Town of Dumfries
Council Meeting

Meeting Date:	August 20, 2013
Agenda Item#	IX - B

AGENDA ITEM FORM

TYPE OF AGENDA ITEM:
- ☐ CONSENT AGENDA
- ☐ PRESENTATION
- ☐ ACTION ITEM
- ☐ TOWN MANAGER & STAFF COMMENTS
- ☐ PUBLIC HEARING
  - ☐ Duly Advertised

PURPOSE OF ITEM:
- ☐ INFORMATION ONLY
- ☑ DISCUSSION ONLY
- ☐ DISCUSSION AND/OR DECISION
  - ☐ Introduction ☐ Resolution
  - ☐ Ordinance ☐ Grant/MOU
  - ☐ By Motion ☐ Bylaws
  - ☐ Certificate

PRESENTER: Richard West **PRESENTER TITLE:** Director of Public Works

AGENDA ITEM: Quantico Creek Update

BACKGROUND / SUMMARY:

Summary of the status of the Quantico Creek Restoration project and next steps

ATTACHMENTS:

Quantico Creek Stream Restoration Assessment Summary

REQUESTED ACTION: ☐ NO ACTION REQUESTED

FOR MORE INFORMATION, CONTACT: Name: Richard West

Phone#: 703 221-3400 E-mail: rwest@dumfriesva.gov

FOR USE DURING MEETING **VOTE:** ☐ PASSED ☐ NOT PASSED

Y	N		Y	N		Y	N	
☐	☐	Brewer	☐	☐	Foreman	☐	☐	Forrester
☐	☐	Reynolds	☐	☐	Toney	☐	☐	Washington
☐	☐	Wood						

QUANTICO CREEK
STREAM RESTORATION
ASSESSMENT SUMMARY

Town of Dumfries
Prince William County, Virginia
June 28, 2013

Prepared for:
TOWN OF DUMFRIES
17755 Main Street
P.O. Box 56
Dumfries, Virginia 22026

McCormick Taylor
Engineers & Planners Since 1946

North Shore Commons "A"
4951 Lake Brook Drive, Suite 275
Glen Allen, Virginia 23060

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1.0 INTRODUCTION AND BACKGROUND INFORMATION

The Town of Dumfries contracted McCormick Taylor to assess an approximate 1.21 miles of Quantico Creek for potential restoration opportunities. The project extends from the I-95 Bridge to the Eastern Route 1 Bridge and continues from the Route 1 Bridge to the mouth of Quantico Bay. The major concern of the Town is flooding that occurs within the town limits, especially during tidal backflow. In addition, the I-95 Bridge is in a depression area and interstate drainage inundates Quantico Creek. The main goal of this project is to reduce flooding within town limits. Secondary goals include reducing stream erosion, returning the stream to a more natural and functional state, and aesthetics.

Quantico Creek was rerouted and straightened in the 1970's to accommodate flows from a sewage treatment plant. Berms were built along the channel using the material removed from the channel. In addition, sediment bars were removed and overland flow areas were excavated. A Natural Resources Conservation Service (NRCS) assessment completed in 2002 states that "the elevation of the stream bottom has dropped six to nine feet in the reaches between Fraley Boulevard (U.S. Route 1 North) and Interstate 95 between 1973 and 2002". In addition, the tributaries eroded vertically to the elevation of the streambed. The banks were described as nearly vertical and bare and floodplain vegetation was sparse and of poor quality.

McCormick Taylor was asked to review the United States Army Corps of Engineers (USACE) study conducted in 2004 which included recommendations for addressing the degraded channel. This memo documents the assessment summary, including the field assessment (***Section 2.0***), recommended channel design approach (***Section 3.0***), outfall retrofit investigation (***Section 4.0***), additional studies and investigations (***Section 5.0***), and long-term maintenance (***Section 6.0***). Estimated restoration costs (***Section 7.0***) will be discussed with the Town following the review of this assessment. The focus of the recommended design approaches focus on meeting the primary and secondary goals in the most cost-effective method with respect to channel conditions and constraints.

