	E	Yes
Terrestrial Forested Habitat	--	--	E	--	F	--	--	--	Yes
E. coli Concentration	--	--	--	--	--	--	--	--	--
TSS Concentration	P	P	P	P	P	--	--	--	Yes
TN Concentration	P		P	P	P	--	--	--	Yes
TP Concentration	P	P	P	P	P	--	--	--	Yes

Impact Indicators

Benthic and Fish Communities (not used) Both of these indicators are derived from bioassessments conducted at a limited number of sites in the three watersheds, which resulted in most of the subwatersheds being ranked using surrogate values. These indicators are not predictive, as there are no models or other methods to forecast changes from proposed improvements.

Aquatic Habitat Habitat is based on monitoring data for a large number of stream conditions for which there are no models or forecasting methods available to estimate changes from proposed improvements.

Channel Morphology (ICEM) ICEM describes the channel pattern, geometry and degree of stability of the stream. The following table shows the quintile ranges for this indicator based on existing conditions. There was a limited range of values of Existing Conditions Score for the Belle Haven, Dogue Creek and Four Mile Run watersheds. Most of the subwatershed scores were 2.0, some were 4.0 and there were a few scores of 6.0. Over 60% of the data points were equal to 2.0, (quintiles 0% to 60%) so the Preliminary Project Score could only receive two possible values, as seen in Table 4. Channel morphology is a predictive indicator for stream condition; for the purposes of forecasting, BPJ was used to estimate improvements from stream restoration and channel protection projects.

Table 4: Channel Morphology ICEM Metric Score

Percentile	Existing Conditions Score (greater than or equal to)	Preliminary Project Score

Percentile	Existing Conditions Score (greater than or equal to)	Preliminary Project Score
80%	4	1
60%	4	5
40%	2	5
20%	2	5
0%	2	5

Instream Sediment Instream sediment is derived from two attributes of the habitat assessment, Bank Vegetative Protection and Bank Stability. It is not considered a predictive indicator. The following table shows the quintile ranges for this indicator. Most of the Scores were 5.0, some others were 2.50 and 7.50. Using the quintiles, over 40% of the Existing Conditions data points were equal to 5.0, so the Preliminary Project Score could only receive three possible values.

Table 5: Instream Sediment Metric Score

Percentile	Existing Conditions Score (greater than or equal to)	Preliminary Project Score
80%	7.50	1
60%	5.00	3
40%	5.00	3
20%	5.00	3
0%	2.50	5

Hydrology This indicator is the peak flow rate for the cumulative upstream drainage area from the 2-year rainfall event, developed from SWMM modeling. It is predictive and can be used to forecast improvements; however, for Subtask 3.4 this level of modeling has not been completed so the indicator was used to prioritize projects using the change between existing and future without project conditions.

Table 6: Hydrology

Percentile	% Change: Existing to Future w/o Project (greater or equal to)	Preliminary Project Score
80%	0%	1
60%	0%	2
40%	0%	3
20%	0%	4
0%	-50%	5

Number of Road Hazards The road hazard indicator shows the number of road crossings affected by flood events. The indicator is derived from updated project-related HEC-RAS modeling, which has not been performed as part of subtask 3.4. The indicator was used to show the change between existing and future without project conditions. The following table shows the quintile ranges for this indicator; few subwatersheds show a change. This indicator is predictive for proposed Flood Protection Mitigation and Culvert Retrofit projects. For purposes of forecasting, BPJ was used to estimate the effect of proposed projects on flooding.

Table 7: Number of Road Hazards

Percentile	% Change: Existing to Future w/o Project (greater or equal to)	Preliminary Project Score
80%	0%	1
60%	0%	2
40%	0%	3
20%	-30.0%	4
0%	-75.0%	5

Magnitude of Road Hazards This indicator rates the severity of flooding of road crossings. It is derived from HEC-RAS hydraulic modeling and represents the depth of water overtopping the crossing. Modeling for future with project conditions has not been completed, so the indicator was used with a comparison of existing and future conditions only. For purposes of forecasting, BPJ was used to estimate the effect of proposed projects. The following table shows the quintile ranges for this indicator.

Table 8: Magnitude of Road Hazards

Percentile	% Change: Existing to Future w/o Project (greater or equal to)	Preliminary Project Score
80%	0%	1
60%	0%	2
40%	0%	3
20%	0%	4
0%	0%	5

Residential and Non-Residential Building Hazards Building Hazards indicate the number of buildings in the modeled 100-yr flood limit. This is used as a predictive indicator for Flood Protection Mitigation projects. The indicator is derived from HEC-RAS modeling, which has not been performed as part of subtask 3.4, so the indicator was used with a comparison of existing and future conditions only. Because of the degree of build-out, there was essentially no difference. For purposes of forecasting, BPJ has been used to estimate the effect of proposed projects on flooding of buildings.

Flood Complaints (not used) Flood complaints have been estimated based on County maintenance records. The indicator is not predictive and there is no way to model or forecast the change in complaints based on proposed projects.

RPA Riparian Habitat, Headwater Riparian Habitat, Wetland, and Terrestrial Forested Habitat
The Riparian Habitat indicators measure the amount of wetlands and forest within stream buffer areas. Wetland and Terrestrial Forested Habitat indicators measure the area in the entire

subwatershed. They only changed as a result of development or programs for reforestation or wetland creation. None of these indicators have changed from existing to future conditions in these watersheds. Future with project conditions were estimated because these are all predictive indicators. For the buffer projects, the change in forested area was derived from GIS; however, the change was so small that the scores did not change from future conditions without projects to with projects.

E. *coli* Concentration (not used) This indicator is derived from monitoring conducted at a limited number of sites in the three watersheds. It is not a predictive indicator as there are no models or other methods to forecast changes from proposed improvements.

STEPL Modeling, Stream Erosion and Pollutant Load Indicators

Two methods were used to estimate pollutant loads for the subwatersheds and the reductions attributable to proposed projects. Runoff loads were calculated using The Spreadsheet Tool for Estimating Pollutant Loads (STEPL). The tool computes pollutant loads based on land use, soils and various stormwater management practices. Stream erosion loads and load reductions were estimated with a spreadsheet method using stream assessment data, dimensions, and soil characteristics as input.

The Fairfax County Data Processor (FCDP) tool was used to obtain the required input land use and soils distribution per subwatershed for STEPL. The FCDP is a GIS-based tool with the following input files:

- drainage area of the proposed and existing projects
- parcels included in the project drainage area
- control type based on the BMP facility (detention, wet detention with water quality, dry detention with water quality and water quality alone)
- future land use
- hydrologic soil group

In order to obtain land use and representative soil distribution for the proposed project drainage area, the parcels which are used as input for the tool are clipped to the proposed project drainage boundary. As part of the QC procedure, KCI ran STEPL runs for future land use with no proposed projects and compared the results (land use and HSG distribution, total area per treatment type and pollutant loads with and without BMP reductions) with the Future STEPL model provided by TetraTech to test for consistency with the modeling to be performed for the proposed projects. Most of the results had insignificant discrepancies, but a few subwatersheds had considerable differences. In these cases, the analysis was run with KCI's future STEPL model results so the future with and without project scenarios would be comparable.

The FCDP tool was run multiple times. Each run included several projects with one project per subwatershed. The results of the run and intermediate files were saved and identified with the run number inside the corresponding WMA. The structure of each run folder included three sub folders named GIS, STEPL and Tools where the intermediate files, STEPL and ranking tables and output from the FCDP tool were saved.

TSS, TN, and TP Concentration Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP) are calculated using STEPL modeling for existing, future and future with projects. They are predictive and used to forecast changes in subwatershed conditions for all types of stormwater management projects. The following tables exhibit the quintile ranges for these indicators based on the changes in the metrics.

Table 9: TSS (Upland Sediment) Metric Score

Percentile	% Change: Future w/o Project vs. Future w/ Projects (greater or equal to)	Preliminary Project Score
80%	0.000%	1
60%	-0.483%	2
40%	-1.249%	3
20%	-7.320%	4
0%	-90.635%	5

Table 10: TN Metric Score

Percentile	% Change: Future w/o Project vs. Future w/ Projects (greater or equal to)	Preliminary Project Score
80%	-0.018%	1
60%	-0.217%	2
40%	-0.491%	3
20%	-1.121%	4
0%	-12.026%	5

Table 11: TP Metric Score

Percentile	% Change: Future w/o Project vs. Future w/ Projects (greater or equal to)	Preliminary Project Score
80%	0.000%	1
60%	-0.291%	2
40%	-0.923%	3
20%	-4.159%	4
0%	-47.053%	5

Source Indicators

Table 12: Source Indicators

Project Type Code:	1	2	3	4	5	6	7	8	
	New / Retrofit SWM Pond	Stream Restoration	Area Wide Improvement	Culvert Retrofit	New / Retrofit BMP/ LID	Flood Protection / Mitigation	Outfall Improvement	Buffer Restoration	Predictive Indicator
Channelized / piped streams	E	P	--	P	--	P	--	--	--
DCIA	P	--	P	--	P	P	--	--	Yes
TIA	--	--	P	--	P	P	--	--	Yes
Stormwater Outfalls	E	E	E	--	E	E	--	--	--
Sanitary Sewer Crossings	--	--	--	--	--	--	--	--	--
Streambank Buffer Deficiency		E	--	--	--	--	--	E	--
TSS Concentration	--	--	--	--	--	--	--	--	Yes
TN Concentration	--	--	--	--	--	--	--	--	Yes
TP Concentration	--	--	--	--	--	--	--	--	Yes

Channelized / piped streams This indicator describes the percentage of piped/channelized streams in each subwatershed. While not a predictive indicator, forecasting is possible using BPJ.

Table 13: Channelized / piped streams

Percentile	% Change: Existing to Future w/o Project (greater or equal to)	Preliminary Project Score
80%	0%	1
60%	0%	2
40%	0%	3
20%	0%	4
0%	0%	5

Directly Connected Impervious Area (DCIA) and Total Impervious Area (TIA) These indicators measure the imperviousness of the subwatershed. While they are predictive indicators, they are only affected by non-structural programs for impervious disconnection, which are not prioritized with this procedure. The analysis was completed using a comparison of existing and future conditions without projects.

Table 14: DCIA and TIA

Percentile	% Change: Existing to Future w/o Project (greater or equal to)	Preliminary Project Score
80%	0%	1
60%	0%	2
40%	0%	3
20%	0%	4
0%	0%	5

Stormwater Outfalls The Outfall indicator measures the number of outfalls within stream buffers for a subwatershed. The values are the same for existing and future conditions, and do not vary with any proposed projects. The prioritization process used the outfall indicator to show which subwatersheds had higher impacts.

Table 15: Stormwater Outfalls

Percentile	Existing Conditions/ Future Conditions			Preliminary Project Score
0%			2.50	5
20%	2.50	to	2.50	4
40%	2.50	to	2.50	3
60%	2.50	to	5.00	2
80%	5.00	to	7.50	1

Sanitary Sewer Crossings (not used) Data for this indicator was not available for subwatershed ranking and it has not been used for prioritization.

Streambank Buffer Deficiency This indicator measures the percent of forested area within the stream buffer area in each subwatershed. While not a predictive indicator, it is used to forecast effects of stream restoration and buffer projects. The following table shows the quintile ranges for this indicator.

Table 16: Streambank Buffer Deficiency

Percentile	Existing Conditions/ Future Conditions			Preliminary Project Score
0%			2.50	5
20%	2.50	to	2.50	4
40%	2.50	to	2.50	3
60%	2.50	to	5.00	2
80%	5.00	to	7.50	1

TSS, TN, and TP Concentration (not used) TSS, TN, and TP are calculated using STEPL pollutant load modeling for existing, future and future with project conditions. While they are predictive, they were not used in this part of the analysis because they duplicate the same information used in the impact indicator scoring.

LOCATION, SEQUENCING AND IMPLEMENTABILITY FACTORS

Location within Priority Subwatersheds Projects were scored based on the priority ranking of the subwatershed in which they were located. The Composite Score in Subwatershed Ranking for future conditions without projects was used as the baseline. Using quintiles, each subwatershed was scored from 1 to 5, with 1 representing the best conditions and 5 representing the worst conditions. The subwatershed score was entered for each project. The following table exhibits the quintiles ranges for this indicator.

Table 17: Location

Percentile	Subwatershed Impact Overall Composite Score	Preliminary Project Score
80%	6	1
60%	5.23	2
40%	4.75	3
20%	3.67	4
0%	2.89	5

Sequencing Projects were scored based on their subwatershed location in each WMA. This was done by ordering the subwatershed based on stream order, which is a measure of the location upstream or downstream. Headwater subwatersheds are given stream order 1. Subwatersheds where two headwaters combine are assigned stream order 2, and the order increases similarly working downstream. The highest stream order values are at the mouth of the stream. The score for location is the inverse of the stream order, with high scores at the headwaters and low scores downstream. Scores were assigned manually.

Table 18: Sequencing

Stream Order	BPJ Score
1	5.00
2 or 3	3.00
> 3	1.00

Implementability Two qualitative metrics were used to identify which projects would be easier to implement: whether or not they were on County-owned or maintained property, and whether or not upstream quantity controls were required for them to be successfully implemented. Scores were assigned manually as follows:

Table 19: Implementability

No Upstream Quantity Control Req'd	County-Owned or Maintained Property	BPJ Score
Yes	Yes	5.00
Yes	No	3.00
No	Yes or No	1.00

PROJECT SCORE CALCULATION

Initial Project Score

KCI developed a spreadsheet to calculate project ranking scores based on the procedures presented in section 5.1E of the WMPDS, version 3.2, and the correction about using metrics and not scores for TSS, TN and TP following Technical Team Meeting #6.

The initial project score was calculated using a weighted average of the five factors discussed above, as follows:

Effect on Impact Indicators	30%
Effect on Source Indicators	30%
Location within Priority Subwatersheds	10%
Sequencing	20%
Implementability	10%

Best Professional Judgment (BPJ)

For three types of projects (Stream Restoration, Buffer Restoration and Flood Mitigation) predictive indicator values were revised for five indicators:

Channel Morphology (ICEM) ICEM was forecast directly for stream restoration projects by assuming the reach moves from current conditions to Type 5: Recovered. The same assumption was made for reaches downstream of ponds which are proposed for channel protection storage.

Number of Road Hazards Road Hazards were forecast with the BPJ assumption that flood mitigation projects will eliminate the hazard.

Residential and Non-Residential Building Hazards Changes in Building Hazards have been forecast with the BPJ assumption that flood mitigation projects will eliminate the hazard.

Channelized / piped streams Forecasting for this indicator using BPJ was done by estimating the amount of paved or piped conveyances that are removed in restoration projects.

Streambank Buffer Deficiency Forecasts of the effects of stream restoration and buffer projects on this indicator were made with the BPJ assumption that all of the buffer within the restored reach would become forested.

Adjustment for BPJ was carried out at the most basic level possible. For each of the projects, the score used in the subwatershed ranking was reviewed and revised based on the approach described above. This score was substituted for the initial Future w/ Projects score and a percent change was calculated. Depending on the degree of this percentage change, the initial project score was adjusted upward by 5%. An additional factor was the effectiveness of the project at mitigating the identified problems in the subwatershed. For these projects, the initial project score was adjusted by 10%.

PRIORITIZATION RESULTS

Candidate Sites

There were a total of 91 feasible candidate projects prioritized in this subtask, consisting of the following distribution:

Table 20: Project Distribution among Candidate Sites

Code	Project Type	Total
1	New Stormwater Pond	5
1	Retrofit Stormwater Pond	16
2	Stream Restoration	24
3	Area wide Improvement	1
4	Culvert Retrofit	2
5	New / Retrofit BMP/LID	38
6	Flood Mitigation	2
7	Outfall Improvement	0
8	Buffer Restoration	3
	Total	91

Two types of projects need discussion, outfall improvements and buffer restorations. While four outfall Improvements were identified as candidate sites, they were not prioritized based on the indicators provided for this task. Three buffer projects were prioritized; however, they are presented as non-structural projects in the remainder of the watershed plan.

The sites in this table included several locations where multiple smaller projects were consolidated into single projects for prioritization, based on the lower limit of $80,000 per project. A discussion of the cost estimating and grouping procedure follows.

Cost Estimating Procedure

Planning-level costs were required for Subtask 3.4 in order to group projects to meet the $80,000 cost threshold. Cost templates were provided for estimating, but in some cases they relied on more detailed design information that was not available at this stage of the project. For that reason, a set of planning-level cost factors were developed that could be used with readily-available GIS coverages for the candidate projects.

For four types of projects, the factors were developed from the cost templates provided, as follows:

Buffer Restoration -- $130/LF

The GIS data shows the length of stream reach with deficient buffer. The cost template is based on construction costs of $25,000 per acre, or $57,000 with indirects and contingencies. It was necessary to convert the cost per acre to a cost per LF. This was done by assuming the buffer was 50 ft wide on each side of channel, for a total width of 100 ft. The area of one foot of buffer is 100 SF, or 0.0023 acres, with an associated cost of (0.0023)($57,000) = $130.85, rounded to $130/LF.

Stream Restoration -- $625/LF

The Physical Stream Assessment data shows the length of stream reach to be restored. The cost template is based on construction costs of $200/LF, with additional cost for plantings and the first 500 LF of restoration. The planning-level cost approach assumed no plantings, and a 1,000 LF project. Base construction cost was $300,000, or $625,000 with indirects and contingencies, which is equivalent to $625/LF.

BMP/LID Retrofit – $28,000/IMP AC

GIS data were available for the drainage areas to BMP/LID retrofit sites. The cost templates are designed to work with a wide variety of potential LID systems, including swales, trenches, filters and bioretention, all of which have different design parameters which will not be established until concept plans are underway. For this estimate, it was assumed that all LID/BMP systems would be bioretention systems, with a cost of $150/SY. Typical design parameters were assumed and used to calculate the size of a bioretention unit to treat one impervious acre. The calculations gave a construction cost of $12,960, or $28,000 with indirects and contingencies to treat one impervious acre.

Tree Box Filter - $88,000/IMP AC

GIS data were available for the drainage areas to these project sites. The cost for each filter unit was provided in the templates at on $10,000 each, or $22,000 with indirects and contingencies. In lieu of designing the layout and estimating the number of units needed, the assumption was made based on Filterra specifications that each unit is sized to treat 1/4 impervious acre. This gives a cost of $88,000 per impervious acre for treatment with this type of system.

New ponds, pond retrofits, and culvert retrofits are more difficult to estimate based on these types of parameters. An approach using empirical cost equation was developed, as follows:

Pond Retrofit – Based on pond surface area

GIS data were available for the footprint of dry ponds and wet ponds to be retrofit. Using cost data from prior watershed plans, a regression equation was developed that gave a reasonable approximation of cost based on pond size. ($R^2 = 0.54$)

New Ponds and Culvert Retrofits – Based on pond volume.

There were seven new ponds and one culvert retrofit among the proposed candidate projects. For these few projects, the pond retrofit cost equation was used. Costs are most likely underestimated with this approach, which may result in grouping one or two projects that could be separated later in the planning process.

Project Costs and Groups

Projects were grouped based on a number of factors. The primary reason was to consolidate similar types of projects that were prioritized with the same indicators. Consolidation was based on the following factors:

- Projects should not be grouped if they are not in the same subwatershed.
- Combine projects within parcels with the same ownership.
- Combine projects in adjacent or reasonably close properties

There are several individual projects remaining with an estimated cost of less than $80,000. In these cases, there was no reasonable method of combining them with similar projects and the projects were considered to beneficial enough to warrant consideration in subsequent prioritization.