McCormick Taylor has a detailed list of Final Goals and Objectives that are found in Section 3.0, Table 1: Summary of Stream Design Goals and Recommendations. Our goals for this assessment are to reduce flooding, reduce stream erosion, and return the stream to a more natural and functional state and aesthetics. Improving water quality is the overall goal; however, while there will be improvements with the completion of the recommendations included in this report, existing constraints limit the ability to fully achieve this goal.

2.0 FIELD ASSESSMENT

In March, 2013 McCormick Taylor, Inc. performed a field assessment along the Quantico Creek project reach. The current stream channel conditions and outfalls were assessed. The project site was broken into four reaches, similar to the 2004 USACE report. Reach 1 begins at I-95 and extends to just downstream of Outfall Q. Reach 2 extends from the downstream extent of Reach 1 and continues to U.S. Route 1 South (Main Street). Reach 3 extends from U.S. Route 1 South U.S. (Main Street) to U.S. Route 1 North

(Fraley Boulevard). Reach 4 extends from U.S. Route 1 North (Fraley Boulevard) and continues to the mouth of the Quantico Bay. The location of each reach can be found in ***Appendix A***. Photographs documenting the project site are located in ***Appendix B***. Right and left are determined by facing downstream.

Each reach was walked and the following site features, if applicable, were identified:

- Geomorphic grade control
- Exposed bedrock
- Exposed or endangered utilities
- Large woody debris or log jams
- Unstable banks
- Barriers to aquatic species migration
- Bars
- Culverts, pipes, and bridges,
- Hydraulic controls

In addition, overall reach characteristics were noted, including channel condition, buffer condition and width, in-stream habitat, and other unique features. Site mapping is located in **Appendix A.**

Overall along the Quantico Creek study site, banks were typically tall (>4 ft), steep, and vegetated with a few scattered trees. Numerous fallen and leaning trees were observed. There was a distinct change of channel conditions approximately mid-way of Reach 2 near Outfall M. Upstream of Outfall M, the channel consisted of riffles and pools, bars, and gravel substrate. Downstream of Outfall M, the channel was featureless, lacked bars, and consisted of mostly sand substrate. In Reach 3, benches with split flow have developed. The channel type was plane bed and the facet slope breaks of riffles and pools are absent. Channel material consisted mainly of sand. A grade control consisting of riprap is located under the U.S. Route 1 South (Main Street). In Reach 4, the channel becomes deep and is typically not wadeable. The stream is generally plane bed and the facet slope breaks of riffles and pools are absent. In addition, the stream lacks woody debris. The banks here are typically less high and steep, but floodplain vegetation is lacking along the left floodplain in some areas. The right floodplain has a relatively large buffer that includes a large area of greenbrier.

A comparison between the 2004 conditions from the USACE report and the 2012 conditions are summarized below.

Reach 1

Condition in 2004:

- Severe bank erosion along the right bank
- Accreting materials along the left bank

Condition in 2013:

- Severe bank erosion along right and left banks

  - banks are steep, tall (>4ft), and mostly devoid of vegetation
  - undercut and fallen trees observed

Accreting materials along left and right banks

  - one small bar along right bank
  - one large bar along left floodplain
  - gravel material

- Channel substrate consists mostly of gravel
- Good in-stream habitat
  - riffles, gravel substrate, pools, rootwads, and woody debris
- Mostly adequate floodplain
  - consists of small to large deciduous trees and undergrowth
  - right floodplain width sufficient (> 50')
  - left floodplain width varies (10 to 50+ ft) and is devoid of trees near the upstream extent of the reach
  - limited by residential properties along right and road along left

Reach 2

Condition in 2004:

- Severe bank erosion along right and left banks
- Accreting materials along center of channel

Condition in 2013:

- Severe bank erosion along right and left banks
  - banks are steep, tall (>4ft), and mostly devoid of vegetation
  - undercut and fallen trees observed, along with fallen fence
  - bank stabilized with grouted riprap along left bank near apartment building
- Accreting materials along left and right banks
  - found from upstream extent of reach to Outfall M
  - divided flow
  - gravel material
- Channel substrate varies
  - consists mostly of gravel from upstream extent of reach to Outfall M
  - consists mostly of sand and sandy gravel from Outfall M to downstream extent of reach