Table 21: Belle Haven - Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
BE-BH-0015-F01	BE9600	Flood Protection/ Mitigation	$593,000	
BE-BH-0015-R01A BE-BH-0015-R01C	BE9504	BMP/LID	$145,000	Belle View Shopping Center
BE-BH-0015-R01B	BE9507	BMP/LID	$257,000	
BE-BH-0015-R01Z	BE9506	BMP/LID	$91,000	
BE-BH-0015-R02	BE9100	Stormwater Pond Retrofit	$174,000	
BE-BH-0015-R04 BE-BH-0015-R14	BE9503	BMP/LID	$251,000	River Towers

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
BE-BH-0015-R05 BE-BH-0015-R12	BE9508	BMP/LID	$62,000	Belle View Elementary School
BE-BH-0015-R05A	BE9102	New Stormwater Pond	$277,000	
BE-BH-0015-R07	BE9510	BMP/LID	$85,000	
BE-BH-0015-R15	BE9505	BMP/LID	$83,000	
BE-BH-0015-R16A	BE9509	BMP/LID	$241,000	
BE-BH-0015-S01	BE9201	Stream Restoration	$883,000	
BE-HC-0010-F01	BE9203	Stream Restoration	$1,122,000	
BE-HC-0010-S01	BE9200	Stream Restoration	$1,614,000	
BE-HC-0015-R01	BE9701	Outfall Improvement	$15,000	
BE-HC-0015-R03	BE9502	BMP/LID	$69,000	
BE-HC-0020-R01 BE-HC-0020-R09	BE9501	BMP/LID	$283,000	Wal-Mart and Chuck E. Cheese parking lot
BE-HC-0020-R10	BE9103	New Stormwater Pond	$750,000	
BE-HC-0020-S01	BE9202	Stream Restoration	$388,000	
BE-HC-0025-R03	BE9500	BMP/LID	$105,000	

Table 22: Dogue Creek Barnyard Run - Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-BY-0030-R01 DC-BY-0030-R02 DC-BY-0030-R03	DC9703	Outfall Improvement	$45,000	Harrison Ln
DC-BY-0030-R04	DC9512	BMP/LID	$34,000	
DC-BY-0030-R05	DC9106	Stormwater Pond Retrofit	$89,000	
DC-BY-0030-R08	DC9513	BMP/LID	$45,000	
DC-BY-0035-R04	DC9514	BMP/LID	$50,000	
DC-BY-0035-S01	DC9210	Stream Restoration	$547,000	
DC-BY-0040-S01	DC9211	Stream Restoration	$578,000	

Table 23: Dogue Creek Mainstem- Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-DC-0000-B01	DC9800	Buffer Restoration	$50,000	
DC-DC-0000-S01	DC9217	Stream Restoration	$707,000	

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-DC-0010-S01	DC9208	Stream Restoration	$450,000	
DC-DC-0015-S01	DC9209	Stream Restoration	$430,000	
DC-DC-0050-R01 DC-DC-0050-R02 DC-DC-0050-R04	DC9510	BMP/LID	$223,000	Hayfield Secondary School
DC-DC-0050-R03	DC9511	BMP/LID	$228,000	
DC-DC-0065-S01	DC9212	Stream Restoration	$280,000	
DC-DC-0075-R91	DC9400	Culvert Retrofit	$27,000	
DC-DC-0080-B01	DC9801	Buffer Restoration	$180,000	
DC-DC-0085-R01	DC9107	Stormwater Pond Retrofit	$310,000	
DC-DC-0085-R03	DC9516	BMP/LID	$40,000	
DC-DC-0085-R04	DC9108	Stormwater Pond Retrofit	$50,000	
DC-DC-0085-R07	DC9515	BMP/LID	$70,000	
DC-DC-0090-S01	DC9213	Stream Restoration	$1,228,000	
DC-DC-0100-R01	DC9517	BMP/LID	$20,000	
DC-DC-0100-S01	DC9214	Stream Restoration	$1,261,000	
DC-DC-0110-R02	DC9522	BMP/LID	$21,000	
DC-DC-0110-R03	DC9520	BMP/LID	$163,000	
DC-DC-0110-R04	DC9109	Stormwater Pond Retrofit	$60,000	
DC-DC-0110-R06	DC9523	BMP/LID	$48,000	
DC-DC-0110-R07	DC9110	Stormwater Pond Retrofit	$30,000	
DC-DC-0110-R08	DC9521	Stormwater Pond Retrofit	$20,000	
DC-DC-0110-R10	DC9518	BMP/LID	$46,000	
DC-DC-0110-R11	DC9519	BMP/LID	$58,000	

Table 24: Dogue Creek North Fork - Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-NE-0005-S01	DC9205	Stream Restoration	$1,460,000	
DC-NE-0020-S01	DC9201	Stream Restoration	$646,000	
DC-NE-0020-S02	DC9200	Stream Restoration	$1,460,000	
DC-NE-0025-S01	DC9202	Stream Restoration	$925,000	
DC-NE-0030-S01	DC9203	Stream Restoration	$744,000	

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-NE-0035-R01 DC-NE-0035-R04 DC-NE-0035-R05 DC-NE-0035-R09	DC9505	BMP/LID	$209,000	Mount Vernon High School
DC-NE-0035-R02	DC9101	Stormwater Pond Retrofit	$50,000	
DC-NE-0035-R03	DC9504	BMP/LID	$189,000	
DC-NE-0035-R10 DC-NE-0035-R12	DC9503	BMP/LID	$74,000	Riverside Elementary School
DC-NE-0035-R13	DC9100	New Stormwater Pond	$480,000	
DC-NE-0035-S01	DC9204	Stream Restoration	$859,000	
DC-NW-0005-S02	DC9206	Stream Restoration	$860,000	
DC-NW-0015-R02	DC9500	BMP/LID	$262,000	
DC-NW-0015-R04 DC-NW-0015-R07 DC-NW-0015-R08 DC-NW-0015-R09 DC-NW-0015-R10	DC9501	BMP/LID	$69,000	Various
DC-NW-0015-R05	DC9502	BMP/LID	$40,000	
DC-NW-0015-S02	DC9207	Stream Restoration	$646,000	
DC-NW-0030-F01	DC9600	Flood Protection/Mitigation	$488,000	
DC-NW-0030-R04	DC9401	Culvert Retrofit	$50,000	

Table 25: Dogue Creek Piney Run - Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-PY-0020-B01	DC9802	Buffer Restoration	$120,000	
DC-PY-0020-R03	DC9102	Stormwater Pond Retrofit	$40,000	
DC-PY-0020-R04	DC9506	BMP/LID	$145,000	
DC-PY-0025-R01	DC9104	Stormwater Pond Retrofit	$80,000	
DC-PY-0030-R02 DC-PY-0030-R03 DC-PY-0030-R05	DC9701	Outfall Improvement	$45,000	Behind 6115 Summer Park Ln
DC-PY-0035-S01	DC9215	Stream Restoration	$1,480,000	
DC-PY-0040-R03	DC9507	BMP/LID	$121,000	
DC-PY-0040-S01	DC9218	Stream Restoration	$872,000	

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
DC-PY-0045-R05 DC-PY-0045-R07	DC9702	Outfall Improvement	$30,000	Rock Ridge Ln
DC-PY-0045-S01	DC9216	Stream Restoration	$690,000	
DC-PY-0050-R01 DC-PY-0050-R02	DC9509	BMP/LID	$20,000	Calvary Baptist Church and Christian School
DC-PY-0050-R04	DC9508	BMP/LID	$240,000	
DC-PY-0055-R01	DC9105	Stormwater Pond Retrofit	$50,000	

Table 26: Four Mile Run - Project Costs and Grouped Projects

KCI_ID	Project ID	Proposed Project	Project Cost	Group Site
FM-FM-0000-R01	FM9104	Stormwater Pond Retrofit	$99,000	
FM-FM-0010-R04	FM9105	New Stormwater Pond	$498,000	
FM-FM-0015-R01	FM9106	Stormwater Pond Retrofit	$40,000	
FM-FM-0020-R01	FM9101	Stormwater Pond Retrofit	$30,000	
FM-FM-0020-R02	FM9100	Stormwater Pond Retrofit	$40,000	
FM-FM-0035-R01	FM9300	Area-wide Drainage Improvements	$1,833,000	
FM-LO-0000-R07	FM9102	New Stormwater Pond	$2,326,000	
FM-LO-0000-R10	FM9103	Stormwater Pond Retrofit	$40,000	
FM-LO-0000-R11	FM9503	BMP/LID	$79,000	
FM-LO-0000-R12	FM9502	BMP/LID	$479,000	
FM-LO-0000-R19	FM9501	BMP/LID	$52,000	
FM-LO-0000-R23	FM9500	BMP/LID	$92,000	
FM-LO-0000-S03	FM9200	Stream Restoration	$240,000	

Selection of 10-Year Projects

The distribution of the project types for the proposed 10-year projects is shown in Table 2727 below. The detailed list of 10-year and 25-year projects is shown in Tables 28 and 29.

Table 27: Project Distribution among Highest Ranked Projects

Code	Project Type	Total
1	New Stormwater Pond	5
1	Retrofit Stormwater Pond	3
2	Stream Restoration	16
3	Area wide Improvement	1

Code	Project Type	Total
4	Culvert Retrofit	1
5	New / Retrofit BMP/LID	32
6	Flood Mitigation	2
7	Outfall Improvement	0
8	Buffer Restoration	0
	Total	60

The selection of 10-year projects was based on meeting the County's goal of a maximum of 60 structural projects. This goal was defined during the watershed plan scoping process, and has guided the selection of candidate sites, field assessments, and selection of projects for prioritization.

The 10-year projects correspond to the 60 with the highest "Composite Prioritization Score adjusted with BPJ" value developed during analysis presented in this Tech Memo. The cutoff threshold that provided this number of projects was 3.29.

Table 28: List of 10-Year Projects (60 Total)

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ
BE-HC-0020-R10	BE9103	4.2	4.7	5.0	5.0	5.0	4.7	4.7
BE-HC-0020-R01	BE9501	3.9	4.7	5.0	5.0	3.0	4.4	4.4
FM-FM-0035-R01	FM9300	4.0	5.0	4.0	5.0	3.0	4.4	4.4
BE-BH-0015-R05	BE9508	3.5	4.2	5.0	5.0	5.0	4.3	4.3
BE-BH-0015-R01Z	BE9506	3.5	4.2	5.0	5.0	5.0	4.3	4.3
BE-BH-0015-R01A	BE9504	3.8	4.5	5.0	5.0	3.0	4.3	4.3
DC-PY-0050-R04	DC9508	4.0	5.0	3.0	5.0	3.0	4.3	4.3
BE-BH-0015-R01B	BE9507	3.8	4.5	5.0	5.0	3.0	4.3	4.3
DC-DC-0000-S01	DC9217	3.9	4.8	2.0	5.0	5.0	4.3	4.3
FM-LO-0000-R11	FM9503	3.4	4.2	4.0	5.0	5.0	4.2	4.2
DC-NE-0035-R01	DC9505	3.6	4.3	3.0	5.0	5.0	4.2	4.2

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ
FM-FM-0010-R04	FM9105	3.2	4.8	5.0	5.0	3.0	4.2	4.2
DC-NE-0020-S01	DC9201	3.7	4.8	4.0	5.0	3.0	4.2	4.2
DC-NE-0025-S01	DC9202	3.4	4.8	4.0	5.0	3.0	4.2	4.2
FM-LO-0000-R07	FM9102	3.3	5.0	4.0	5.0	3.0	4.2	4.2
DC-BY-0030-R08	DC9513	3.5	4.2	3.0	5.0	5.0	4.1	4.1
DC-BY-0030-R05	DC9106	3.8	4.6	3.0	5.0	3.0	4.1	4.1
BE-BH-0015-R15	BE9505	3.5	4.2	5.0	5.0	3.0	4.1	4.1
BE-HC-0020-S01	BE9202	3.7	4.8	5.0	5.0	1.0	4.1	4.1
FM-LO-0000-R12	FM9502	3.6	4.5	4.0	5.0	3.0	4.1	4.1
FM-FM-0000-R01	FM9104	3.0	4.6	4.0	5.0	3.0	4.0	4.0
BE-BH-0015-R02	BE9100	2.8	3.8	5.0	5.0	5.0	4.0	4.0
DC-DC-0050-R01	DC9510	3.4	4.0	3.0	5.0	5.0	4.0	4.0
BE-BH-0015-R04	BE9503	3.4	4.0	5.0	5.0	3.0	4.0	4.0
DC-DC-0050-R03	DC9511	3.6	4.3	3.0	5.0	3.0	4.0	4.0
DC-NW-0015-S02	DC9207	4.0	4.6	1.0	5.0	3.0	4.0	4.0
DC-NE-0030-S01	DC9203	2.8	4.8	2.0	5.0	5.0	4.0	4.0
DC-PY-0040-S01	DC9218	3.3	4.8	3.0	5.0	3.0	4.0	4.0
BE-HC-0015-R03	BE9502	3.1	3.7	4.0	5.0	5.0	3.9	3.9
DC-NE-0035-R10	DC9503	3.3	3.8	3.0	5.0	5.0	3.9	3.9
DC-BY-0030-R04	DC9512	3.3	3.8	3.0	5.0	3.0	3.7	3.9
BE-BH-0015-R07	BE9510	2.9	3.3	5.0	5.0	5.0	3.9	3.9
DC-NW-0015-R02	DC9500	4.0	4.2	1.0	5.0	3.0	3.9	3.9
BE-BH-0015-R05A	BE9102	2.5	3.7	5.0	5.0	5.0	3.9	3.9
DC-DC-0100-S01	DC9214	3.7	4.8	1.0	5.0	3.0	3.9	3.9
DC-PY-0035-S01	DC9215	3.0	4.8	1.0	5.0	5.0	3.9	3.9
BE-BH-0015-R16A	BE9509	2.8	3.2	5.0	5.0	5.0	3.8	3.8
DC-NW-0030-F01	DC9600	1.7	4.8	4.0	5.0	5.0	3.8	3.8
BE-HC-0010-S01	BE9200	3.4	4.8	4.0	3.0	3.0	3.8	3.8
DC-DC-0110-R11	DC9519	3.4	4.0	2.0	5.0	3.0	3.7	3.7
DC-PY-0020-R04	DC9506	3.4	4.0	1.0	5.0	3.0	3.6	3.7
DC-PY-0040-R03	DC9507	3.1	3.8	3.0	5.0	3.0	3.7	3.7
BE-BH-0015-F01	BE9600	1.7	4.8	5.0	5.0	3.0	3.7	3.7
BE-BH-0015-S01	BE9201	2.6	3.2	5.0	5.0	5.0	3.7	3.7
DC-DC-0110-R10	DC9518	3.3	3.8	2.0	5.0	3.0	3.6	3.6

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ
FM-LO-0000-R19	FM9501	2.9	3.5	4.0	5.0	3.0	3.6	3.6
FM-LO-0000-R23	FM9500	2.9	3.5	4.0	5.0	3.0	3.6	3.6
BE-HC-0025-R03	BE9500	3.5	4.2	4.0	3.0	3.0	3.6	3.6
DC-DC-0110-R03	DC9520	3.3	3.8	2.0	5.0	3.0	3.6	3.6
DC-NE-0035-R03	DC9504	2.8	3.2	3.0	5.0	5.0	3.6	3.6
DC-DC-0110-R02	DC9522	3.1	3.7	2.0	5.0	3.0	3.5	3.5
DC-BY-0035-S01	DC9210	2.8	3.2	2.0	5.0	5.0	3.5	3.5
DC-NE-0035-S01	DC9204	2.3	3.2	3.0	5.0	5.0	3.5	3.5
DC-DC-0090-S01	DC9213	3.2	3.2	3.0	5.0	3.0	3.5	3.5
DC-NW-0015-R04	DC9501	3.4	3.3	1.0	5.0	3.0	3.4	3.4
DC-DC-0110-R06	DC9523	2.9	3.3	2.0	5.0	3.0	3.4	3.4
DC-DC-0075-R91	DC9400	1.7	2.0	1.0	5.0	5.0	2.7	3.3
DC-NE-0035-R13	DC9100	1.3	2.8	3.0	5.0	5.0	3.1	3.3
DC-BY-0040-S01	DC9211	2.6	3.2	1.0	5.0	5.0	3.3	3.3
BE-HC-0010-F01	BE9203	2.6	3.2	4.0	3.0	3.0	3.0	3.3

Table 29: List of 25-Year Projects (31 Total)

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ
DC-BY-0035-R04	DC9514	2.9	3.3	2.0	5.0	3.0	3.4	3.3
DC-DC-0085-R01	DC9107	4.0	4.8	1.0	3.0	3.0	3.6	3.2
DC-DC-0080-B01	DC9801	3.8	5.0	1.0	1.0	5.0	3.4	3.2
DC-NW-0015-R05	DC9502	3.4	3.3	1.0	5.0	3.0	3.4	3.2
DC-DC-0110-R04	DC9109	2.2	3.8	2.0	5.0	3.0	3.3	3.2
DC-DC-0110-R07	DC9110	2.0	3.6	2.0	5.0	3.0	3.2	3.2
DC-PY-0055-R01	DC9105	2.3	2.8	3.0	5.0	3.0	3.1	3.1
DC-DC-0100-R01	DC9517	2.6	3.0	1.0	5.0	3.0	3.1	3.1
DC-NE-0035-R02	DC9101	1.8	3.0	3.0	5.0	3.0	3.1	3.1
DC-NW-0030-R04	DC9401	1.6	2.8	4.0	5.0	3.0	3.0	3.0
FM-FM-0020-R02	FM9100	2.8	4.4	2.0	5.0	3.0	3.7	3.0
DC-DC-0085-R07	DC9515	3.0	3.5	1.0	3.0	3.0	3.0	3.0
DC-NE-0005-S01	DC9205	1.9	3.2	1.0	5.0	3.0	2.9	2.9
DC-PY-0045-S01	DC9216	2.6	3.2	3.0	3.0	3.0	2.9	2.9
FM-LO-0000-S03	FM9200	2.3	3.4	4.0	5.0	1.0	3.2	2.9
DC-DC-0010-S01	DC9208	3.9	4.8	1.0	1.0	5.0	3.4	2.9
DC-DC-0015-S01	DC9209	3.9	4.8	1.0	3.0	5.0	3.8	2.9
DC-DC-0000-B01	DC9800	3.0	5.0	2.0	1.0	5.0	3.3	2.9
DC-NW-0005-S02	DC9206	2.8	3.2	4.0	1.0	5.0	2.9	2.9
DC-NE-0020-S02	DC9200	2.8	3.2	4.0	5.0	3.0	3.5	2.9
FM-FM-0020-R01	FM9101	3.0	4.6	2.0	5.0	3.0	3.8	2.9
DC-PY-0020-B01	DC9802	2.6	5.0	1.0	5.0	5.0	3.9	2.9
DC-PY-0050-R01	DC9509	2.5	3.0	3.0	5.0	3.0	3.3	2.9
DC-DC-0110-R08	DC9521	1.5	3.0	2.0	5.0	3.0	2.9	2.9
DC-PY-0020-R03	DC9102	1.7	2.4	1.0	5.0	5.0	2.8	2.8
DC-DC-0065-S01	DC9212	3.0	3.4	1.0	1.0	5.0	2.7	2.7
DC-DC-0085-R03	DC9516	2.6	3.0	1.0	3.0	3.0	2.7	2.7
FM-LO-0000-R10	FM9103	2.3	3.8	4.0	5.0	3.0	3.5	2.5
FM-FM-0015-R01	FM9106	2.0	3.4	4.0	5.0	3.0	3.3	2.3
DC-DC-0085-R04	DC9108	2.0	2.4	1.0	3.0	3.0	2.3	2.3
DC-PY-0025-R01	DC9104	1.0	2.4	1.0	3.0	3.0	2.0	2.0

ADDENDUM: PROJECT SCORES, ALL PROJECTS

1. Impact indicators

Project ID	Aquatic Habitat	Channel Morphology ICEM Metric Score	Instream Sediment Metric Score	Hydrology Metric Score	Number of Road Hazards	Magnitude of Road Hazards	Residential Building Hazards	Non Residential Building Hazards	Flood Complaints	RPA Riparian Habitats	Headwater Riparian Habitats	Wetland Habitats	Terrestrial Forested Habitat	E. Coli Metric Score	TSS (Upland Sediment) Metric Score	Total Nitrogen Metric Score	Total Phosphorus Metric Score	Final Project Scores based on Impact Indicators
BE9100	-	5	1	1	-	-	-	-	-	-	-	-	-	-	4	2	4	2.83
BE9102	-	5	1	1	-	-	-	-	-	-	-	-	-	-	2	3	3	2.50
BE9103	-	5	5	1	-	-	-	-	-	-	-	-	-	-	4	5	5	4.17
BE9200	1	5	3	1	-	-	-	-	-	5	1	5		-	5		5	3.44
BE9201	3	5	1	1	-	-	-	-	-	5	1	5		-	1		1	2.56
BE9202	1	5	5	1	-	-	-	-	-	5	1	5		-	5		5	3.67
BE9203	1	5	3	1	-	-	-	-	-	5	1	5		-	1		1	2.56
BE9500	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	3	4	3.50
BE9501	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	5	5	3.88
BE9502	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	1	3	3.13
BE9503	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	3	3.38
BE9504	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	5	4	3.75
BE9505	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	4	3.50
BE9506	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	4	3.50
BE9507	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	5	4	3.75
BE9508	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	4	3.50
BE9509	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	1	2	2.75
BE9510	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	2	2	2.88
BE9600	-	5	-	1	1	1	1	1		-	-	-	-	-	-	-	-	1.67
DC9100	-	1	3	1	-	-	-	-	-	-	-	-	-	-	1	1	1	1.33
DC9101	-	1	3	1	-	-	-	-	-	-	-	-	-	-	2	2	2	1.83
DC9102	-	5	1	1	-	-	-	-	-	-	-	-	-	-	1	1	1	1.67
DC9104	-	1	1	1	-	-	-	-	-	-	-	-	-	-	1	1	1	1.00
DC9105	-	5	3	1	-	-	-	-	-	-	-	-	-	-	2	1	2	2.33
DC9106	-	5	3	1	-	-	-	-	-	-	-	-	-	-	4	5	5	3.83
DC9107	-	5	3	1	-	-	-	-	-	-	-	-	-	-	5	5	5	4.00
DC9108	-	5	3	1	-	-	-	-	-	-	-	-	-	-	1	1	1	2.00

Project ID	Aquatic Habitat	Channel Morphology ICEM Metric Score	Instream Sediment Metric Score	Hydrology Metric Score	Number of Road Hazards	Magnitude of Road Hazards	Residential Building Hazards	Non Residential Building Hazards	Flood Complaints	RPA Riparian Habitats	Headwater Riparian Habitats	Wetland Habitats	Terrestrial Forested Habitat	E. Coli Metric Score	TSS (Upland Sediment) Metric Score	Total Nitrogen Metric Score	Total Phosphorus Metric Score	Final Project Scores based on Impact Indicators
DC9109	-	1	1	1	-	-	-	-	-	-	-	-	-	-	3	4	3	2.17
DC9110	-	1	1	1	-	-	-	-	-	-	-	-	-	-	3	3	3	2.00
DC9200	3	5	3	1	-	-	-	-	-	5	1	5		-	1		1	2.78
DC9201	3	5	3	1	-	-	-	-	-	5	1	5		-	5		5	3.67
DC9202	1	5	3	1	-	-	-	-	-	5	1	5		-	5		5	3.44
DC9203	1	1	1	1	-	-	-	-	-	5	1	5		-	5		5	2.78
DC9204	3	1	3	1	-	-	-	-	-	5	1	5		-	1		1	2.33
DC9205	1	1	1	1	-	-	-	-	-	5	1	5		-	1		1	1.89
DC9206	3	5	3	1	-	-	-	-	-	5	1	5		-	1		1	2.78
DC9207	3	5	3	5	-	-	-	-	-	5	1	5		-	5		4	4.00
DC9208	3	5	1	5	-	-	-	-	-	5	1	5		-	5		5	3.89
DC9209	3	5	1	5	-	-	-	-	-	5	1	5		-	5		5	3.89
DC9210	3	5	3	1	-	-	-	-	-	5	1	5		-	1		1	2.78
DC9211	5	1	3	1	-	-	-	-	-	5	1	5		-	1		1	2.56
DC9212	5	1	3	5	-	-	-	-	-	5	1	5		-	1		1	3.00
DC9213	3	5	3	5	-	-	-	-	-	5	1	5		-	1		1	3.22
DC9214	1	5	5	1	-	-	-	-	-	5	1	5		-	5		5	3.67
DC9215	3	1	1	1	-	-	-	-	-	5	1	5		-	5		5	3.00
DC9216	3	5	1	1	-	-	-	-	-	5	1	5		-	1		1	2.56
DC9217	3	5	1	5	-	-	-	-	-	5	1	5		-	5		5	3.89
DC9218	1	5	3	1	-	-	-	-	-	5	1	5		-	5		4	3.33
DC9400	3	-	-	1	5	1	1	1	-	-	-	-	-	-	1	1	1	1.67
DC9401	3	-	-	1	1	1	1	1	-	-	-	-	-	-	2	2	2	1.56
DC9500	-	-	-	5	-	-	-	-	-	5	1	5	5	-	3	4	4	4.00
DC9501	-	-	-	5	-	-	-	-	-	5	1	5	5	-	2	2	2	3.38
DC9502	-	-	-	5	-	-	-	-	-	5	1	5	5	-	2	2	2	3.38
DC9503	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	3	3	3.25
DC9504	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	1	1	2.75
DC9505	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	4	4	3.63
DC9506	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	3	3.38

Project ID	Aquatic Habitat	Channel Morphology ICEM Metric Score	Instream Sediment Metric Score	Hydrology Metric Score	Number of Road Hazards	Magnitude of Road Hazards	Residential Building Hazards	Non Residential Building Hazards	Flood Complaints	RPA Riparian Habitats	Headwater Riparian Habitats	Wetland Habitats	Terrestrial Forested Habitat	E. Coli Metric Score	TSS (Upland Sediment) Metric Score	Total Nitrogen Metric Score	Total Phosphorus Metric Score	Final Project Scores based on Impact Indicators
DC9507	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	3	3	3.13
DC9508	-	-	-	1	-	-	-	-	-	5	1	5	5	-	5	5	5	4.00
DC9509	-	-	-	1	-	-	-	-	-	5	1	5	5	-	1	1	1	2.50
DC9510	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	3	3	3.38
DC9511	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	4	4	3.63
DC9512	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	3	3	3.25
DC9513	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	4	3.50
DC9514	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	2	2	2.88
DC9515	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	1	2	3.00
DC9516	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	1	1	2.63
DC9517	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	1	1	2.63
DC9518	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	3	3	3.25
DC9519	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	3	3	3.38
DC9520	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	3	3	3.25
DC9521	-	1	1	1	-	-	-	-	-	-	-	-	-	-	2	2	2	1.50
DC9522	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	3	3	3.13
DC9523	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	2	2	2.88
DC9600	-	5	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	1.67
DC9800	3	-	1	-	-	-	-	-	-	5	1	5		-	-	-	-	3.00
DC9801	5	-	3	-	-	-	-	-	-	5	1	5		-	-	-	-	3.80
DC9802	1	-	1	-	-	-	-	-	-	5	1	5		-	-	-	-	2.60
FM9100	-	1	3	1	-	-	-	-	-	-	-	-	-	-	4	5	3	2.83
FM9101	-	1	3	1	-	-	-	-	-	-	-	-	-	-	4	5	4	3.00
FM9102	-	1	3	1	-	-	-	-	-	-	-	-	-	-	5	5	5	3.33
FM9103	-	1	3	1	-	-	-	-	-	-	-	-	-	-	3	3	3	2.33
FM9104	-	1	3	1	-	-	-	-	-	-	-	-	-	-	4	5	4	3.00
FM9105	-	1	3	1	-	-	-	-	-	-	-	-	-	-	5	5	4	3.17
FM9106	-	1	3	1	-	-	-	-	-	-	-	-	-	-	3	2	2	2.00
FM9200	3	1	3	1	-	-	-	-	-	5	1	5		-	1		1	2.33
FM9300	-	-	-	1	-	-	-	-	-	5	1	5	5	-	5	5	5	4.00

Project ID	Aquatic Habitat	Channel Morphology ICEM Metric Score	Instream Sediment Metric Score	Hydrology Metric Score	Number of Road Hazards	Magnitude of Road Hazards	Residential Building Hazards	Non Residential Building Hazards	Flood Complaints	RPA Riparian Habitats	Headwater Riparian Habitats	Wetland Habitats	Terrestrial Forested Habitat	E. Coli Metric Score	TSS (Upland Sediment) Metric Score	Total Nitrogen Metric Score	Total Phosphorus Metric Score	Final Project Scores based on Impact Indicators
FM9500	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	2	2	2.88
FM9501	-	-	-	1	-	-	-	-	-	5	1	5	5	-	2	2	2	2.88
FM9502	-	-	-	1	-	-	-	-	-	5	1	5	5	-	4	4	4	3.63
FM9503	-	-	-	1	-	-	-	-	-	5	1	5	5	-	3	4	3	3.38

2. Source Indicators

Project ID	TSS Metric Scores	TN Metric Scores	TP Metric Scores	Channelized or piped streams	Directly Connected Impervious Area (DCIA) Metric Score	Impervious Surface	Storm Water Outfalls Metric Score	Sanitary Sewer Crossings	Stream bank buffer defficiency	Final Project Scores based on Source Indicators
BE9100	4	2	4	-	5	-	4	-	-	3.80
BE9102	2	3	3	5	5	-	4	-	-	3.67
BE9103	4	5	5	5	5	-	4	-	-	4.67
BE9200	5	-	5	5	-	-	4	-	5	4.80
BE9201	1	-	1	5	-	-	4	-	5	3.20
BE9202	5	-	5	5	-	-	4	-	5	4.80
BE9203	1	-	1	5	-	-	4	-	5	3.20
BE9500	4	3	4	-	5	5	4	-	-	4.17
BE9501	4	5	5	-	5	5	4	-	-	4.67
BE9502	4	1	3	-	5	5	4	-	-	3.67
BE9503	3	4	3	-	5	5	4	-	-	4.00
BE9504	4	5	4	-	5	5	4	-	-	4.50
BE9505	3	4	4	-	5	5	4	-	-	4.17
BE9506	3	4	4	-	5	5	4	-	-	4.17
BE9507	4	5	4	-	5	5	4	-	-	4.50
BE9508	3	4	4	-	5	5	4	-	-	4.17
BE9509	2	1	2	-	5	5	4	-	-	3.17
BE9510	2	2	2	-	5	5	4	-	-	3.33
BE9600	-	-	-	5	5	5	4	-	-	4.75
DC9100	1	1	1	5	5	-	4	-	-	2.83
DC9101	2	2	2	-	5	-	4	-	-	3.00
DC9102	1	1	1	-	5	-	4	-	-	2.40
DC9104	1	1	1	-	5	-	4	-	-	2.40
DC9105	2	1	2	-	5	-	4	-	-	2.80
DC9106	4	5	5	-	5	-	4	-	-	4.60
DC9107	5	5	5	-	5	-	4	-	-	4.80
DC9108	1	1	1	-	5	-	4	-	-	2.40
DC9109	3	4	3	-	5	-	4	-	-	3.80
DC9110	3	3	3	-	5	-	4	-	-	3.60

Project ID	TSS Metric Scores	TN Metric Scores	TP Metric Scores	Channelized or piped streams	Directly Connected Impervious Area (DCIA) Metric Score	Impervious Surface	Storm Water Outfalls Metric Score	Sanitary Sewer Crossings	Stream bank buffer defficiency	Final Project Scores based on Source Indicators
DC9200	1	-	1	5	-	-	4	-	5	3.20
DC9201	5	-	5	5	-	-	4	-	5	4.80
DC9202	5	-	5	5	-	-	4	-	5	4.80
DC9203	5	-	5	5	-	-	4	-	5	4.80
DC9204	1	-	1	5	-	-	4	-	5	3.20
DC9205	1	-	1	5	-	-	4	-	5	3.20
DC9206	1	-	1	5	-	-	4	-	5	3.20
DC9207	5	-	4	5	-	-	4	-	5	4.60
DC9208	5	-	5	5	-	-	4	-	5	4.80
DC9209	5	-	5	5	-	-	4	-	5	4.80
DC9210	1	-	1	5	-	-	4	-	5	3.20
DC9211	1	-	1	5	-	-	4	-	5	3.20
DC9212	1	-	1	5	-	-	5	-	5	3.40
DC9213	1	-	1	5	-	-	4	-	5	3.20
DC9214	5	-	5	5	-	-	4	-	5	4.80
DC9215	5	-	5	5	-	-	4	-	5	4.80
DC9216	1	-	1	5	-	-	4	-	5	3.20
DC9217	5	-	5	5	-	-	4	-	5	4.80
DC9218	5	-	4	5	-	-	5	-	5	4.80
DC9400	1	1	1	5		-	-	-	-	2.00
DC9401	2	2	2	5		-	-	-	-	2.75
DC9500	3	4	4	-	5	5	4	-	-	4.17
DC9501	2	2	2	-	5	5	4	-	-	3.33
DC9502	2	2	2	-	5	5	4	-	-	3.33
DC9503	3	3	3	-	5	5	4	-	-	3.83
DC9504	3	1	1	-	5	5	4	-	-	3.17
DC9505	4	4	4	-	5	5	4	-	-	4.33
DC9506	3	4	3	-	5	5	4	-	-	4.00
DC9507	2	3	3	-	5	5	5	-	-	3.83
DC9508	5	5	5	-	5	5	5	-	-	5.00
DC9509	1	1	1	-	5	5	5	-	-	3.00

Project ID	TSS Metric Scores	TN Metric Scores	TP Metric Scores	Channelized or piped streams	Directly Connected Impervious Area (DCIA) Metric Score	Impervious Surface	Storm Water Outfalls Metric Score	Sanitary Sewer Crossings	Stream bank buffer defficiency	Final Project Scores based on Source Indicators
DC9510	4	3	3	-	5	5	4	-	-	4.00
DC9511	4	4	4	-	5	5	4	-	-	4.33
DC9512	3	3	3	-	5	5	4	-	-	3.83
DC9513	3	4	4	-	5	5	4	-	-	4.17
DC9514	2	2	2	-	5	5	4	-	-	3.33
DC9515	4	1	2	-	5	5	4	-	-	3.50
DC9516	2	1	1	-	5	5	4	-	-	3.00
DC9517	2	1	1	-	5	5	4	-	-	3.00
DC9518	3	3	3	-	5	5	4	-	-	3.83
DC9519	4	3	3	-	5	5	4	-	-	4.00
DC9520	3	3	3	-	5	5	4	-	-	3.83
DC9521	2	2	2	-	5	-	4	-	-	3.00
DC9522	2	3	3	-	5	5	4	-	-	3.67
DC9523	2	2	2	-	5	5	4	-	-	3.33
DC9600	-	-	-	5	5	5	4	-	-	4.75
DC9800	-	-	-	-	-	-	-	-	5	5.00
DC9801	-	-	-	-	-	-	-	-	5	5.00
DC9802	-	-	-	-	-	-	-	-	5	5.00
FM9100	4	5	3	-	5	-	5	-	-	4.40
FM9101	4	5	4	-	5	-	5	-	-	4.60
FM9102	5	5	5	5	5	-	5	-	-	5.00
FM9103	3	3	3	-	5	-	5	-	-	3.80
FM9104	4	5	4	-	5	-	5	-	-	4.60
FM9105	5	5	4	5	5	-	5	-	-	4.83
FM9106	3	2	2	-	5	-	5	-	-	3.40
FM9200	1		1	5	-	-	5	-	5	3.40
FM9300	5	5	5	-	5	5	5	-	-	5.00
FM9500	2	2	2	-	5	5	5	-	-	3.50
FM9501	2	2	2	-	5	5	5	-	-	3.50
FM9502	4	4	4	-	5	5	5	-	-	4.50
FM9503	3	4	3	-	5	5	5	-	-	4.17

3. Priority Subwatershed

Project ID	Impact Composite Score	Project Score
BE9100	3.10	5.00
BE9102	3.10	5.00
BE9103	3.48	5.00
BE9200	3.90	4.00
BE9201	3.10	5.00
BE9202	3.48	5.00
BE9203	3.90	4.00
BE9500	4.29	4.00
BE9501	3.48	5.00
BE9502	3.91	4.00
BE9503	3.10	5.00
BE9504	3.74	5.00
BE9505	3.10	5.00
BE9506	3.10	5.00
BE9507	3.10	5.00
BE9508	3.10	5.00
BE9509	3.10	5.00
BE9510	3.10	5.00
BE9600	3.10	5.00
DC9100	4.97	3.00
DC9101	4.97	3.00
DC9102	5.65	2.00
DC9104	5.78	2.00
DC9105	4.66	4.00
DC9106	4.77	3.00
DC9107	4.90	3.00
DC9108	4.90	3.00
DC9109	5.43	2.00
DC9110	5.43	2.00
DC9200	3.93	4.00
DC9201	3.93	4.00

Project ID	Impact Composite Score	Project Score
DC9202	4.24	4.00
DC9203	4.53	4.00
DC9204	4.97	3.00
DC9205	4.67	4.00
DC9206	3.72	4.00
DC9207	4.31	4.00
DC9208	5.26	2.00
DC9209	5.04	3.00
DC9210	4.62	4.00
DC9211	4.83	3.00
DC9212	6.99	1.00
DC9213	4.85	3.00
DC9214	5.10	3.00
DC9215	5.63	2.00
DC9216	5.21	3.00
DC9217	4.52	4.00
DC9218	4.63	4.00
DC9400	4.66	4.00
DC9401	4.34	4.00
DC9500	4.31	4.00
DC9501	4.31	4.00
DC9502	4.31	4.00
DC9503	4.97	3.00
DC9504	4.97	3.00
DC9505	4.97	3.00
DC9506	5.65	2.00
DC9507	4.63	4.00
DC9508	4.74	4.00
DC9509	4.74	4.00
DC9510	4.96	3.00
DC9511	4.96	3.00
DC9512	4.77	3.00
DC9513	4.77	3.00
DC9514	4.62	4.00

Project ID	Impact Composite Score	Project Score
DC9515	4.90	3.00
DC9516	4.90	3.00
DC9517	5.10	3.00
DC9518	5.43	2.00
DC9519	5.43	2.00
DC9520	5.43	2.00
DC9521	5.43	2.00
DC9522	5.43	2.00
DC9523	5.43	2.00
DC9600	4.34	4.00
DC9800	4.52	4.00
DC9801	4.93	3.00
DC9802	5.65	2.00
FM9100	5.20	3.00
FM9101	5.20	3.00
FM9102	3.74	4.00
FM9103	3.74	4.00
FM9104	3.92	4.00
FM9105	3.55	5.00
FM9106	3.79	4.00
FM9200	3.74	4.00
FM9300	4.12	4.00
FM9500	3.74	4.00
FM9501	3.74	4.00
FM9502	3.74	4.00
FM9503	3.74	4.00

4. Sequencing

Project ID	Subwatershed Order	Preliminary Project Score	BPJ Adjustment	Score adjusted with BPJ
BE9100	1.00	5	-	5
BE9102	1.00	5	-	5
BE9103	1.00	5	-	5
BE9200	2.00	5	-2	3
BE9201	1.00	5	-	5
BE9202	1.00	5	-	5
BE9203	2.00	5	-2	3
BE9500	3.00	5	-2	3
BE9501	1.00	5	-	5
BE9502	1.00	5	-	5
BE9503	1.00	5	-	5
BE9504	1.00	5	-	5
BE9505	1.00	5	-	5
BE9506	1.00	5	-	5
BE9507	1.00	5	-	5
BE9508	1.00	5	-	5
BE9509	1.00	5	-	5
BE9510	1.00	5	-	5
BE9600	1.00	5	-	5
DC9100	1.00	5	-	5
DC9101	1.00	5	-	5
DC9102	1.00	5	-	5
DC9104	3.00	5	-2	3
DC9105	1.00	5	-	5
DC9106	1.00	5	-	5
DC9107	3.00	5	-2	3
DC9108	3.00	5	-2	3
DC9109	1.00	5	-	5
DC9110	1.00	5	-	5
DC9200	1.00	5	-	5
DC9201	1.00	5	-	5
DC9202	1.00	5	-	5

Project ID	Subwatershed Order	Preliminary Project Score	BPJ Adjustment	Score adjusted with BPJ
DC9203	1.00	5	-	5
DC9204	1.00	5	-	5
DC9205	1.00	5	-	5
DC9206	4.00	5	-4	1
DC9207	1.00	5	-	5
DC9208	11.00	5	-4	1
DC9209	2.00	5	-2	3
DC9210	1.00	5	-	5
DC9211	1.00	5	-	5
DC9212	5.00	5	-4	1
DC9213	1.00	5	-	5
DC9214	1.00	5	-	5
DC9215	1.00	5	-	5
DC9216	2.00	5	-2	3
DC9217	12.00	5	-	5
DC9218	1.00	5	-	5
DC9400	1.00	5	-	5
DC9401	1.00	5	-	5
DC9500	1.00	5	-	5
DC9501	1.00	5	-	5
DC9502	1.00	5	-	5
DC9503	1.00	5	-	5
DC9504	1.00	5	-	5
DC9505	1.00	5	-	5
DC9506	1.00	5	-	5
DC9507	1.00	5	-	5
DC9508	1.00	5	-	5
DC9509	1.00	5	-	5
DC9510	1.00	5	-	5
DC9511	1.00	5	-	5
DC9512	1.00	5	-	5
DC9513	1.00	5	-	5
DC9514	1.00	5	-	5
DC9515	3.00	5	-2	3

Project ID	Subwatershed Order	Preliminary Project Score	BPJ Adjustment	Score adjusted with BPJ
DC9516	3.00	5	-2	3
DC9517	1.00	5	-	5
DC9518	1.00	5	-	5
DC9519	1.00	5	-	5
DC9520	1.00	5	-	5
DC9521	1.00	5	-	5
DC9522	1.00	5	-	5
DC9523	1.00	5	-	5
DC9600	1.00	5	-	5
DC9800	12.00	5	-4	1
DC9801	4.00	5	-4	1
DC9802	1.00	5	-	5
FM9100	1.00	5	-	5
FM9101	1.00	5	-	5
FM9102	1.00	5	-	5
FM9103	1.00	5	-	5
FM9104	1.00	5	-	5
FM9105	1.00	5	-	5
FM9106	1.00	5	-	5
FM9200	1.00	5	-	5
FM9300	1.00	5	-	5
FM9500	1.00	5	-	5
FM9501	1.00	5	-	5
FM9502	1.00	5	-	5
FM9503	1.00	5	-	5

5. Implementability

Project ID	No U/S Water Quantity Required	County , Schools, not privately owned	Score
BE9100	Yes	Yes	5
BE9102	Yes	Yes	5
BE9103	Yes	Yes	5
BE9200	Yes	No	3
BE9201	Yes	Yes	5
BE9202	No	No	1
BE9203	Yes	No	3
BE9500	Yes	No	3
BE9501	Yes	No	3
BE9502	Yes	Yes	5
BE9503	Yes	No	3
BE9504	Yes	No	3
BE9505	Yes	No	3
BE9506	Yes	Yes	5
BE9507	Yes	No	3
BE9508	Yes	Yes	5
BE9509	Yes	Yes	5
BE9510	Yes	Yes	5
BE9600	Yes	No	3
DC9100	Yes	Yes	5
DC9101	Yes	No	3
DC9102	Yes	Yes	5
DC9104	Yes	No	3
DC9105	Yes	No	3
DC9106	Yes	No	3
DC9107	Yes	No	3
DC9108	Yes	No	3
DC9109	Yes	No	3
DC9110	Yes	No	3
DC9200	Yes	No	3

Project ID	No U/S Water Quantity Required	County , Schools, not privately owned	Score
DC9201	Yes	No	3
DC9202	Yes	No	3
DC9203	Yes	Yes	5
DC9204	Yes	Yes	5
DC9205	Yes	No	3
DC9206	Yes	Yes	5
DC9207	Yes	No	3
DC9208	Yes	Yes	5
DC9209	Yes	Yes	5
DC9210	Yes	Yes	5
DC9211	Yes	Yes	5
DC9212	Yes	Yes	5
DC9213	Yes	No	3
DC9214	Yes	No	3
DC9215	Yes	Yes	5
DC9216	Yes	No	3
DC9217	Yes	Yes	5
DC9218	Yes	No	3
DC9400	Yes	Yes	5
DC9401	Yes	No	3
DC9500	Yes	No	3
DC9501	Yes	No	3
DC9502	Yes	No	3
DC9503	Yes	Yes	5
DC9504	Yes	Yes	5
DC9505	Yes	Yes	5
DC9506	Yes	No	3
DC9507	Yes	No	3
DC9508	Yes	No	3
DC9509	Yes	No	3
DC9510	Yes	Yes	5
DC9511	Yes	No	3

Project ID	No U/S Water Quantity Required	County , Schools, not privately owned	Score
DC9512	Yes	No	3
DC9513	Yes	Yes	5
DC9514	Yes	No	3
DC9515	Yes	No	3
DC9516	Yes	No	3
DC9517	Yes	No	3
DC9518	Yes	No	3
DC9519	Yes	No	3
DC9520	Yes	No	3
DC9521	Yes	No	3
DC9522	Yes	No	3
DC9523	Yes	No	3
DC9600	Yes	Yes	5
DC9800	Yes	Yes	5
DC9801	Yes	Yes	5
DC9802	Yes	Yes	5
FM9100	Yes	No	3
FM9101	Yes	No	3
FM9102	Yes	No	3
FM9103	Yes	No	3
FM9104	Yes	No	3
FM9105	Yes	No	3
FM9106	Yes	No	3
FM9200	No	No	1
FM9300	Yes	No	3
FM9500	Yes	No	3
FM9501	Yes	No	3
FM9502	Yes	No	3
FM9503	Yes	Yes	5

TECHNICAL MEMORANDUM

TO:	Fairfax County DPWES
FROM:	KCI Technologies, Inc.
DATE:	February 23, 2010 Revised December 8, 2010
SUBJECT:	Belle Haven, Dogue Creek, and Four Mile Run Watersheds Task 3.5 Final Non-Structural Project Selection and Prioritization
PROJECT:	Belle Haven, Dogue Creek and Four Mile Run Watershed Mgmt Plan
KCI PROJECT NO:	01-071644

INTRODUCTION

Non-structural projects are a group of projects that do not require traditional construction measures to be implemented and may be programmatic in nature. Additionally, these projects and programs may not be confined to any single watershed but could be implemented throughout the County as opportunities occur. Because of these differences, non-structural projects were evaluated and will be implemented with a different process than the structural projects.