- Variable in-stream habitat
    - riffles, pools, and woody debris found from upstream extent of reach to Outfall M
    - sand, few to no riffles, and rootwads found from Outfall M to downstream extent of reach
- Floodplain
    - consists of small to large deciduous trees and undergrowth
    - small bamboo stand
    - left and right width varies, typically less than 50 ft
    - limited by road and residential properties

Reach 3

Condition in 2004:

- Vegetated floodplain benches
- Stable riffle sections
- Some areas of accelerated bank erosion

Condition in 2013:

- Vegetated floodplain benches
    - typically divided flow around them
- Some areas of severe bank erosion along right and left banks
    - found in areas that do not have floodplain benches
    - banks are steep, tall (>4ft), and mostly devoid of vegetation in localized areas
    - undercut and fallen trees observed
- Channel substrate
    - consists mostly of sand and sandy gravel
- Poor in-stream habitat
    - mostly sand, little to no gravel
    - lack of flow diversity (few riffles)
    - limited woody debris scattered throughout reach
- Floodplain
    - consists of small to large deciduous trees and undergrowth
    - right width sufficient (> 50')
    - left width varies, typically less than 50 ft

Reach 4

Condition in 2004:

- Erosion processes not highly active

Condition in 2013:

- Some areas of severe bank erosion along right and left banks
    - most banks are less high and steep as those found in the other reaches
    - banks are steep, tall (>4ft), and mostly devoid of vegetation in localized areas
    - bedrock found along right bank in specific area, may extend into bed
- Channel substrate
    - consists mostly of sand and sandy gravel
- Poor in-stream habitat
    - mostly sand, little to no gravel
    - lack of flow diversity (few to no riffles)
    - limited woody debris scattered throughout reach
- No benches or bars
- Floodplain
    - consists of small to large deciduous trees and undergrowth
    - right width sufficient (> 50')
    - left width varies, typically less than 50 ft
    - sufficient width along upstream area of reach
    - typically little to no trees along industrial areas (development continues to top of bank)

3.0 RECOMMENDED CHANNEL DESIGN APPROACH

Stream conditions noted during the 2013 assessment include unstable banks, lack of in-stream habitat, unstable outfalls, and lack of riparian zone. In addition, flooding is reported as an issue by the Town of Dumfries. Restoration alternatives recommended in the 2004 USACE study include bank stabilization, reducing shear stress, outfall stabilization and full restoration. Each restoration alternative from 2004 is discussed below with recommendations based on present stream conditions and 2013 goals.

Bank stabilization consists of armoring with either rock or vegetation. As most of the banks are unstable in 2013, bank stabilization is recommended throughout most of the study site. The specific bank stabilization method used will vary depending on various factors such as site conditions, constraints, and cost. The banks are typically high and steep throughout the project site which will require significant grading. Grading to a more stable slope from the toe of slope may be difficult in areas where floodplain width is

limited. In addition, building banks out from the top of bank is not a good option since this will result in the reduction of channel capacity. It is likely that hard methods may be required, including rock toe protection and imbricated walls. Rock may be chocked with sediment and planted for a more natural appearance. In addition, rootwads may be incorporated into rock toe protection to provide habitat. If modeled shear stresses are low to moderate, more natural materials and structures may be used, including live fascines, natural fiber rolls, brush mattresses, and rootwads.

The USACE study recommended using in-stream and in-bank structures to reduce bank shear stress. Two methods were proposed - (1) install log or rock vanes and (2) create a narrow floodplain bench along the reach. The installation of vanes may not be sufficient to direct flow away from bank. Floodplain benches are recommended to reduce bank shear stress in areas that are over-widened and/or have floodplain area available. Hydraulic modeling should be used to insure that the floodplain benches do not increase the storm discharge elevations since the main goal of the project is to reduce flooding.