The non-structural projects discussed in this Technical Memorandum were derived from two sources. First, pollution prevention measures were identified during the upland reconnaissance of residential and commercial areas which assessed potential pollutant sources. As part of the assessment, several possible programs were identified for specific areas which had the potential to reduce or control sources of pollution or stormwater runoff. The second approach included indentifying site specific areas for obstruction removal, buffer restoration, and wetland restoration measures through the use and analysis of GIS mapping.

Desktop analysis was undertaken to identify sites where a particular type of project or program could be useful to mitigate problems in the watershed, which were defined in Subtask 3.2 as Stormwater Runoff Impacts, Habitat Health, Flooding Hazards, and Water Quality.

PROJECT TYPES

The work for developing specific non-structural projects and programs was undertaken using the project types defined in the County's Watershed Management Plan Development Standards, Version 3.2, (WMPDS) issued in March, 2009. These were categorized by their effectiveness at mitigating the four types of watershed impairments. Specific potential projects for each WMA are described in the tables which follow this section. The proposed action column shows the general type of non-structural project, while the final action column shows the specific action for each area. One specific action is listed for each area. While others may be applicable, only the most significant was listed as a potential project.

Stormwater Runoff Impacts (Objective 1A)

Candidate sites for non-structural stream restoration projects were identified through PSA data and review of photography taken during the assessment. Potential projects include:

> *Dumpsite / Obstruction Removal* Obstructions refer to items in the streambed that impede flow sufficiently to accelerate streambank erosion or increase the risk of flooding. These are maintenance-level projects to remove trash and debris dumped in the stream or stream valley or to remove natural or man-made obstructions within the stream channel.

Flooding Hazards (Objective 1B)

Hydrologic / hydraulic modeling of the 100-year event was the basis for identifying both structural and non-structural projects to mitigate flooding hazards. Potential non-structural projects for these sites include:

> *Studies, Surveys, and Assessments* Additional modeling studies to verify the results of the planning-level model and to test various mitigation projects. Projects to review and investigate new or alternative approaches for watershed improvement.

Habitat Health (Objective 2A)

Low ratings for habitat health were caused by low percentages of forest cover, wetlands, or riparian buffers within a subwatershed. Candidate sites for reforestation and wetland improvements were identified by review of land use mapping and orthophotography. Buffer restoration sites were identified through the PSA data, by flagging buffers with moderate to severe impacts and moderate or better restoration potential. Assessment included review of orthophotos and field photography. Potential projects include:

> *Buffer Restoration* Revegetation of stream banks, reforestation of buffer areas in publicly-owned areas, outreach and coordination with private land owners to re-establish buffer areas. Forested buffers provide streambank stability, food for aquatic life and shading of the stream. Stream buffers also provide important wildlife habitat. Buffer Restoration projects were prioritized in Subtask 3.4.
>
> *Wetland Restoration* Creation, expansion, or enhancement of wetlands in publicly-owned areas or outreach with private land owners to create additional wetlands. These projects were not prioritized in subtask 3.4.

Water Quality (Objective 3)

Candidate sites for non-structural water quality improvements were identified through the NSA and HSI surveys conducted as part of the upland reconnaissance. The following types of candidate projects were identified:

> *Impervious Disconnection* Disconnecting downspouts and using rain gardens or rain barrels to collect rain water is another stewardship program that can reduce the volume of runoff and improve water quality but also can improve neighborhood aesthetics. Rooftop runoff redirected in this fashion is treated by surface filtration through the

vegetated area and infiltration into the soil. Directing runoff onto vegetation allows the biological processes to reduce pollutants. This is also an effective method of preventing temperature increases in runoff.

Community Outreach / Public Education Behaviors such as littering, over-fertilizing, pesticide use and dumping of illicit substances can negatively impact water quality. Programs specifically targeting residents include:

- Storm drain stenciling, which reminds residents that anything that enters the storm drain also enters the stream system
- Pet waste outreach to reduce bacteria and excess nutrients in stormwater runoff.
- Providing information on environmentally friendly lawn care, which can reduce nitrogen and phosphorus in runoff
- Encouraging and assisting residents with planting trees on their property to help reduce runoff volumes and peak flow
- Outreach to groundskeepers and turf managers at golf courses and other facilities to also help reduce runoff impacts from fertilizer and pesticides

Inspection / Enforcement A number of potential water quality issues were identified which could be subject to inspection and enforcement by County agencies. These include leaking or overflowing dumpsters, outdoor materials storage, spill prevention, and litter or trash. These programs can reduce the amount of trash, oil and grease, metals, bacteria, sediment, and nutrients in runoff.

Street Sweeping Build up of leaf litter, organic material, trash, and other pollutants on streets varies by land use and neighborhood. Street sweeping and leaf collection programs have been proposed for specific areas.

CANDIDATE SITES AND POTENTIAL PROJECTS

Belle Haven

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
BE-BH-0005				
BE-BH-0005-M07B	N/A	Outreach / Education	DC9905 Tree planting	Single-family residential neighborhood, Westgrove. Tree cover was less than 40%.
BE-BH-0015				
BE-BH-0015-M05B	N/A	Outreach / Education	DC9905 Tree planting	Single-family residential neighborhood, New Alexandria. Tree cover was less than 40%.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
BE-BH-0015-M06	N/A	Outreach / Education	DC9905 Tree planting	Tree cover was only 10%.
BE-BH-0015-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site BEPO001.T001. Debris and logjam in channel of Quander Brook.
BE-HC-0000				
BE-HC-0000-M01	N/A	Outreach / Education	DC9906 Turf management	Work with greenskeepers and managers at Belle Haven Country Club
BE-HC-0010				
BE-HC-0010-M01B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Multi-family residential neighborhood, Belle Haven Towers.
BE-HC-0010-M02B, M03B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhoods, Belle Haven, Penn Daw MHP, Fordham Village.
BE-HC-0015				
BE-HC-0015-M04B	N/A	Outreach / Education	DC9905 Tree planting	Single-family residential neighborhood, Belle Haven Meadows. Few to no mature trees in neighborhood.
BE-HC-0020				
BE-HC-0020-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site BEBE007.T001. Debris and downed trees in channel behind Swan Terrace.
BE-HC-0025				
BE-HC-0025-N01	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Car dealership with materials stored outside; storage area lacks cover and is connected to storm drain; visible staining around storage area. Vehicles maintained, washed, repaired and stored outside lacking runoff diversion methods; no evidence of spills/leaks.
N/A	N/A	Studies, surveys, assessments	DC9913 Floatables control	Review potential technologies and approaches for collecting floatable litter and trash at outfalls or tidewater
BE-PO-0005				
BE-PO-0005-M08B	N/A	Outreach / Education	DC9905 Tree planting	Single-family residential neighborhood, Villamay. Tree cover less than 40%.

Four Mile Run

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
FM-FM-0000				
FM-FM-0000-N18	N/A	Inspection / Enforcement	DC9907 Dumpster management.	Strip mall at corner of George Mason Dr and Seminary Rd with evidence of leaking dumpster located near a storm drain inlet.
FM-FM-0000-N18A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Strip mall at corner of George Mason Dr and Seminary Rd with downspouts discharging to impervious surface.
FM-FM-0000-N20	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Hess gas station and McDonalds on Leesburg Pike with uncovered fueling area.
FM-FM-0000-N20A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Hess gas station and McDonalds on Leesburg Pike; downspouts discharge to impervious surface.
FM-FM-0010				
FM-FM-0010-N24	N/A	Inspection / Enforcement	DC9905 Tree Planting	National Transmission Inspection on Seminary Rd with vehicles stored and repaired outside
FM-FM-0035				
FM-FM-0035-M06A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Westmoreland Park; rain barrels at downspouts.
FM-FM-0035-M06B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhoods Westmoreland Park, Oakwood.
FM-FM-0035-M06C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhoods Westmoreland Park, Oakwood Park; organic matter, leaves, lawn clippings in curb and gutter.
FM-FM-0035-M07A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Brilyn Park; rain barrels at downspouts.
FM-FM-0035-M07B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Brilyn Park; no stencil on storm drain inlets.
FM-FM-0035-M08	N/A	Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Brilyn Park. Tree cover less than 40%.
FM-FM-0035-M08A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Westmore Gardens; rain barrels at downspouts.
FM-FM-0035-M08C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhood Westmore Gardens; trash, litter and debris in curb and gutter. Storm drain inlets obstructed by debris.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
FM-LO-0000				
FM-LO-0000-M01	N/A	Inspection / Enforcement	DC9907 Dumpster management	Multi-family residential neighborhood, Hollybrook Condominiums; prevention of potential dumpster runoff into stream.
FM-LO-0000-N01	N/A	Inspection / Enforcement	DC9905 Tree Planting	Seven Corners shopping center on Arlington Blvd; vehicles washed outdoors; discharge into storm drains.
FM-LO-0000-M01	N/A	Outreach / Education	DC9905 Tree Planting	Less than 40% tree cover in neighborhood.
FM-LO-0000-M03	N/A	Outreach / Education	DC9905 Tree Planting	Less than 40% tree cover in neighborhood.
FM-LO-0000-M04	N/A	Outreach / Education	DC9905 Tree Planting	Less than 40% tree cover in neighborhood.
FM-LO-0000-M02B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Lee Boulevard Heights; no stencil on storm drain inlets.
FM-LO-0000-M05B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Glen Forest. No stencil on storm drain inlets.
FM-LO-0000-N08	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Comfort Inn and Mc Donald's at intersection of Patrick Henry Dr and Arlington Blvd; vehicles repaired and lack runoff diversion methods. Fueling areas directly connected to storm drains.
FM-LO-0000-N11A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Columbia Crossroads Church, Corpus Christi School and St. Anthony Parish; downspout discharge to impervious surface.
FM-LO-0000-N11C	N/A	Street Sweeping	DC9912 Street Sweeping	Columbia Crossroads Church, Corpus Christi School and St. Anthony Parish; landscaped areas drain to storm drain system; accumulation of organic matter in gutters and storm drains.
FM-LO-0000-N13	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance;	Liberty Gas Station and carpet store on Leesburg Pike; vehicles maintained, washed, repaired and stored outside lacking runoff diversion methods; presence of uncovered outdoor fueling areas which connects directly to storm drains.

Dogue Creek

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-BY-0020				
DC-BY-0020-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCBY010.T001. Trees, debris and sediment in stream in Huntley Meadows Park.
DC-BY-0020-T02	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCBY010.T002. Trees, debris and sediment in stream in Huntley Meadows Park.
DC-DC-0010				
DC-DC-0010-N17	N/A	Inspection / Enforcement	DC9907 Dumpster management	Woodley Shopping Center on Richmond Hwy; dumpster located near storm drain inlet lacks runoff diversion methods.
DC-DC-0010-N17C	N/A	Street Sweeping	DC9912 Street Sweeping	Woodley Shopping Center on Richmond Hwy; landscaped areas drain to storm drain system and accumulation of organic matter on adjacent impervious surface.
DC-DC-0010-N20	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance;	Two gas stations, Plaza and auto center at corner of Rt.1 and Mt.Vernon Memorial Hwy; vehicles stored, repaired and maintained outside; evidence of spill and leakage from vehicles, uncovered fueling areas present and are directly connecting to storm drains; dumpster located near storm drain inlet lacks runoff diversion methods.
DC-DC-0010-N20A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Two gas stations, Plaza and auto center at corner of Rt.1 and Mt.Vernon Mem. Hwy; some downspouts discharge to imperious surface and some are directly connected to the storm drains.
DC-DC-0080				
DC-DC-0080-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCDC506.T001. Sediment, debris in stream behind Lake Cove Dr in Huntley Meadows Park.
DC-DC-0080-T02	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCDC506.T002.Trees, debris and sediment in stream behind Sheridonna Ln in Huntley Meadows Park.
DC-DC-0090				
DC-DC-0090-M01	N/A	Outreach / Education	DC9906 Turf management	Work with greenskeepers and managers at Greendale Golf Course

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-DC-0095				
DC-DC-0095-M06B	N/A	Outreach / Education	DC9903 Lawn care outreach	Multifamily residential neighborhood Gilford; no stencil on inlets, high proportion of high management lawns.
DC-DC-0105				
DC-DC-0105-M05B	N/A	Outreach / Education	DC9905 Tree Planting	Multifamily residential neighborhood Gilford; high proportion of high management lawns. Tree cover was less than 40%.
DC-DC-0105-N02	N/A	Inspection / Enforcement	DC9907 Dumpster management	Shopping Center on Sir Viceroy Drive; dumpster with evidence of leaking; evidence of leaking grease trap behind Wal-Mart center.
DC-DC-0105-N03A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Shopping Center on Sir Viceroy Drive; downspouts directly connected to storm drains; landscaped areas and irrigation areas flowing into storm drain system.
DC-DC-0105-N03	N/A	Inspection / Enforcement	DC9907 Dumpster management	Ruby Tuesday and Golf Center on Van Dorn St; damaged overflowing dumpster with no cover and evidence of leaking.
DC-NE-0000				
DC-DC-0000-M01	N/A	Outreach / Education	DC9906 Turf management	Work with greenskeepers and managers at Mount Vernon Country Club
DC-NE-0003				
DC-NE-0003-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF002.T001. Trees and debris in stream in Mt.Vernon Country Club.
DC-NE-0005				
DC-NE-0005-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF003.T001. Trees and debris in stream in Mt.Vernon Country Club.
DC-NE-0015				
DC-NE-0015-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF012.T001. Trees and debris in stream behind Southwood Dr.
DC-NE-0020				
DC-NE-0020-M04A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Mt Vernon Park; rain barrels at downspouts.
DC-NE-0020-M04B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Mt Vernon Park; no stencil on storm drain inlets.
DC-NE-0020-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF014.T001. Trees, debris, sediment in stream behind Mavis Ct.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-NE-0025				
DC-NE-0025-M03A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Southwood; rain barrels at downspouts.
DC-NE-0025-M03B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Southwood; no stencil on storm drain inlets.
DC-NE-0025-M03C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhood Southwood; trash, litter and debris in curb and gutter.
DC-NE-0025-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF011.T001. Trees and debris in stream behind Sulgrave Dr.
DC-NE-0030				
DC-NE-0030-M01A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Mt Vernon Manor; rain barrels at downspouts.
DC-NE-0030-M01B	N/A	Outreach / Education	DC9904 Storm drain stenciling	Single-family residential neighborhood Mt Vernon Manor; no stencil on storm drain inlets.
DC-NE-0030-M01C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhood Mt Vernon Manor; trash, litter and debris in curb and gutter.
DC-NE-0030-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF005.T001. Sediment, trees, debris in stream behind Mill Brook Pl.
DC-NE-0030-T02	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF005.T002.Trees,debris in stream behind Mill Brook Pl.
DC-NE-0030-T03	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF009.T001.Concrete, trash, sediment, trees in stream behind Kings Hill Ct.
DC-NE-0035				
DC-NE-0035-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF008.T001.Trees,debris,trash in stream behind Quisenberry Rd.
DC-NW-0000				
DC-NW-0000-N22	N/A	Inspection / Enforcement	DC9907 Dumpster management	Mc Donald's on Cooper Rd; dumpster located near the storm drain inlets lacks runoff diversion methods.
DC-NW-0000-N23	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Church, auto body and strip mall at corner of Rt.1 and Lukens Ln; vehicles repaired and stored outside lacks runoff diversion methods; dumpster located near storm drain inlet lacks runoff diversion methods.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-NW-0005				
DC-NW-0005-M07B	N/A	Outreach / Education	DC9905 Tree planting	Single-family residential neighborhood Pinewood Lawn. Tree cover was less than 40%.
DC-NW-0005-M08A	N/A	Rain Barrel Programs	DC9902 Rain barrel	Single-family residential neighborhood Mt Pinewood Lawn; rain barrels at downspouts.
DC-NW-0005-M08C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhood Mt Pinewood Lawn; trash, litter and debris in curb and gutter.
DC-NW-0005-N16	N/A	Inspection / Enforcement	DC9907 Dumpster management	Woodley Shopping center on Richmond Hwy; dumpster located near storm drain inlets lacks runoff diversion methods.
DC-NW-0005-N16C	N/A	Street Sweeping	DC9912 Street Sweeping	Woodley Shopping center on Richmond Hwy; landscaped areas drain to storm drain system and accumulation of organic matter on adjacent impervious surfaces.
DC-NW-0010				
DC-NW-0010-N12	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Car Care Garage on Richmond Hwy; vehicles maintained and stored outside and lack runoff diversion methods. Some organic matter around dumpster.
DC-NW-0010-N14	N/A	Inspection / Enforcement	DC9908 Outdoor material storage	Wicks Repair Inc. on Highland Ln. Materials stored outside without cover.
DC-NW-0010-N15	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Engleside Plaza Shopping Center, Auto body shop on Richmond Hwy; vehicles stored, repaired and maintained; vehicles washed outdoors; leaking dumpster with no cover and located near storm drain with lack of runoff diversion methods.
DC-NW-0010-N15C	N/A	Street Sweeping	DC9912 Street Sweeping	Engleside Plaza Shopping Center, Auto body shop on Richmond Hwy; landscaped areas drain to storm drain system and accumulation of organic matter on adjacent impervious surfaces.
DC-NW-0010-N24	N/A	Inspection / Enforcement	DC9907 Dumpster management	Seven-Eleven on Frontage Rd; dumpster near the storm drain inlet lacks runoff diversion method.
DC-NW-0015				
DC-NW-0015-N01	N/A	Inspection / Enforcement	DC9907 Dumpster management	Mt.Vernon Shopping Center; dumpster located near a storm drain inlet lacks runoff diversion methods.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-NW-0015-N02	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Gas station Sunoco at Mt.Vernon; vehicles maintained and repaired. Landscaped areas drain to storm drain system and accumulation of organic matter on adjacent impervious surfaces.
DC-NW-0015-N02A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Gas station Sunoco at Mt.Vernon; downspouts directly connected to storm drains.
DC-NW-0015-N03	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Mt Zephyr Business Center, BP Gas Station on Richmond Hwy; vehicles maintained; fueling areas directly connected to storm drains; materials stored outside.
DC-NW-0015-N03A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Mt Zephyr Business Center, BP Gas Station on Richmond Hwy; downspouts directly connected to storm drains.
DC-NW-0015-N04	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Auto clinic, County bldg, and vet office on Richmond Hwy; vehicles stored repaired and maintained; lacks runoff diversion methods.
DC-NW-0015-N04A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Auto clinic, County bldg, and vet office on Richmond Hwy; downspouts directly connected to storm drains.
DC-NW-0015-N09	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Rent All Center and Budget Auto on Richmond Hwy; vehicles stored and repaired outside and lack runoff diversion methods; dumpster located near storm drain inlet lacks diversion methods.
DC-NW-0015-N10	N/A	Inspection / Enforcement	DC9908 Outdoor material storage	Smitty's Wood Yard on Richmond Hwy; uncovered loading/unloading operations present which drain towards the storm drain; materials stored outside lack cover.
DC-NW-0015-N11	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Shell gas station on Richmond Hwy; vehicles maintained and fueled; presence of uncovered fueling areas.
DC-NW-0015-N11A	N/A	Rain Barrel Programs	DC9901 Downspout disconnection	Shell gas station on Richmond Hwy; some downspouts discharge to impervious surface and some downspouts are directly connected to storm drains.
DC-NW-0020				
DC-NW-0020-M01B		Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Timothy Park; no stencils on storm drain inlets. Tree cover was less than 40%.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-NW-0025				
DC-NW-0025-M02B	N/A	Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Mt.Vernon Park; no stencils on storm drain inlets. Tree cover was less than 40%.
DC-NW-0025-M03	N/A	Outreach / Education	DC9905 Tree Planting	Tree cover was less than 40%.
DC-NW-0025-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCNF015.T001.Beaver dam in stream behind Keeler St.
DC-NW-0030				
DC-NW-0030-M04B	N/A	Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Fairfield; no stencils on storm drain inlets. Tree cover was less than 40%.
DC-PO-0000				
N/A	N/A	Studies, surveys, assessments	DC9913 Floatables control	Review potential technologies and approaches for collecting floatable litter and trash at outfalls or tidewater
DC-PO-0010				
DC-PO-0010-M05A	N/A	Rain Barrel Programs	DC9902 Rain Barrels	Single-family residential neighborhood Mt Vernon on Potomac; rain barrels at downspouts. Tree canopy less than 25%.
DC-PO-0010-M05	N/A	Outreach / Education	DC9905 Tree planting	Mt Vernon on Potomac; tree canopy less than 25%.
DC-PO-0010-M05C	N/A	Street Sweeping	DC9912 Street Sweeping	Single-family residential neighborhood Mt Vernon on Potomac; trash, litter and debris in curb and gutter.
DC-PO-0020				
DC-PO-0020-M06A	N/A	Rain Barrel Programs	DC9905 Tree Planting	Single-family residential neighborhood Fairfield; no stencils on storm drain inlets. Tree cover was less than 40%.
DC-PY-0055				
DC-PY-0055-M07B	N/A	Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Fairfield; no stencils on storm drain inlets. Tree cover was less than 40%.
DC-PY-0025				
DC-PY-0025-T01	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCPY009.T001. Beaver dam in stream behind Cross Gate Ln.
DC-PY-0025-T02	N/A	Dumpsite / Obstructions	DC9911 Obstruction removal	Site DCPY004.T002. Beaver dam in stream behind Piney Woods Ct.

Site_ID	Candidate Project	Proposed Action	Final Action	Notes
DC-PY-0035				
DC-PY-0035-N06	N/A	Inspection / Enforcement	DC9907 Dumpster management	Shopping mall on Silver Lake Blvd; Overflowing dumpster in poor condition located near a storm drain inlet which lacks runoff diversion methods.
DC-PY-0035-M08A	N/A	Rain Barrel Programs	DC9902 Rain Barrels	Multi -family residential neighborhood Windsor Gable; rain barrels at downspouts.
DC-PY-0035-M08B	N/A	Outreach / Education	DC9905 Tree Planting	Single-family residential neighborhood Fairfield; no stencils on storm drain inlets. Tree cover was less than 40%.
DC-PY-0050				
DC-PY-0050-N05	N/A	Inspection / Enforcement	DC9909 Vehicle maintenance	Kingstowne Auto Inc and Manchester Lakes Shopping Center on Manchester Blvd. Vehicles maintained repaired, washed outside; evidence of spill/leak from vehicle; loading/unloading areas present and materials stored outside; the storage area is directly connected to storm drains lacks covers; storage containers in poor condition and are missing labels. Dumpster located near the storm drain inlets lacks runoff diversion methods.

PROJECT PRIORITIZATION

Many of the pollution prevention measures could be carried out more efficiently if they were done on a watershed-wide or countywide basis. With this in mind, the proposed projects were grouped by project type. Projects that spanned across several watersheds were given project numbers related to Dogue Creek, the largest watershed in the plan grouping. Projects which could be tied to a specific location were given project numbers keyed to the watershed in which they were located. These included Buffer Restoration and two large Litter/Trash removal projects at the mouths of Hunting Creek and Dogue Creek.

The non-structural projects were prioritized similarly to the structural projects, with the goal of identifying high and low priority projects. Two factors were used in the prioritization:

Impact Indicators Projects were scored using best professional judgment based on the effectiveness at improvements in runoff impacts on streams, flood mitigation, habitat enhancement, and water quality.

Impact Indicators Best professional judgment was used to determine ease of implementation, based on cost and time commitment by Fairfax County required.

Scores were calculated based on a weighted average of these two factors:

- Effect on Impact Indicators 60%
- Implementability 40%

The highest priority watershed-wide project was Downspout Disconnection, followed by Obstruction Removal and Litter/Trash Enforcement. Tree Planting projects were next in priority. These four projects, along with Buffer Restoration DC9801, prioritized with the structural projects, were the five highest priority non-structural projects.

The following table summarizes the prioritization for the non-structural projects.

Project ID	Non-Structural Measure	Detailed Action	Priority
DC9801	Buffer Restoration	Buffer Restoration	High
DC9803	Wetland Mitigation	Wetland Mitigation	High
DC9901	Rain Barrel Programs	Downspout Disconnection	High
DC9905	Outreach / Education	Tree Planting	High
DC9910	Inspection / Enforcement	Litter/Trash Enforcement	High
DC9911	Dumpsite / Obstruction Removal	Obstruction Removal	High
DC9800	Buffer Restoration	Buffer Restoration	Low
DC9802	Buffer Restoration	Buffer Restoration	Low
DC9902	Rain Barrel Programs	Rain Barrels	Low
DC9903	Outreach / Education	Lawn Care Outreach	Low
DC9904	Outreach / Education	Storm Drain Marking	Low
DC9906	Outreach / Education	Turf Management	Low
DC9907	Inspection / Enforcement	Dumpster Maintenance	Low
DC9908	Inspection / Enforcement	Outdoor Materials	Low
DC9909	Inspection / Enforcement	Vehicle Maintenance	Low
DC9912	Street Sweeping	Street Sweeping	Low
DC9913	Studies, Surveys and Assessments	Floatables Control	High

TECHNICAL MEMORANDUM

TO:	Fairfax County DPWES
FROM:	KCI Technologies, Inc.
DATE:	October 25, 2010 Updated December 8, 2010
SUBJECT:	Belle Haven, Dogue Creek, and Four Mile Run Watersheds Task 3.6 Model Analysis and Evaluation of Alternative Scenarios Update: Revised Projects and Pollutant Loading
PROJECT:	Belle Haven, Dogue Creek and Four Mile Run Watershed Mgmt Plan
KCI PROJECT NO:	01-07-1644

INTRODUCTION

Task 3.6 requires that the proposed 10-yr implementation projects be further analyzed using EPA's Storm Water Management Model (SWMM), the Hydrologic Engineering Center's River Analysis System (HEC-RAS) developed by the Corps of Engineers, and other methods in consultation with the County team to evaluate hydrologic and hydraulic (H&H) benefits. These analyses allow for an evaluation of potential impacts from the selected projects and how they meet the previously identified objectives for their respective sub-watersheds.

The following represents occasions where modeled output is essential:

- Water quality retrofits that have strong potential to create or exacerbate upstream or downstream flooding conditions;
- Projects where the objective is to reduce/mitigate erosive downstream velocities; or
- Projects where the objective is to reduce/mitigate downstream flooding.

In these cases, modeled SWMM and HEC-RAS analysis allowed KCI to quantify whether adverse impacts were avoided or that objectives were met. A description of the model setup, results and analysis of the SWMM and HEC-RAS models and cost - benefit analysis are included in this TM.

Design Storms

Storms are hard to predict in terms of how much (amount of rain) and how long they last (duration). Using a variety of statistical approaches, storms can be classified based on their intensity (amount of rain/duration); which are called storm events. In general, low intensity storm events occur more frequently than high intensity storm events. In order to analyze the response of a watershed to an event, scientists have used statistical methods to develop storms with a similar duration (in general 24-hrs, although they could be shorter or longer), which are referred to as synthetic storms. They are referenced based on the expected return period and the duration: a 2-yr, 24-hr storm represents a return period of 2 years (or having a 50 percent chance of occurring in a given year) with a duration of 24 hours. A 10-yr, 24-hr storm will have a 10 percent chance of occurring in a given year.

Modeling is a way to mathematically estimate and spatially represent what will occur with a given storm event. Hydrologic and hydraulic models are commonly used to achieve this goal.

The ones used in this plan are briefly described as follows:

- Hydrologic models take into account several factors including: the particular rainfall event of interest, the physical nature of the land area affected by the rainfall; and how quickly the stormwater runoff drains off of the given land area. Hydrologic models can describe the quantity of stormwater runoff and some can also estimate the resulting pollution, such as nutrients (nitrogen and phosphorus) and sediment, that is transported by the runoff. The model selected for this plan, SWMM, has the capability of estimating both water quality and quantity, but another model, the Spreadsheet Tool for Estimating Pollutant Loads (STEPL), was selected to model pollutants based on the versatility that it offered.
- Hydraulic models represent the effect the stormwater runoff has on both man-made and natural systems. These models can predict both the capability of man-made culverts or channels to convey stormwater runoff and the spatial extent of potential flooding. In this study, the HEC-RAS model was selected as the hydraulic model. Table 1 provides the modeling rationale for the three storm events that were modeled for this project.

Table 1: Modeling rationale

Storm Event	Modeling Rationale
2-yr, 24-hr	Represents the amount of runoff equivalent to the channel-forming discharge in the receiving stream.
10-yr, 24-hr	Used to determine which road culverts will have adequate capacity to convey this storm without overtopping the road.
100-yr, 24-hr	Used to define the limits of flood inundation zones.

Selection of projects

Table 2 lists a total of 60 projects for the 10-year plan. Eight of these projects were selected to be modeled with SWMM, three with HEC-RAS, 16 with the stream pollutant modeling procedure and 42 with STEPL. Some projects were included in two or more different models. Subprojects within a project group, such as with LID treatment projects located in the same subarea, were analyzed individually but were assessed together per the guidance document, “Clarification of Language From March 2009 WMP Standards Version 3.2 (Subtasks 3.4 & 3.6)”. Table 2 shows the projects modeled for this subtask and the models used for each project. The procedure for combining projects in a run is discussed below in Section Pollutant loading model setup.

Table 2: Modeling strategies for 10-year projects

Watershed	Project #	Project Type	Modeled in:			
			STEPL	SWMM	HEC-RAS	Stream Loads
BE-BH-0015	BE9100	Stormwater Pond Retrofit	X	X		
BE-BH-0015	BE9102	New Stormwater Pond	X	X		
BE-HC-0020	BE9103	New Stormwater Pond	X	X		
BE-HC-0010	BE9200	Stream Restoration				X
BE-BH-0015	BE9201	Stream Restoration				X
BE-HC-0020	BE9202	Stream Restoration				X
BE-HC-0010	BE9203	Stream Restoration				X

Watershed	Project #	Project Type	Modeled in:			
			STEPL	SWMM	HEC-RAS	Stream Loads
BE-HC-0025	BE9500	BMP/LID	X			
BE-HC-0020	BE9501	BMP/LID	X			
BE-HC-0015	BE9502	BMP/LID	X			
BE-BH-0015	BE9503	BMP/LID	X			
BE-BH-0015	BE9504	BMP/LID	X			
BE-BH-0015	BE9505	BMP/LID	X			
BE-BH-0015	BE9506	BMP/LID	X			
BE-BH-0015	BE9507	BMP/LID	X			
BE-BH-0015	BE9508	BMP/LID	X			
BE-BH-0015	BE9509	BMP/LID	X			
BE-BH-0015	BE9510	BMP/LID	X			
BE-BH-0015	BE9600	Flood Protection/Mitigation			X	
DC-NE-0035	DC9100	New Stormwater Pond	X	X		
DC-BY-0030	DC9106	Stormwater Pond Retrofit	X	X		
DC-NE-0020	DC9201	Stream Restoration				X
DC-NE-0025	DC9202	Stream Restoration				X
DC-NE-0030	DC9203	Stream Restoration				X
DC-NE-0035	DC9204	Stream Restoration				X
DC-NW-0015	DC9207	Stream Restoration				X
DC-BY-0035	DC9210	Stream Restoration				X
DC-BY-0040	DC9211	Stream Restoration				X
DC-DC-0090	DC9213	Stream Restoration				X
DC-DC-0100	DC9214	Stream Restoration				X
DC-PY-0035	DC9215	Stream Restoration				X
DC-DC-0000	DC9217	Stream Restoration				X
DC-PY-0040	DC9218	Stream Restoration				X
DC-DC-0075	DC9400	Culvert Retrofit	X		X	
DC-NW-0015	DC9500	BMP/LID	X			
DC-NW-0015	DC9501	BMP/LID	X			
DC-NE-0035	DC9503	BMP/LID	X			
DC-NE-0035	DC9504	BMP/LID	X			
DC-NE-0035	DC9505	BMP/LID	X			
DC-PY-0020	DC9506	BMP/LID	X			
DC-PY-0040	DC9507	BMP/LID	X			
DC-PY-0050	DC9508	BMP/LID	X			
DC-DC-0050	DC9510	BMP/LID	X			
DC-DC-0050	DC9511	BMP/LID	X			
DC-BY-0030	DC9512	BMP/LID	X			
DC-BY-0030	DC9513	BMP/LID	X			

Watershed	Project #	Project Type	Modeled in:			
			STEPL	SWMM	HEC-RAS	Stream Loads
DC-DC-0110	DC9518	BMP/LID	X			
DC-DC-0110	DC9519	BMP/LID	X			
DC-DC-0110	DC9520	BMP/LID	X			
DC-DC-0110	DC9522	BMP/LID	X			
DC-DC-0110	DC9523	BMP/LID	X			
DC-NW-0030	DC9600	Flood Protection/Mitigation			X	
FM-LO-0000	FM9102	New Stormwater Pond	X	X		
FM-FM-0000	FM9104	Stormwater Pond Retrofit	X	X		
FM-FM-0010	FM9105	New Stormwater Pond	X	X		
FM-FM-0035	FM9300	Area-wide Drainage Improvements	X			
FM-LO-0000	FM9500	BMP/LID	X			
FM-LO-0000	FM9501	BMP/LID	X			
FM-LO-0000	FM9502	BMP/LID	X			
FM-LO-0000	FM9503	BMP/LID	X			

Project selection process

Projects were selected based on the criteria established at Technical Team Meeting #6 and in accordance with the guidance document entitled, "Clarification of language from March 2009 WMP Standards Version 3.2 (Subtasks 3.4 & 3.6)". Based on these criteria, projects that were capable of providing meaningful increased quantity control, decreased downstream flow velocities or reduced flooding were selected for additional modeling in subtask 3.6.
New stormwater ponds and stormwater pond retrofits which contribute significant reductions to peak runoff in their subwatersheds were modeled in SWMM and flood protection/mitigation projects involving culvert modification were modeled in HEC-RAS only.

Model scenarios

Four different modeled scenarios were included in this analysis: 1) Existing, 2) Future without Projects, 3) Future with Projects and 4) Comprehensive of all 10-yr time frame projects.

1. **The Existing condition** scenario included conditions of the watersheds at the time the models were created using existing land use, hydrologic soil type, existing stormwater management facilities, previous stream and watershed assessments (SPA analysis), and field visits. This model provides a reference for the existing condition of the watersheds.
2. **The Future without Projects** scenario included the same considerations as the Existing condition scenario but with the future land use condition that was derived from the County's comprehensive plan and build-out predictions. No additional projects (proposed projects) other than what were included in the Existing Conditions model were included. This scenario presents a framework for the worst case conditions and trends caused by development.
3. **The Future with Projects** scenario takes into consideration individual or bundled proposed projects (new alternatives and changes in existing facilities). This scenario

provides a condition that accounts for improvements in the subwatershed condition due to the implementation of each the 10-yr projects individually. It also provides a tool to develop a project benefit analysis.

4. **The Comprehensive 10-yr time frame projects** scenario provide a vision of the watershed conditions if all the 10-yr time frame projects are implemented and achieve their design goals. This scenario provides an overall condition of the watersheds at the end of the 10-yr time frame project development phase.

The Watershed Consultants (WC) were provided with the Existing and Future without Projects conditions models (1 and 2) and developed the Future with Projects and the Comprehensive 10-yr models (3 and 4) following an established procedure. The ultimate goal to compare the pollutant loading and stormwater runoff reductions for scenario #4 compared to the Future without Projects scenario is presented in the analysis of results section, discussed below.

Projects not included in the hydrologic and hydraulic models

Projects providing water quality treatment only but not providing significant detention (model treatment type C), although included in the Existing and Future without Projects SWMM models, were not added in the SWMM Future with Projects models following criteria established at the Technical Meeting #6. These projects mostly constitute onsite treatment (Bioretention filters and basins, water quality inlets and swales).

All types of detention structures (A, B1 and B2) are bypassed in the 100-yr SWMM model that is used to delineate the floodplain maps; therefore no changes are anticipated in the floodplain because of the proposed models other than the two culvert retrofits. These two flood protection/mitigation projects were included in HEC-RAS by changing the culvert sizes to convey the overtopping 2-yr, 10-yr and 100-yr storms meeting the treatment objectives.

MODEL DESCRIPTION

STEPL Pollutant Loading Model

The STEPL model was used to quantify the nutrient and sediment loads generated by stormwater runoff. The STEPL model calculates loads using algorithms based on the runoff volume and the pollutant concentrations in the runoff as influenced by factors such as the land use distribution and management practices. The annual sediment load is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Sediment and pollutant load reductions that result from the implementation of existing and/or proposed stormwater management facilities or best management practices (BMPs) are computed using known pollutant removal efficiencies.

Pollutant loading model setup

The Fairfax County Data Processor (FCDP) tool was used to obtain the required input land use and soils distribution per subwatershed for STEPL. The FCDP is a GIS-based tool with the following input files:

- Drainage area of the proposed and existing projects
- Parcels with stormwater treatment included in the project drainage area
- Stormwater treatment type based on the BMP facility (detention, wet detention with water quality, dry detention with water quality alone)
- Future land use
- Hydrologic soil group

In order to obtain land use and representative soil distribution for the proposed project drainage areas, the parcels which are used as input for the tool were clipped to the proposed project drainage boundaries. KCI ran STEPL for Future without Projects and compared the results (land use and HSG distribution, total area per treatment type and pollutant loads with and without BMP reductions) with the Future without Projects STEPL model provided by Tetra Tech to test for consistency with the modeling to be performed for the proposed projects. Most of the results did not have a significant discrepancy, so the analysis was performed with KCI's Future without Projects STEPL model results in order to have a consistent Future with and without Project scenarios and eliminate discrepancies caused by differences in the process. Results for these blank runs were saved under the TESTRUN folder for each WMA. A similar folder schematic as the one used in Dogue Creek and shown in **Error! Reference source not found.** was used for Belle Haven and Four Mile Run.

The FCDP tool was run multiple times. Each run included several projects with one project per subwatershed. The results of the run and intermediate files were saved and identified with the run number inside the corresponding WMA. The structure of each run folder included three sub folders named GIS, STEPL and Tools (**Error! Reference source not found.**) where the intermediate files, STEPL and ranking tables and output from the FCDP tool were saved.

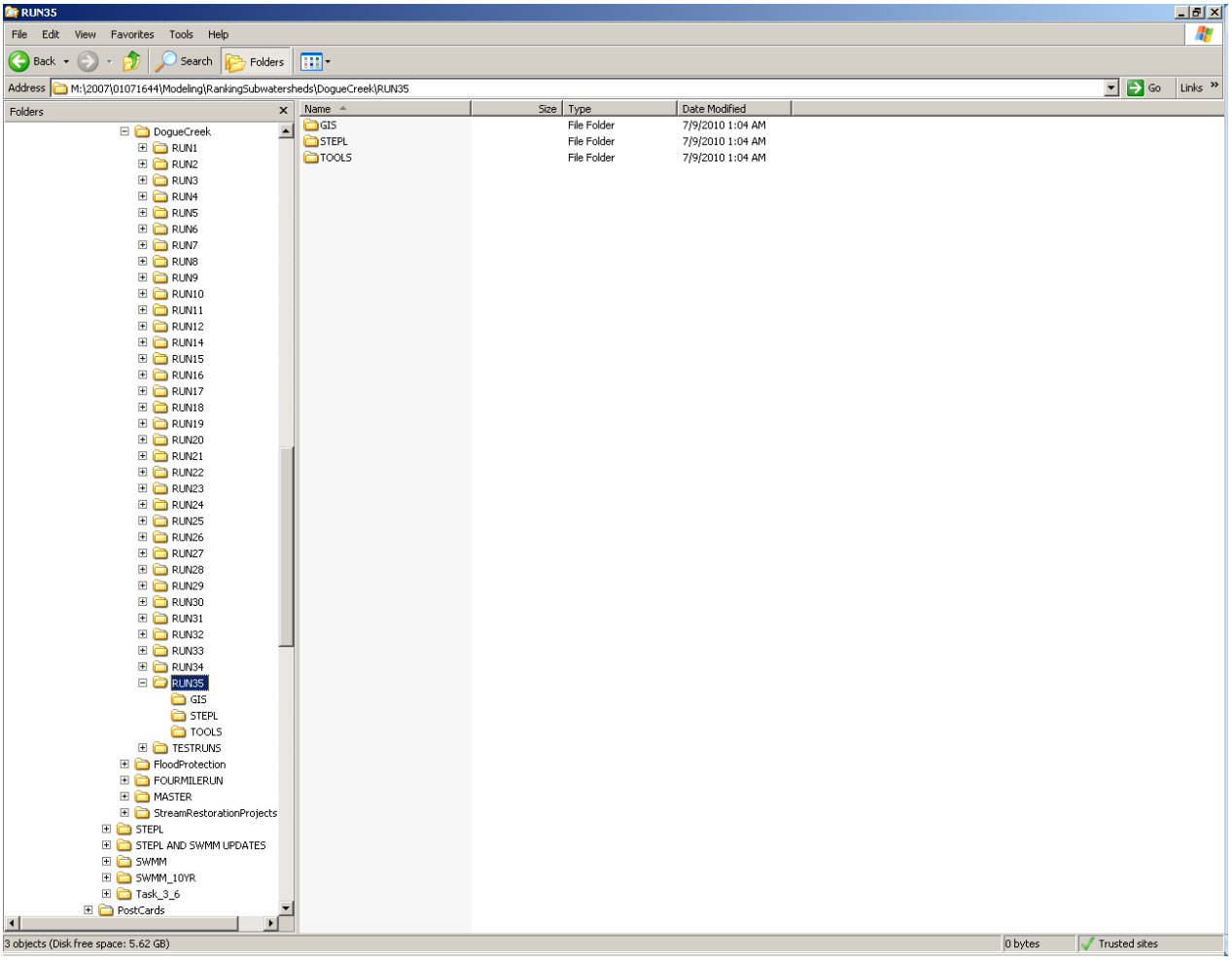
Land use and soils tables obtained in the .dbf form from running the FCDP tools were imported in to the STEPL model to calculate the nutrient and sediment loads from different land uses and reductions that would result from the implementation of the proposed projects. Both tables were incorporated by using the STEPL menu tool provided (Load SubArea Landuse and Load SubArea Major Soil data) respectively. The pollutant load reductions obtained from the implementation of project at the subwatershed scale were added to obtain the water quality benefits for the entire watershed management plan.

Total reductions for each subwatershed caused by each individual project were incorporated in the Priority Ranking Model that included the following digital datasheets:

- Impact Indicator Metrics
- Impact Indicator Scoring
- Overall_and_Objective_Composite_Scores_Template
- Source_Metrics_and_Scoring_Database

The final ranking for each subwatershed, including each individual project STEPL result, was incorporated in a summary digital datasheet (along with other metrics) in order to rank the effectiveness of the each project as described in Technical Memorandum 3.4.

Figure 1: Directory Schematic for Storing Run Data for STEPL



Stream Pollutant Loading Model

In addition to the STEPL model that was used to quantify the nutrient and sediment loads generated by stormwater runoff, pollutant loads generated by stream erosion were calculated as follows.

Pollutant loading model setup

The annual sediment load from stream bank (ton/yr) is equal to:

L*H*RR*DW*NCF

where: L = Streambank Length, ft (for ICEM II and ICEM III).
H = Streambank Height, ft, estimated from field photos, topographic mapping and SPA data.
RR = Lateral Recession Rate, ft/year, based on data provided by TetraTech.
DW = Soil Dry Weight, ton/ft^3, based on the soil texture, determined from soils texture.
NCF = Nutrient correction factor, based on the soil texture (optional), determined from soils texture.

The effectiveness of the proposed projects was estimated as a 100% recovered for each project, therefore the pollutant reduction was estimated as a weighted average based on the length of each project to the total length of ICEM II and III classes added together. Table 3 summarizes the pollutants per subwatershed.

Table 3: Stream erosion pollutant loads

Subwatershed	Area (ac)	TSS (Tons/yr)	TN (lb/yr)	TP (lb/yr)	TSS (Ton/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
BE-BH-0015	349.3	37.7	60.3	23.4	0.108	0.173	0.067
BE-HC-0010	327.1	465.2	744.4	288.4	1.422	2.276	0.882
BE-HC-0020	108.5	169.9	271.8	105.3	1.565	2.505	0.971
DC-BY-0020	184.2	13.0	20.8	8.0	0.070	0.113	0.044
DC-BY-0035	268.3	20.1	32.1	12.4	0.075	0.120	0.046
DC-BY-0040	137.7	2.1	3.3	1.3	0.015	0.024	0.009
DC-DC-0000	100.3	54.9	87.8	34.0	0.547	0.875	0.339
DC-DC-0010	276.3	28.1	44.9	17.4	0.102	0.162	0.063
DC-DC-0015	118.0	18.8	30.1	11.7	0.160	0.255	0.099
DC-DC-0025	124.7	56.1	89.7	34.8	0.450	0.720	0.279
DC-DC-0090	227.6	6.0	9.6	3.7	0.026	0.042	0.016
DC-DC-0095	184.8	98.3	157.3	61.0	0.532	0.851	0.330
DC-DC-0100	66.0	40.2	64.3	24.9	0.609	0.974	0.377
DC-DC-0105	257.6	26.5	42.3	16.4	0.103	0.164	0.064
DC-NE-0000	105.3	246.7	394.8	153.0	2.343	3.749	1.453
DC-NE-0010	67.6	9.8	15.6	6.1	0.144	0.231	0.090
DC-NE-0020	222.3	13.7	21.9	8.5	0.062	0.098	0.038
DC-NE-0025	122.7	51.3	82.1	31.8	0.418	0.670	0.259
DC-NE-0030	356.8	30.5	48.8	18.9	0.085	0.137	0.053
DC-NW-0000	130.7	42.1	67.3	26.1	0.322	0.515	0.199
DC-NW-0005	189.9	17.8	28.5	11.0	0.094	0.150	0.058
DC-NW-0010	187.6	51.1	81.7	31.7	0.272	0.436	0.169
DC-NW-0015	295.8	22.5	36.0	14.0	0.076	0.122	0.047
DC-PY-0000	201.6	30.2	48.2	18.7	0.150	0.239	0.093
DC-PY-0005	154.4	198.1	316.9	122.8	1.283	2.053	0.795
DC-PY-0010	128.4	10.9	17.4	6.8	0.085	0.136	0.053
DC-PY-0015	71.9	11.7	18.7	7.2	0.162	0.260	0.101
DC-PY-0020	262.2	16.3	26.0	10.1	0.062	0.099	0.038
DC-PY-0025	233.8	58.1	92.9	36.0	0.248	0.398	0.154
DC-PY-0030	108.5	8.3	13.3	5.2	0.077	0.123	0.048
DC-PY-0035	121.5	44.4	71.0	27.5	0.365	0.584	0.226
DC-PY-0040	182.5	19.1	30.6	11.8	0.105	0.167	0.065
DC-PY-0045	142.9	6.4	10.2	4.0	0.045	0.072	0.028

Subwatershed	Area (ac)	TSS (Tons/yr)	TN (lb/yr)	TP (lb/yr)	TSS (Ton/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
FM-FM-0035	174.8	8.0	12.8	5.0	0.046	0.073	0.028

Hydrologic model

The SWMM model was used to model rainfall/runoff relationships in the Belle Haven, Dogue Creek and Four Mile Run watersheds. The model was used to assess the peak flow rate and total volume of runoff in each subwatershed and reductions from the implementation of the proposed projects.

Hydrologic model setup

The Future with Projects model was evaluated in several model runs, taking care that no two proposed projects were included in the same subwatershed in each model run. This process allowed KCI to measure the benefits of each individual project in each of the subwatersheds. A folder schematic of all the different runs was created to store the information for each individual project results as shown in **Error! Reference source not found.**. Under each folder labeled by RUNX the GIS and interface output were saved under GIS or TOOLS respectively, the SWMM model under SWMM folder.

The procedure outlined in the "GIS Processing for updating SWMM and STEPL Models" documentation was followed to derive the summary of each area from parcels with controls, drainage areas and facility delineation files in GIS. Using the impervious calculation option of the SWMM tool process, the tabular tool in Arc GIS and the SWMM5 processor tool, the Future without Projects SWMM models were updated to represent the scenario for the Future with Projects. An example was run and submitted to Tetra Tech to ensure that the procedure that was followed was appropriate.

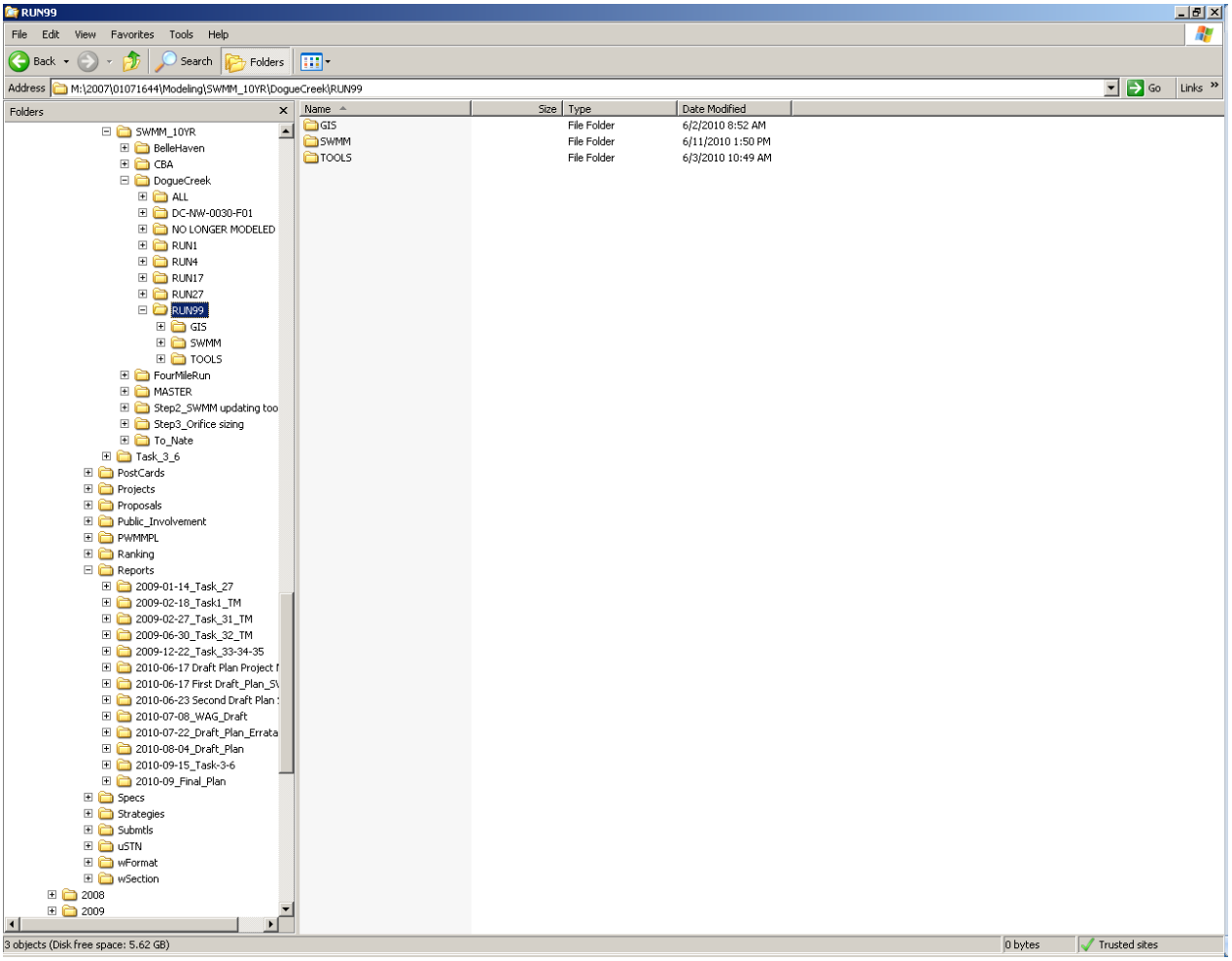
From procedures discussed at Technical Team Meeting #6, the parcels were clipped to the drainage areas in order to avoid inclusion of untreated parcels due to the SWMM tools inaccuracy in estimating the treatment types from the facility.

Subareas were delineated from subwatersheds to adequately characterize all of the stormwater treatment that was occurring in the subwatershed. However, in some cases, the Existing and Future without Projects subareas were calculated. The treatment by some ponds was not included in the appropriate subarea because either the pond was not included in the County's stormwater network and not identified until candidate project field reconnaissance, or the drainage area to the pond did not contain any parcels included in the County's controlled parcels GIS layer. The treatment of some other areas was overestimated either because the parcels were included in the County's controlled parcels GIS layer but not located within the drainage area of an existing stormwater management facility, or because candidate project field reconnaissance indicated that an existing pond provided less treatment than was originally modeled. These inaccuracies inherent in the GIS processing methodology are minimal at the watershed scale; however, they are problematic at an individual project scale. Best Professional Judgment was used to determine whether individual project benefits were over- or under-estimated in pollution modeling. Some projects were excluded from hydrologic modeling due to these inconsistencies.

During the GIS processing, output tables were created for each run, which contained the land

use and soils data for the proposed stormwater management areas for use in STEPL and SWMM modeling. The output tables from the GIS processing were used as inputs in the SWMM model using the SWMM processor tool provided by Tetra Tech. Parameters such as width, Dstore-Imperv, Dstore-Perv, and percent slope were manually entered in the SWMM model for newly delineated subareas. The infiltration parameters for areas with no proposed treatment were changed to the Future without Projects model values (calibrated parameters). The stage-storage information for the proposed facilities was entered based on the facility design. The water quality, 2-yr, 10-yr and overflow orifices were sized based on the facility design using the "orifice sizing spreadsheet" provided by Tetra Tech.

Figure 2: Directory Schematic for Storing Run Data for SWMM



Hydraulic model

HEC-RAS was initially developed by the U.S. Army Corps of Engineers (USACE) in the early 1990s as a tool to manage the rivers and harbors in their jurisdiction. HEC-RAS has found wide acceptance as the standard for simulating the hydraulics of water flow through natural and/or manmade channels and rivers, with the objective of computing water surface elevations.

Hydraulic model setup

The hydraulic model was developed to:

1. Evaluate overtopping road crossings
2. Evaluate number of flooded structures, such as buildings
3. Delineate existing and future conditions 100-yr flood plain limit
4. Compare the water surface elevations for the Future without Projects and Future with Projects scenarios

The 100-yr flood limit was delineated using HEC-RAS model results with the pre- and post-processing modules of HEC-GeoRAS. The HEC-RAS model included 35 miles of stream network (a total 84 individual reaches), 43 crossing structures (6 bridges and 37 culverts) and over 750 cross sections, including the crossings. Cross sections were cut at points where there was a change in the stream, such as significant changes in slope, flood limit elevation, or crossings.

The input geometric data for HEC-RAS was processed using HEC-GeoRAS in ArcGIS. Most of the input data, such as cross sections and flowpaths were drawn manually. Digital information was manipulated to obtain a representative model of the physical conditions of the terrain. A description of the relevant data follows.

Triangulated Irregular Network (TIN): HEC GeoRAS was setup using a TIN provided by Fairfax County.

Field survey. Selected cross sections were surveyed to model the structures and stream reaches in HEC-RAS. Two cross sections on the upstream and downstream side of each of the 43 structures were surveyed. These sections were digitally extended using 2-ft elevation contours to encompass the 100-yr flood elevation. Extended cross sections and the surveyed low flow channel were combined using a spreadsheet specifically designed for this purpose.

Stream layer. The stream centerlines were taken by cleaning the hydrology line digital file provided by the County. The cleaning process included: elimination of loops and double streams, combining multiple flow lines into a single reach, setting up the correct direction of flow for all streams and naming all of them.

Flow paths. These lines were manually drawn for all modeled streams considering a high event (100 yr flood). They are used in the HEC-GeoRAS model to model the bends of the streamline.

Import geometry. Raw geometry was created from a TIN using HEC-GeoRAS in GIS. This software uses stream cross section and flow path shape files and intersects them with the TIN to create a table with station and elevation for each cross section. This data is exported directly into HEC-RAS where it can be edited and modified.

Manning's roughness coefficient (n). A very important parameter for estimating the channel flow is the roughness of the channel and the flood limits. This was estimated from the photographs taken during the fieldwork. Since this is very subjective estimation, KCI assigned only two staff to define Manning's n to keep consistency across the watershed.

Banks. From the fieldwork, the banks were identified and marked down in the fieldwork books. These values were input into the model assuring a good representation of these features.

Structures. Data for 37 culverts and 6 bridges was processed and prepared for HEC-RAS using a digital spreadsheet.

Hydrologic input flow data: The cross sections with flow changes were located and the flows from the corresponding nodes in SWMM were extracted for 2-, 10- and 100-yr storms. The data thus obtained was used to create the input flow profile data in HEC-RAS for these three return periods.

Output analysis. Once the HEC-RAS model was revised and executed, the results were exported into a GIS file. This file can be read by HEC-GeoRAS post processing module and used to generate a flood limit shape file. Minor corrections were made to this file by eliminating and merging polygons to obtain a smooth and representative flood limit delineation.

The discharges from the 2-, 10- and 100-yr storms were used to estimate the future areas of restoration. The flows from the 10-yr storm were used to analyze the overtopping structures like bridges and culverts and their safety levels. The flooded structures were further analyzed and the ones with high priority were included in the 10-yr frame model projects for improvements. The discharges from the 100-yr storm were used to delineate the foodplain and estimate the number of residential and non-residential buildings within this area. The properties at risk of flooding during the 100-yr storm event were analyzed and mapped.

ANALYSIS OF STORMWATER MODELING RESULTS

Results of the modeling efforts were compiled and analyzed to determine the magnitude and extent of flooding and flow changes caused by implementation of the modeled projects. Pollutant load reductions were evaluated for all projects in the watershed management plan.

STEPL and Stream Pollutant Model Results

STEPL and stream pollutant model results for the overall 10-year implementation plan are presented Table 8. Implementation of the 10-year projects will reduce 744 tons per year of suspended solids, 2,076 pounds per year of nitrogen and 597 pounds per year of phosphorus.

These models have been developed to be consistent with the other watershed studies in Fairfax County. Some of the parameters may have a higher effect on other watersheds than in Dogue Creek, Belle Haven or Four Mile Run, because they are more urbanized than less developed watersheds in the County. The STEPL and stream pollutant load results were used in the Project Prioritization Ranking by giving a weighted incidence in the overall ranking (a more detailed description is presented in TM 3.4 and TM Stream Erosion Estimating Procedure). Table 4 through Table 7 summarizes the pollutant loads per project, per watershed, per WMA and for the entire watershed resulting from combining STEPL and stream erosion loads.

SWMM model results for 10-yr implementation plan

In general, the peak flows from the Future with Projects models are lower than the Future without Projects models peak flows.

The SWMM model setup considers a road as an untreated area, but, in most of the projects, runoff from the roads does get treated by the ponds. To model this situation, two approaches were taken: 1) design and model ponds with the drainage area including the roads and 2) model the ponds assuming the roads are untreated. The first was used to conclude if the project was feasible, partially feasible or not feasible at all; the second approach was used in updating the ranking of the subwatersheds based on the effects of the project.

Storage information from the design stage was included in the 10-yr SWMM model and the stage-discharge was modeled following the procedure given by Fairfax County. Wherever there were two or more pond projects with the same treatment type in the same subwatershed (either existing or proposed ponds), the ponds were combined into a single storage table. Sometimes this process did not reflect a realistic storage design. Outflow orifices were re-sized following this procedure to match the water quality volume when applicable and the 2- and 10-yr storm. These orifice sizes are different from the design phase and do not take into consideration the limitation of effectiveness of each proposed pond during the planning stage.

HEC-RAS model results

The HEC-RAS model was developed on a planning level; as it uses the peak flows generated from the SWMM model, it also inherits the approximations from the SWMM model.
In general, the Future without Projects models showed increased water surface elevations compared to Existing conditions models, although the extent of flooding was very similar in both scenarios. Peak flow values for Future with Projects models were generally lower than Future without Projects model and resulted in lower water surface elevations.
The culvert retrofit project DC9400 and the flood mitigation projects BE9600 and DC9600 were modeled by changing the culvert configuration (size, elevations and upstream and downstream cross sections) to pass the overtopping storms, thus eliminating the overtopping. Peak flows from the Future with Projects SWMM model were added to the proposed HEC-RAS model as well.

Table 4: Pollutant loads and reductions per project

KCI ID	PROJECT ID	TSS					Total Nitrogen					Total Phosphorus				
		Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project
BE-BH-0015-R02	BE9100	0.25	0.25	1%	0.24	-1.9%	6.41	6.53	2%	6.53	-0.1%	1.02	1.04	2%	1.02	-1.6%
BE-BH-0015-R05A	BE9102	0.25	0.25	1%	0.25	-0.5%	6.41	6.53	2%	6.51	-0.4%	1.02	1.04	2%	1.03	-0.5%
BE-HC-0020-R10	BE9103	1.74	1.76	1%	1.69	-3.9%	11.20	12.10	8%	10.64	-12.0%	2.16	2.26	5%	2.03	-9.9%
BE-HC-0025-R03	BE9500	0.24	0.24	0%	0.23	-5.1%	10.80	10.79	0%	10.75	-0.3%	1.62	1.62	0%	1.59	-2.1%
BE-HC-0020-R01	BE9501	1.74	1.76	1%	1.73	-1.6%	11.20	12.10	8%	11.36	-6.1%	2.16	2.26	5%	2.14	-5.1%
BE-HC-0015-R03	BE9502	0.12	0.13	3%	0.12	-2.5%	5.62	5.87	4%	5.87	0.0%	0.86	0.88	3%	0.88	-0.9%
BE-BH-0015-R04	BE9503	0.25	0.25	1%	0.25	-0.6%	6.41	6.53	2%	6.50	-0.5%	1.02	1.04	2%	1.03	-0.7%
BE-BH-0015-R01A	BE9504	0.25	0.25	1%	0.24	-2.3%	6.41	6.53	2%	6.38	-2.3%	1.02	1.04	2%	1.01	-2.3%
BE-BH-0015-R15	BE9505	0.25	0.25	1%	0.25	-0.9%	6.41	6.53	2%	6.47	-0.9%	1.02	1.04	2%	1.02	-1.0%
BE-BH-0015-R01Z	BE9506	0.25	0.25	1%	0.25	-1.2%	6.41	6.53	2%	6.48	-0.9%	1.02	1.04	2%	1.02	-1.3%
BE-BH-0015-R01B	BE9507	0.25	0.25	1%	0.24	-2.3%	6.41	6.53	2%	6.38	-2.3%	1.02	1.04	2%	1.01	-2.3%
BE-BH-0015-R05	BE9508	0.25	0.25	1%	0.25	-1.0%	6.41	6.53	2%	6.48	-0.8%	1.02	1.04	2%	1.02	-1.2%
BE-BH-0015-R16A	BE9509	0.25	0.25	1%	0.25	-0.1%	6.41	6.53	2%	6.53	0.0%	1.02	1.04	2%	1.04	0.0%
BE-BH-0015-R07	BE9510	0.25	0.25	1%	0.25	-0.1%	6.41	6.53	2%	6.53	-0.1%	1.02	1.04	2%	1.03	-0.1%
DC-NE-0035-R13	DC9100	0.10	0.10	1%	0.10	0.0%	4.38	4.48	2%	4.48	0.0%	0.70	0.72	2%	0.72	0.0%
DC-NE-0035-R02	DC9101	0.10	0.10	1%	0.10	-0.4%	4.38	4.48	2%	4.47	-0.2%	0.70	0.72	2%	0.72	-0.3%
DC-PY-0020-R03	DC9102	0.11	0.12	10%	0.12	0.7%	2.09	2.40	15%	2.41	0.7%	0.34	0.40	18%	0.40	1.0%
DC-PY-0025-R01	DC9104	0.30	0.31	4%	0.31	0.0%	3.12	3.43	10%	3.43	0.0%	0.54	0.60	11%	0.60	0.0%
DC-PY-0055-R01	DC9105	0.11	0.13	28%	0.13	-0.1%	5.73	6.29	10%	6.29	0.0%	0.81	0.94	16%	0.94	-0.1%
DC-BY-0030-R05	DC9106	0.15	0.16	2%	0.15	-7.3%	7.68	7.90	3%	7.62	-3.6%	1.14	1.17	2%	1.11	-5.0%

KCI ID	PROJECT ID	TSS					Total Nitrogen					Total Phosphorus				
		Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project
DC-DC-0085-R01	DC9107	0.16	0.16	2%	0.13	-22.2%	7.59	7.65	1%	6.88	-10.1%	1.13	1.14	1%	0.97	-14.9%
DC-DC-0085-R04	DC9108	0.16	0.16	2%	0.16	0.0%	7.59	7.65	1%	7.65	0.0%	1.13	1.14	1%	1.14	0.0%
DC-DC-0110-R04	DC9109	0.13	0.13	4%	0.13	-1.1%	5.92	6.26	6%	6.23	-0.5%	0.87	0.92	5%	0.91	-0.7%
DC-DC-0110-R07	DC9110	0.13	0.13	4%	0.13	-0.7%	5.92	6.26	6%	6.24	-0.3%	0.87	0.92	5%	0.91	-0.4%
DC-DC-0075-R91	DC9400	0.15	0.16	6%	0.16	0.0%	7.47	8.07	8%	8.07	0.0%	1.09	1.16	7%	1.16	0.0%
DC-NW-0030-R04	DC9401	0.14	0.14	1%	0.14	-0.2%	6.09	6.12	1%	6.11	-0.1%	0.95	0.95	1%	0.95	-0.1%
DC-NW-0015-R02	DC9500	0.22	0.23	6%	0.23	-1.1%	7.06	7.72	9%	7.66	-0.9%	1.05	1.13	8%	1.12	-0.9%
DC-NW-0015-R04	DC9501	0.22	0.23	6%	0.23	0.0%	7.06	7.72	9%	7.71	-0.2%	1.05	1.13	8%	1.13	-0.2%
DC-NW-0015-R05	DC9502	0.22	0.23	6%	0.23	0.0%	7.06	7.72	9%	7.72	0.0%	1.05	1.13	8%	1.13	0.0%
DC-NE-0035-R10	DC9503	0.10	0.10	1%	0.10	-0.8%	4.38	4.48	2%	4.46	-0.5%	0.70	0.72	2%	0.71	-0.7%
DC-NE-0035-R03	DC9504	0.10	0.10	1%	0.10	-0.7%	4.38	4.48	2%	4.54	1.2%	0.70	0.72	2%	0.72	0.3%
DC-NE-0035-R01	DC9505	0.10	0.10	1%	0.10	-1.8%	4.38	4.48	2%	4.44	-1.1%	0.70	0.72	2%	0.71	-1.5%
DC-PY-0020-R04	DC9506	0.11	0.12	10%	0.12	-0.5%	2.09	2.40	15%	2.38	-0.6%	0.34	0.40	18%	0.40	-0.7%
DC-PY-0040-R03	DC9507	0.25	0.27	8%	0.27	-0.5%	7.62	8.05	6%	8.03	-0.3%	1.16	1.24	7%	1.23	-0.4%
DC-PY-0050-R04	DC9508	0.12	0.19	51%	0.17	-10.0%	7.50	9.02	20%	8.62	-4.5%	0.98	1.27	30%	1.19	-6.0%
DC-PY-0050-R01	DC9509	0.12	0.19	51%	0.19	0.0%	7.50	9.02	20%	9.02	0.0%	0.98	1.27	30%	1.27	0.0%
DC-DC-0050-R01	DC9510	0.13	0.13	0%	0.13	-1.3%	5.80	5.82	0%	5.80	-0.3%	0.90	0.90	0%	0.89	-0.8%
DC-DC-0050-R03	DC9511	0.13	0.13	0%	0.13	-1.8%	5.80	5.82	0%	5.76	-1.0%	0.90	0.90	0%	0.89	-1.0%
DC-BY-0030-R04	DC9512	0.15	0.16	2%	0.16	-0.7%	7.68	7.90	3%	7.88	-0.3%	1.14	1.17	2%	1.16	-0.4%
DC-BY-0030-R08	DC9513	0.15	0.16	2%	0.16	-1.1%	7.68	7.90	3%	7.84	-0.8%	1.14	1.17	2%	1.15	-1.0%
DC-BY-0035-R04	DC9514	0.21	0.21	1%	0.21	-0.1%	7.00	7.03	0%	7.02	-0.1%	1.06	1.06	0%	1.06	-0.1%
DC-DC-0085-R07	DC9515	0.16	0.16	2%	0.16	-1.6%	7.59	7.65	1%	7.65	0.0%	1.13	1.14	1%	1.13	-0.2%
DC-DC-0085-R03	DC9516	0.16	0.16	2%	0.16	0.0%	7.59	7.65	1%	7.65	0.0%	1.13	1.14	1%	1.14	0.0%

KCI ID	PROJECT ID	TSS					Total Nitrogen					Total Phosphorus				
		Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project
DC-DC-0100-R01	DC9517	0.67	0.67	0%	0.67	0.0%	3.57	3.60	1%	3.60	0.1%	0.80	0.80	0%	0.80	0.0%
DC-DC-0110-R10	DC9518	0.13	0.13	4%	0.13	-0.8%	5.92	6.26	6%	6.24	-0.3%	0.87	0.92	5%	0.92	-0.3%
DC-DC-0110-R11	DC9519	0.13	0.13	4%	0.13	-1.6%	5.92	6.26	6%	6.24	-0.3%	0.87	0.92	5%	0.91	-0.5%
DC-DC-0110-R03	DC9520	0.13	0.13	4%	0.13	-0.8%	5.92	6.26	6%	6.23	-0.4%	0.87	0.92	5%	0.91	-0.5%
DC-DC-0110-R08	DC9521	0.13	0.13	4%	0.13	-0.4%	5.92	6.26	6%	6.25	-0.2%	0.87	0.92	5%	0.92	-0.3%
DC-DC-0110-R02	DC9522	0.13	0.13	4%	0.13	-0.5%	5.92	6.26	6%	6.24	-0.2%	0.87	0.92	5%	0.92	-0.3%
DC-DC-0110-R06	DC9523	0.13	0.13	4%	0.13	-0.5%	5.92	6.26	6%	6.25	-0.2%	0.87	0.92	5%	0.92	-0.3%
FM-FM-0020-R02	FM9100	0.06	0.06	-1%	0.06	-1.7%	2.93	2.93	0%	2.90	-1.1%	0.44	0.44	0%	0.44	-0.9%
FM-FM-0020-R01	FM9101	0.06	0.06	-1%	0.06	-3.2%	2.93	2.93	0%	2.90	-1.1%	0.44	0.44	0%	0.43	-1.5%
FM-LO-0000-R07	FM9102	0.13	0.13	1%	0.12	-9.8%	6.11	6.26	3%	5.99	-4.4%	0.90	0.91	1%	0.86	-4.8%
FM-LO-0000-R10	FM9103	0.13	0.13	1%	0.13	-0.8%	6.11	6.26	3%	6.24	-0.3%	0.90	0.91	1%	0.90	-0.4%
FM-FM-0000-R01	FM9104	0.12	0.12	1%	0.12	-2.5%	5.44	5.52	1%	5.45	-1.3%	0.76	0.76	1%	0.75	-1.7%
FM-FM-0010-R04	FM9105	0.21	0.21	0%	0.19	-9.3%	9.73	10.13	4%	9.76	-3.7%	1.30	1.35	4%	1.30	-4.1%
FM-FM-0015-R01	FM9106	0.20	0.20	-2%	0.20	-0.5%	9.21	9.37	2%	9.37	-0.1%	1.31	1.32	1%	1.31	-0.3%
FM-FM-0035-R01	FM9300	0.18	0.18	1%	0.15	-15.3%	6.14	6.27	2%	5.53	-11.7%	0.96	0.98	2%	0.84	-14.0%
FM-LO-0000-R23	FM9500	0.13	0.13	1%	0.13	-0.3%	6.11	6.26	3%	6.25	-0.1%	0.90	0.91	1%	0.91	-0.2%
FM-LO-0000-R19	FM9501	0.13	0.13	1%	0.13	-0.3%	6.11	6.26	3%	6.26	-0.1%	0.90	0.91	1%	0.91	-0.2%
FM-LO-0000-R12	FM9502	0.13	0.13	1%	0.13	-2.1%	6.11	6.26	3%	6.20	-1.0%	0.90	0.91	1%	0.90	-1.1%
FM-LO-0000-R11	FM9503	0.13	0.13	1%	0.13	-1.0%	6.11	6.26	3%	6.23	-0.5%	0.90	0.91	1%	0.90	-0.6%
Stream Restoration Projects with no reductions in Total Nitrogen as per guidelines for project prioritization																
BE-HC-0010-S01	BE9200	1.58	1.59	0%	0.64	-60.0%						1.97	2.00	2%	1.41	-29.5%
BE-BH-0015-S01	BE9201	0.25	0.25	1%	0.25	0.0%						1.02	1.04	2%	1.04	0.0%
BE-HC-0020-S01	BE9202	1.74	1.76	1%	0.20	-88.9%						2.16	2.26	5%	1.29	-43.0%

KCI ID	PROJECT ID	TSS					Total Nitrogen					Total Phosphorus				
		Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project
BE-HC-0010-F01	BE9203	1.58	1.59	0%	1.59	0.0%						1.97	2.00	2%	2.00	0.0%
DC-NE-0020-S02	DC9200	0.18	0.18	0%	0.18	0.0%						0.90	0.91	1%	0.91	0.0%
DC-NE-0020-S01	DC9201	0.18	0.18	0%	0.12	-33.5%						0.90	0.91	1%	0.87	-4.2%
DC-NE-0025-S01	DC9202	0.56	0.56	0%	0.14	-75.0%						1.24	1.25	1%	0.99	-20.7%
DC-NE-0030-S01	DC9203	0.20	0.20	1%	0.12	-41.8%						0.87	0.89	2%	0.83	-6.0%
DC-NE-0035-S01	DC9204	0.10	0.10	1%	0.10	0.0%						0.70	0.72	2%	0.72	0.0%
DC-NE-0005-S01	DC9205	0.11	0.11	0%	0.11	0.0%						0.73	0.73	0%	0.73	0.0%
DC-NW-0005-S02	DC9206	0.22	0.23	3%	0.23	0.0%						0.93	0.96	3%	0.96	0.0%
DC-NW-0015-S02	DC9207	0.22	0.23	6%	0.16	-32.8%						1.05	1.13	8%	1.09	-4.2%
DC-DC-0010-S01	DC9208	0.19	0.19	4%	0.14	-27.9%						0.63	0.68	8%	0.64	-5.0%
DC-DC-0015-S01	DC9209	0.24	0.24	0%	0.08	-65.3%						0.56	0.56	0%	0.47	-17.0%
DC-BY-0035-S01	DC9210	0.21	0.21	1%	0.21	0.0%						1.06	1.06	0%	1.06	0.0%
DC-BY-0040-S01	DC9211	0.14	0.14	0%	0.14	0.0%						0.85	0.85	1%	0.85	0.0%
DC-DC-0065-S01	DC9212	0.05	0.05	0%	0.05	0.0%						0.32	0.32	0%	0.32	0.0%
DC-DC-0090-S01	DC9213	0.15	0.16	6%	0.16	0.0%						0.90	0.97	8%	0.97	0.0%
DC-DC-0100-S01	DC9214	0.67	0.67	0%	0.06	-90.6%						0.80	0.80	0%	0.42	-47.1%
DC-PY-0035-S01	DC9215	0.42	0.42	0%	0.06	-86.7%						0.74	0.74	0%	0.52	-30.4%
DC-PY-0045-S01	DC9216	0.13	0.14	9%	0.14	0.0%						0.70	0.75	7%	0.75	0.0%
DC-DC-0000-S01	DC9217	0.63	0.65	3%	0.51	-21.8%						0.84	0.99	17%	0.90	-8.8%
DC-PY-0040-S01	DC9218	0.25	0.27	8%	0.24	-11.0%						1.16	1.24	7%	1.22	-1.5%
FM-LO-0000-S03	FM9200	0.13	0.13	1%	0.13	0.0%						0.90	0.91	1%	0.91	0.0%
Flood Mitigation Projects with no pollutant reduction																
DC-NW-0030-F01	DC9600															

KCI ID	PROJECT ID	TSS					Total Nitrogen					Total Phosphorus				
		Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project	Existing Conditions	Future w/o Projects Conditions	% Change: Existing to Future w/o Project	Future w/Projects Conditions	% Change: Future w/o to Future w/ Project
BE-BH-0015-F01	BE9600															

Table 5: Pollutant loading and flow reduction by watershed

Watershed	Area (ac)	Scenario[3]	Runoff Volume (in)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2,4]	TP (lb/ac/yr)[2,4]
			2 Year	10 Year	2 Year	10 Year			
Belle Haven	1,737.4	Existing	1.464	3.145	0.560	1.145	1,070.0	6.9169	1.2165
		Future without projects	1.515	3.208	0.576	1.181	1,076.0	7.1047	1.2381
		Future 10-yr projects	1.476	3.174	0.558	1.136	506.6	6.5143	1.0382
		Future 25-yr projects	N/A	N/A	N/A	N/A	506.6	6.5143	1.0382
		Reduction 10-year projects	0.039 (3%)	0.034 (1%)	0.018 (3%)	0.045 (4%)	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
Four Mile Run	1,953.0	Existing	1.592	3.287	0.816	1.604	245.7	5.4505	0.7964
		Future without projects	1.632	3.342	0.824	1.623	246.4	5.5786	0.8077
		Future 10-yr projects	1.583	3.264	0.766	1.503	230.3	5.3949	0.7764
		Future 25-yr projects	N/A	N/A	N/A	N/A	229.4	5.3934	0.7756
		Reduction 10-year projects	0.049 (3%)	0.078 (2%)	0.058 (7%)	0.12 (7%)	16.1 (7%)	0.1837 (3%)	0.0313 (4%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	17.0 (7%)	0.1852 (3%)	0.0321 (4%)
Dogue Creek	12,475.1	Existing	1.286	2.984	0.113	0.295	382.6	4.1327	0.6682
		Future without projects	1.325	3.031	0.127	0.343	390.6	4.3033	0.6932
		Future 10-yr projects	1.273	2.927	0.122	0.329	353.1	4.2479	0.6781
		Future 25-yr projects	N/A	N/A	N/A	N/A	344.8	4.2107	0.6690
		Reduction 10-year projects	0.052 (4%)	0.104 (3%)	0.005 (4%)	0.014 (4%)	37.5 (10%)	0.0554 (1%)	0.0151 (2%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	45.8 (11%)	0.0926 (2%)	0.0242 (4%)

[1]Flow is cumulative
[2]Loads are representative of individual land area contributions
[3]25-year projects were not evaluated in the hydrologic model
[4]Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

Table 6: Pollutant loading and flow reduction by WMA

WMA	Area (ac)	Scenario[3]	Runoff Volume (in)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2,4]	TP (lb/ac/yr)[2,4]
			2 Year	10 Year	2 Year	10 Year			
Belle Haven	1,737.4	Existing	1.464	3.145	0.560	1.145	1,070.0	6.9169	1.2165
		Future without projects	1.515	3.208	0.576	1.181	1,076.0	7.1047	1.2381
		Future 10-yr projects	1.476	3.174	0.558	1.136	506.6	6.5143	1.0382
		Future 25-yr projects	N/A	N/A	N/A	N/A	506.6	6.5143	1.0382
		Reduction 10-year projects	0.039 (3%)	0.034 (1%)	0.018 (3%)	0.045 (4%)	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
Four Mile Run	1,953.0	Existing	1.592	3.287	0.816	1.604	245.7	5.4505	0.7964
		Future without projects	1.632	3.342	0.824	1.623	246.4	5.5786	0.8077
		Future 10-yr projects	1.583	3.264	0.766	1.503	230.3	5.3949	0.7764
		Future 25-yr projects	N/A	N/A	N/A	N/A	229.4	5.3934	0.7756
		Reduction 10-year projects	0.049 (3%)	0.078 (2%)	0.058 (7%)	0.12 (7%)	16.1 (7%)	0.1837 (3%)	0.0313 (4%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	17.0 (7%)	0.1852 (3%)	0.0321 (4%)
Dogue Creek - Barnyard Run	1,528.7	Existing	1.328	3.025	0.125	0.181	197.7	3.2353	0.5020
		Future without projects	1.334	3.032	0.173	0.416	198.9	3.2630	0.5058
		Future 10-yr projects	1.208	2.766	0.162	0.391	197.0	3.2386	0.5016
		Future 25-yr projects	N/A	N/A	N/A	N/A	197.2	3.2446	0.5023
		Reduction 10-year projects	0.126 (9%)	0.266 (9%)	0.011 (6%)	0.025 (6%)	1.9 (1%)	0.0244 (1%)	0.0042 (1%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	1.7 (1%)	0.0184 (1%)	0.0035 (1%)

WMA	Area (ac)	Scenario[3]	Runoff Volume (in)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2,4]	TP (lb/ac/yr)[2,4]
			2 Year	10 Year	2 Year	10 Year			
Dogue Creek - Mainstem	3,775.8	Existing	1.329	3.036	0.124	0.312	350.9	4.0837	0.6544
		Future without projects	1.367	3.082	0.138	0.371	359.8	4.2895	0.6823
		Future 10-yr projects	1.302	2.951	0.132	0.353	327.5	4.2047	0.6654
		Future 25-yr projects	N/A	N/A	N/A	N/A	308.9	4.2293	0.6600
		Reduction 10-year projects	0.065 (5%)	0.131 (4%)	0.006 (4%)	0.018 (5%)	32.3 (9%)	0.0848 (2%)	0.0169 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	50.9 (14%)	0.0602 (1%)	0.0223 (3%)
Dogue Creek - North Fork	2,805.5	Existing	1.448	3.176	0.175	0.392	585.9	5.6584	0.9337
		Future without projects	1.509	3.252	0.240	0.508	592.5	5.8593	0.9582
		Future 10-yr projects	1.479	3.220	0.225	0.473	506.8	5.7795	0.9292
		Future 25-yr projects	N/A	N/A	N/A	N/A	500.6	5.7130	0.9153
		Reduction 10-year projects	0.03 (2%)	0.032 (1%)	0.015 (6%)	0.035 (7%)	85.7 (15%)	0.0798 (1%)	0.0290 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	91.9 (16%)	0.1463 (3%)	0.0429 (5%)
Dogue Creek - Piney Run[5]	1,736.1	Existing	1.225	2.864	0.214	0.492	605.6	3.7192	0.6398
		Future without projects	1.240	2.879	0.221	0.499	625.6	3.9516	0.6855
		Future 10-yr projects	1.240	2.879	0.221	0.499	566.7	3.8883	0.6644
		Future 25-yr projects	N/A	N/A	N/A	N/A	557.5	3.6694	0.6329
		Reduction 10-year projects	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	58.9 (9%)	0.0633 (2%)	0.0211 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	68.1 (11%)	0.2822 (7%)	0.0526 (8%)

WMA	Area (ac)	Scenario[3]	Runoff Volume (in)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2,4]	TP (lb/ac/yr)[2,4]
			2 Year	10 Year	2 Year	10 Year			
Dogue Creek – Potomac[6]	2,629.0	Existing	0.405	1.005	0.446	0.945	171.3	3.3700	0.5200
		Future without projects	0.421	1.026	0.483	1.015	175.7	3.5000	0.5400
		Future 10-yr projects	0.421	1.026	0.483	1.015	175.7	3.5000	0.5400
		Future 25-yr projects	N/A	N/A	N/A	N/A	175.7	3.5000	0.5400
		Reduction 10-year projects	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	0.0 (0%)	0.0 (0%)	0.0 (0%)

[1]Flow is cumulative
[2]Loads are representative of individual land area contributions
[3]25-year projects were not evaluated in the hydrologic model
[4]Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

Table 7: Pollutant loading and flow reduction, overall WMP

	Area (ac)	Scenario[3]	Runoff Volume (in)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2,4]	TP (lb/ac/yr)[2,4]
			2 Year	10 Year	2 Year	10 Year			
Full Plan	16,165.5	Existing	1.342	3.038	1.489	3.044	439.9	4.5911	0.7426
		Future without projects	1.383	3.088	1.527	3.147	446.8	4.7585	0.7656
		Future 10-yr projects	1.332	2.994	1.446	2.968	354.8	4.6301	0.7287
		Future 25-yr projects	N/A	N/A	N/A	N/A	348.3	4.6012	0.7216
		Reduction 10-year projects	0.051 (4%)	0.094 (3%)	0.081 (5%)	0.179 (6%)	92.0 (21%)	0.1284 (3%)	0.0369 (5%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	98.5 (22%)	0.1573 (3%)	0.0440 (6%)

[1]Flow is cumulative
[2]Loads are representative of individual land area contributions
[3]25-year projects were not evaluated in the hydrologic model
[4]Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

Table 8: Overall Pollutant Loading and Flow Reduction

Watershed	Area (acres)	Scenario[3]	Runoff Volume (in/yr)[1]		Peak Flow (cfs/ac)[1]		TSS (lbs/year)[2]	TN (lbs/year)[2]	TP (lbs/year)[2]
			2-Year	10-Year	2-Year	10-Year			
Full Plan	16,165.5	Existing	1.342	3.038	1.489	3.044	7,111,468	74,218	12,005
		Future without projects	1.383	3.088	1.527	3.147	7,223,400	76,923	12,376
		Future 10-yr	1.332	2.994	1.446	2.968	5,735,130	74,847	11,779
		Future 25-yr	N/A	N/A	N/A	N/A	5,630,082	74,380	11,664
		Reduction 10-year	3.7%	3.0%	5.3%	5.7%	744 (20.6%)	2,076 (2.7%)	597 (4.8%)
		Reduction 25-year	N/A	N/A	N/A	N/A	797 (22.1%)	2,543 3.3%	712 (5.8%)

[1]Flow is cumulative
[2]Loads are representative of individual land area contributions
[3]25-year projects were not evaluated in the hydrologic model

COST BENEFIT ANALYSIS

A Cost-Benefit analysis was performed for this study based on the cost estimates calculated for all structural projects. For the 10-year projects a more detailed cost estimate was developed. The total cost of implementing projects in this 10-year phase was calculated to be approximately $26.7 million for all the WMA's: $7.5 million for Belle Haven, $13.7 million for Dogue Creek and $5.5 million for Four Mile Run. The estimated costs for structural projects in the 11-25 year time-frame phase were done at a planning level in less detail than the 10-year time-frame projects, totaling $7.5 million ($7.1 million for Dogue Creek and $0.4 million for Four Mile Run) for a total of $34.2 million. Cost estimates were not calculated for non-structural projects.

The project cost distribution for all projects listed in the 10-year implementation plan was evaluated. The evaluation of the project cost distribution is intended to be used for determination of outliers within the list of projects. A further consideration to keep or replace the outliers was done and Best Professional Judgment (BPJ) was used to determine if these projects should remain in the 10-year list. A cost-to-benefit ratio was calculated based on the subwatershed ranking composite score and the projects' associated costs. Using the cost-to-benefit ratio, all structural projects in the 10-year implementation plan were reordered based on this analysis.

The two groups of projects that had been considered in the previous analysis (projects less than and projects over $1,000,000), were simplified to one single group. Green roofs were not considered in this analysis as they are expensive when compared to the benefits.

For this updated analysis, the Scale Cost Factor (C) for each project is estimated as the individual project cost divided by the ratio of the range of project costs and the range of BPJ Adjusted Composite Scores (BPJ ACS) plus the minimum of the BPJ ACS. This Scale Cost Factor was computed for each of the project groups. The CBA (Final Score/Scale Cost Factor) was computed for each individual project. The projects were ranked based on the CBA. A summary of the final values is presented in Table 9.

The CBA analysis showed an exponential trend in the costs. The lowest Composite Score adjusted with BPJ is 3.3 and the highest is 4.7. The stream restoration projects are generally ranked lower and the LIDs are generally ranked higher. The other project types are spread throughout the rank range.

Table 9: CBA ranking

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ	Rank	Project Cost	Scale Cost Factor (C)	CBA:Final Score/Scale Cost Factor (B/C)	Ranks by CBA
BE-BH-0015-R05	BE9508	3.5	4.2	5.0	5.0	5.0	4.3	4.3	6	$62,000	3.34	1.29	1
BE-BH-0015-R01Z	BE9506	3.5	4.2	5.0	5.0	5.0	4.3	4.3	5	$91,000	3.36	1.28	2
BE-BH-0015-R01A	BE9504	3.8	4.5	5.0	5.0	3.0	4.3	4.3	8	$145,000	3.40	1.26	3
BE-HC-0020-R01	BE9501	3.9	4.7	5.0	5.0	3.0	4.4	4.4	3	$283,000	3.50	1.25	4
FM-LO-0000-R11	FM9503	3.4	4.2	4.0	5.0	5.0	4.2	4.2	15	$79,000	3.35	1.24	5
DC-PY-0050-R04	DC9508	4.0	5.0	3.0	5.0	3.0	4.3	4.3	7	$240,000	3.47	1.24	6
DC-BY-0030-R08	DC9513	3.5	4.2	3.0	5.0	5.0	4.1	4.1	20	$45,000	3.32	1.23	7
DC-BY-0030-R05	DC9106	3.8	4.6	3.0	5.0	3.0	4.1	4.1	18	$89,000	3.36	1.23	8
BE-BH-0015-R01B	BE9507	3.8	4.5	5.0	5.0	3.0	4.3	4.3	9	$257,000	3.48	1.23	9
BE-BH-0015-R15	BE9505	3.5	4.2	5.0	5.0	3.0	4.1	4.1	19	$83,000	3.35	1.22	10
DC-NE-0035-R01	DC9505	3.6	4.3	3.0	5.0	5.0	4.2	4.2	13	$209,000	3.45	1.21	11
BE-HC-0020-R10	BE9103	4.2	4.7	5.0	5.0	5.0	4.7	4.7	1	$750,000	3.85	1.21	12
FM-FM-0000-R01	FM9104	3.0	4.6	4.0	5.0	3.0	4.0	4.0	27	$99,000	3.36	1.18	13
BE-HC-0015-R03	BE9502	3.1	3.7	4.0	5.0	5.0	3.9	3.9	31	$69,000	3.34	1.18	14
DC-NE-0035-R10	DC9503	3.3	3.8	3.0	5.0	5.0	3.9	3.9	32	$74,000	3.35	1.17	15
BE-BH-0015-R02	BE9100	2.8	3.8	5.0	5.0	5.0	4.0	4.0	24	$174,000	3.42	1.17	16
DC-BY-0030-R04	DC9512	3.3	3.8	3.0	5.0	3.0	3.7	3.9	34	$34,000	3.32	1.16	17
DC-DC-0050-R01	DC9510	3.4	4.0	3.0	5.0	5.0	4.0	4.0	23	$223,000	3.46	1.16	18
BE-HC-0020-S01	BE9202	3.7	4.8	5.0	5.0	1.0	4.1	4.1	16	$388,000	3.58	1.16	19
BE-BH-0015-R04	BE9503	3.4	4.0	5.0	5.0	3.0	4.0	4.0	22	$251,000	3.48	1.15	20
DC-DC-0050-R03	DC9511	3.6	4.3	3.0	5.0	3.0	4.0	4.0	25	$228,000	3.46	1.15	21
BE-BH-0015-R07	BE9510	2.9	3.3	5.0	5.0	5.0	3.9	3.9	33	$85,000	3.35	1.15	22
FM-FM-0010-R04	FM9105	3.2	4.8	5.0	5.0	3.0	4.2	4.2	11	$498,000	3.66	1.15	23
FM-LO-0000-R12	FM9502	3.6	4.5	4.0	5.0	3.0	4.1	4.1	17	$479,000	3.65	1.13	24

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ	Rank	Project Cost	Scale Cost Factor (C)	CBA:Final Score/Scale Cost Factor (B/C)	Ranks by CBA
DC-DC-0000-S01	DC9217	3.9	4.8	2.0	5.0	5.0	4.3	4.3	4	$707,000	3.82	1.13	25
DC-NE-0020-S01	DC9201	3.7	4.8	4.0	5.0	3.0	4.2	4.2	10	$646,000	3.77	1.12	26
DC-DC-0110-R11	DC9519	3.4	4.0	2.0	5.0	3.0	3.7	3.7	42	$58,000	3.33	1.11	27
DC-NW-0015-R02	DC9500	4.0	4.2	1.0	5.0	3.0	3.9	3.9	35	$262,000	3.49	1.10	28
BE-BH-0015-R05A	BE9102	2.5	3.7	5.0	5.0	5.0	3.9	3.9	36	$277,000	3.50	1.10	29
DC-PY-0020-R04	DC9506	3.4	4.0	1.0	5.0	3.0	3.6	3.7	43	$145,000	3.40	1.09	30
DC-PY-0040-R03	DC9507	3.1	3.8	3.0	5.0	3.0	3.7	3.7	44	$121,000	3.38	1.09	31
DC-DC-0110-R10	DC9518	3.3	3.8	2.0	5.0	3.0	3.6	3.6	45	$46,000	3.32	1.09	32
BE-BH-0015-R16A	BE9509	2.8	3.2	5.0	5.0	5.0	3.8	3.8	38	$241,000	3.47	1.09	33
FM-LO-0000-R19	FM9501	2.9	3.5	4.0	5.0	3.0	3.6	3.6	47	$52,000	3.33	1.09	34
FM-LO-0000-R23	FM9500	2.9	3.5	4.0	5.0	3.0	3.6	3.6	48	$92,000	3.36	1.08	35
DC-DC-0110-R02	DC9522	3.1	3.7	2.0	5.0	3.0	3.5	3.5	51	$21,000	3.31	1.07	36
BE-HC-0025-R03	BE9500	3.5	4.2	4.0	3.0	3.0	3.6	3.6	49	$105,000	3.37	1.07	37
DC-DC-0110-R03	DC9520	3.3	3.8	2.0	5.0	3.0	3.6	3.6	46	$163,000	3.41	1.06	38
DC-NW-0015-S02	DC9207	4.0	4.6	1.0	5.0	3.0	4.0	4.0	26	$646,000	3.77	1.05	39
DC-NE-0025-S01	DC9202	3.4	4.8	4.0	5.0	3.0	4.2	4.2	14	$925,000	3.98	1.05	40
DC-NW-0030-F01	DC9600	1.7	4.8	4.0	5.0	5.0	3.8	3.8	37	$488,000	3.66	1.05	41
DC-NE-0035-R03	DC9504	2.8	3.2	3.0	5.0	5.0	3.6	3.6	50	$189,000	3.43	1.04	42
DC-NE-0030-S01	DC9203	2.8	4.8	2.0	5.0	5.0	4.0	4.0	28	$744,000	3.85	1.03	43
DC-PY-0040-S01	DC9218	3.3	4.8	3.0	5.0	3.0	4.0	4.0	21	$872,000	3.94	1.02	44
DC-NW-0015-R04	DC9501	3.4	3.3	1.0	5.0	3.0	3.4	3.4	55	$69,000	3.34	1.02	45
DC-DC-0110-R06	DC9523	2.9	3.3	2.0	5.0	3.0	3.4	3.4	56	$48,000	3.33	1.01	46
BE-BH-0015-F01	BE9600	1.7	4.8	5.0	5.0	3.0	3.7	3.7	41	$593,000	3.74	1.00	47
DC-DC-0075-R91	DC9400	1.7	2.0	1.0	5.0	5.0	2.7	3.3	60	$27,000	3.31	1.00	48
DC-BY-0035-S01	DC9210	2.8	3.2	2.0	5.0	5.0	3.5	3.5	53	$547,000	3.70	0.94	49
FM-FM-0035-R01	FM9300	4.0	5.0	4.0	5.0	3.0	4.4	4.4	2	$1,833,000	4.67	0.94	50
BE-BH-0015-S01	BE9201	2.6	3.2	5.0	5.0	5.0	3.7	3.7	40	$883,000	3.95	0.94	51

KCI Project ID	Project ID	1. Watershed Impact indicators	2. Watershed Source indicators	3. Location with Priority Subwatersheds	4. Sequencing	5. Implementability	Initial Composite Prioritization Score	Composite Prioritization Score adjusted with BPJ	Rank	Project Cost	Scale Cost Factor (C)	CBA:Final Score/Scale Cost Factor (B/C)	Ranks by CBA
DC-DC-0100-S01	DC9214	3.7	4.8	1.0	5.0	3.0	3.9	3.9	29	$1,261,000	4.24	0.93	52
DC-NE-0035-R13	DC9100	1.3	2.8	3.0	5.0	5.0	3.1	3.3	59	$480,000	3.65	0.90	53
DC-PY-0035-S01	DC9215	3.0	4.8	1.0	5.0	5.0	3.9	3.9	30	$1,480,000	4.40	0.90	54
DC-BY-0040-S01	DC9211	2.6	3.2	1.0	5.0	5.0	3.3	3.3	58	$578,000	3.72	0.89	55
DC-NE-0035-S01	DC9204	2.3	3.2	3.0	5.0	5.0	3.5	3.5	54	$859,000	3.93	0.88	56
BE-HC-0010-S01	BE9200	3.4	4.8	4.0	3.0	3.0	3.8	3.8	39	$1,614,000	4.50	0.84	57
DC-DC-0090-S01	DC9213	3.2	3.2	3.0	5.0	3.0	3.5	3.5	52	$1,228,000	4.21	0.84	58
FM-LO-0000-R07	FM9102	3.3	5.0	4.0	5.0	3.0	4.2	4.2	12	$2,326,000	5.04	0.83	59
BE-HC-0010-F01	BE9203	2.6	3.2	4.0	3.0	3.0	3.0	3.3	57	$1,122,000	4.13	0.81	60

CONCLUSIONS AND RANKING MODIFICATIONS

Based on the results presented in this memo, the overall impact of implementing the projects identified in the 10-yr priority list is generally beneficial to reducing pollutant loads and stormwater runoff flows. These results were used to adjust the overall ranking of structural projects for the final watershed management plan. Projects showing significant reductions were weighted favorably whereas projects showing increased flows or potential for downstream flooding were further evaluated to determine viability in the 10-yr priority list. Comments from the WAG meetings were added into the project analysis by BPJ and/or by adding new projects to the list.

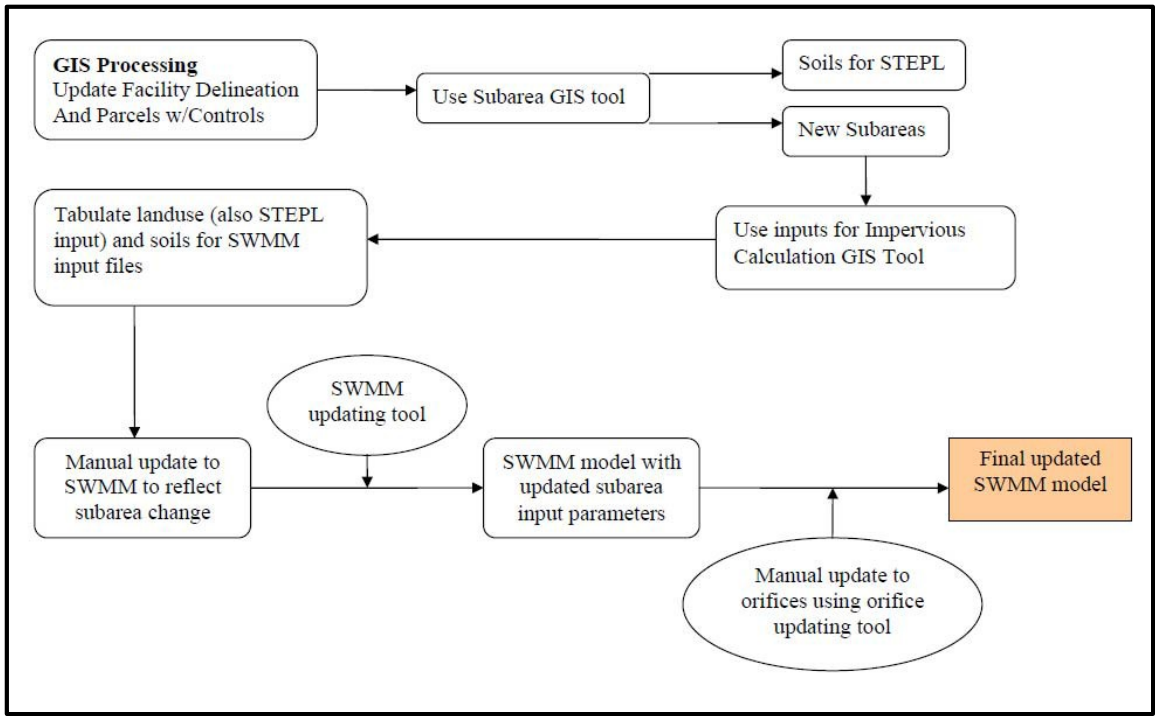
Appendix A:

The procedures followed in the TM 3.6 are according to "Tools_for_STEPL_and_SWMM_updates_060909" guidelines provided by Fairfax County / Tetra Tech to the WC, which includes: Step1_GIS_Processing, Step2_SWMM updating tool and Step3_Orifice sizing.

1. General procedure guideline:

The following diagram, taken from the Tools_for_STEPL_and_SWMM_updates_060909 guidelines, summarizes the flow of processes involved in updating the SWMM model:

Figure 3. Model setup/update flow diagram Tools_for_STEPL_and_SWMM_updates_060909.



Subwatershed boundaries and drainage areas to each individual project have been previously delineated. SWMM models provided to the WC show a graphical representation of treatment type "D" (untreated) areas as the subwatershed boundary; other treatment type areas (A, B1, B2, and C as applicable) are graphically represented as tetra-polygons within subarea "D". This delineation scheme is only a graphical illustration of the subarea composition within a subwatershed, and does not reflect the real location of subareas or influence the routing of

surface runoff. The input parameters for each subarea are entered separately (discussed in Section 2) and flow is routed to downstream components, independent of the size or location of the delineation.

2. Input parameters for subarea

Input parameters for a treatment area include: area, width, slope, percent impervious, Manning's n for both pervious and impervious surfaces, depression storage for both impervious and pervious surfaces, percentage of impervious surfaces with zero depression storage, subarea internal routing method and percentage and the Horton infiltration parameters.

The SWMM input parameters were updated following the procedure indicated in **Tutorial for using the SWMM updating tool.** Using the shape file resulting from running the SubareaCalc script (included in the **FairfaxCountyDataProcessor Tool**) and the Impervious dbf table resulting from running the **Impervious Calculation** script (included in the same **FairfaxCountyDataProcessor** Tool), two additional dbf tables were created with a summary of the Land Use and Soil composition per area type for each subwatershed.

The Future without Projects SWMM model was modified by adding and/or deleting the treatment areas to match the Future with Projects scenario as described in the previous section. Using the SWMM5 PROCESSOR Tool and the summary dbf tables for Land Use, Soils, and Impervious, a new SWMM5 model with proposed projects was created. Some parameters had to be manually updated such as: width, depression storage (pervious and impervious), slope and Horton parameters (these latter ones only for subwatersheds with no changes).

Width – Area weighted average of the total catchment width based on the new distribution of area types (add all width for each subwatersheds and divide the sum by the total area of each subwatershed and multiply the resulting factor by the area of each treatment type area).

Slope – Slope remains the same for all the area types within a subwatershed and is equal to the slope of the same subwatershed in the Future without Projects model.

Percentage of imperviousness – The percentage of imperviousness of a subarea is updated in the SWMM5 model using the SWMM5 PROCESSOR Tool.

Manning's n – The Manning's n for both impervious and pervious surfaces of a subarea is updated in the SWMM5 model using the SWMM5 PROCESSOR Tool.

Depression storage – Manually set to 0.2 for pervious and 0.1 for impervious areas.

Percentage of impervious surface with zero depression storage – A default value of 25% suggested by TM3 is used in the initial model setup.

Internal routing method and percentage – This is a SWMM5 capability which allows for internal routing of flow among pervious and impervious surfaces. SWMM has three categories of

surfaces: directly connected impervious (DCIA), disconnected impervious (NDCIA), and pervious, which makes it possible to reflect runoff from NDCIA surfaces by routing NDCIA runoff to neighboring pervious surfaces. When specifying the internal routing method, flow is routed to pervious surfaces, and the percentage routed is calculated as the NDCIA area divided by the total impervious area (DCIA+NDCIA).

Horton infiltration parameters (WLMIN, WLMAX, and DECAY) – The Horton infiltration parameters are generated based on the soils information within each subarea, following TM3 specifications. The values provided in the Future without Project model have been calibrated, therefore if there is no change in the area treatment, the soil infiltration parameters should remain unchanged.

3. Input parameters for stormwater facilities

There are four types of stormwater facilities: peak-shaving only (subarea A); peak-shaving and water quality, wet pond (subarea B1); peak-shaving and water quality, dry pond (subarea B2); and water-quality only (subarea C). Descriptions of each modeling procedure for each type of detention follow. Based on Technical Meeting #6, no SWMM or HEC-RAS modeling is done for area type “C” under proposed conditions because it does not provide a significant amount of detention.

3.1 Water Quality peak shaving (B1 and B2)

It is assumed that a detention time of 48-hrs should be achieved by this type of detention. Following the guidelines, an orifice was sized such that the estimated water quality volume will be drained in 48-hrs.

3.2 Water Quantity peak shaving (A, B1 and B2)

The peak-shaving facilities serve the purpose of maintaining the pre-development peak flow for both 2-yr and 10-yr design storms. In the model representation, a storage unit with three orifices is used to represent the facility. Facing downstream, the three orifices are the 2-yr orifice, 10-yr orifice, and overflow orifice from left to right. The elevation of the orifices also increase as they change from 2-yr to overflow. The 2-yr orifice height is estimated from either the maximum elevation of the water quality ponding area (B1 type), the maximum water surface elevation of the water quality volume (B2 type), or the bottom of the storage unit if no water quality is provided (A type).

The 10-yr orifice elevation is set at the maximum water surface elevation of the 2-yr storm in the pond and the 100-yr orifice elevation is set at the maximum water surface elevation of the 10-yr storm in the pond. The orifice sizing spreadsheet provided by Fairfax County/Tetra Tech was used to match the pre-developed peak flow conditions for the 2- and 10-yr storms.

Dummy channels carry flow from the three orifices to a downstream converging point before discharging the combined outflow to the subwatershed outlet. In general, the overflow orifice is set to a diameter of 5-ft.