Full restoration included re-establishing the natural dimension, pattern, plan, and profile by establishing a 100-200 ft wide restoration corridor centered along Quantico Creek. This requires mass grading and methods to reduce shear stress and stabilize bank. This option is not viable along much of the study site because of limited floodplain availability due to existing infrastructure and the close proximity to the valley in certain areas. In addition, this method would require the removal of most of the riparian vegetation. To reduce riparian disturbance, the channel could be modified within the existing channel with the addition of inset benches. Cross sectional modeling can be utilized to determine optimum channel dimensions. In addition, the existing alignment may be tweaked in certain areas for a more natural plan form.

Although the 2004 USACE report concluded that Quantico Creek has a vertically unstable bed and is aggrading, the 2002 NRCS assessment reported that the stream bed degraded significantly between 1973 and 2002. As a result of the degradation, utility protection of exposed pipes is recommended. Two exposed pipes, possible a gas line, are located near the upstream extent of Reach 2. A riffle grade control is recommended to protect the pipe. Logs can be added to the riffle grade control to increase habitat value.

The 2004 USACE study recommendations do not address the Town's main project goal of reducing flooding within town limits since the 2004 goals did not include flooding. Flooding can be reduced by increasing the capacity of the channel. This can be accomplished by increasing channel width with the addition of inset benches and/or development of an overflow channel along the right side of the existing channel. Increasing channel capacity can result in the disturbance of the existing riparian zone and/or is limited by floodplain development. Another method is to allow storm flows to access the floodplain along the right side of the channel in Reach 3. This may be accomplished by either increasing the elevation along the left bank with a berm and/or decreasing the floodplain elevation along the right bank. In addition, a secondary channel may be used to direct flows to the right floodplain where the discharge can be stored in a basin. Increasing slope can also decrease flooding, but may be limited based on existing conditions. In addition, the downstream area of the study site is tidal. Storm events during high tide may increase flooding upstream by backwatering effect.

All the outfalls investigated are located in the town of Dumfries within the subdivisions of Forest Park, Barron and Van Buren Village. Because the drainage area upstream of Reach 1 consists of the largely undeveloped forested areas of Prince William Forest Park and Marine Corps Base Quantico, and the drainage area contributing to the storm drain outfalls consists of mostly developed impervious, it is likely all of the outfalls included in the investigation discharge their peak storm flows well before the peak hydrograph of the entirety of the watershed reaches Quantico Creek in Dumfries. In addition, most of the outfalls are along the banks of Quantico creek with existing development limiting the opportunities for SWM, quantity or quality, prior to discharging into Quantico creek. Because of this, it is unlikely that any proposed treatment of the outfalls could help alleviate flooding in the town of Dumfries. The most appropriate design option with the outfalls is to create energy dissipaters and stabilization where scour and erosion are present to help with bank stabilization and reduce the suspension of sediments in the stream flow. Outfalls are discussed in more detail in ***Section 4.0***.

The banks and the floodplain typically lacked trees and shrubs. Trees that did grow along and on the unstable banks were typically undercut and leaning. It is important to first stabilize the banks before planting. Once the banks are stabilized, live stakes, tubelings, and/or shrubs may be planted. In addition, trees and shrubs should be planted in the floodplain to reduce the velocity and quantity of storm flows and provide shading for the stream. In addition, invasive species were found along the project site, including greenbrier and bamboo. It is recommended that the invasive species are removed and controlled after construction by manual removal or chemical treatment.

A summary of the stream design goals and recommendations are found in ***Table 1***.

Table 1: Summary of Stream Design Goals and Recommendations

Goal	***Recommendations***
Reduce Flooding (main goal)	○ Channel modifications (inset benches, overflow channel along stream channel, increase slope) ○ Floodplain modifications (decrease and/or increase floodplain elevation, overflow channel to floodplain) ○ Installation of SWM facilities at outfalls where conditions allow
Reduce Stream Erosion (secondary goal)	○ Bank stabilization (method to be determined based on site conditions and constraints) ○ Reduce shear stress (floodplain benches) ○ Riffle grade control to protect exposed utility ○ Outfall protection and energy dissipation at existing outfalls
Returning stream to a more natural and functional state (secondary goal)	○ Alter channel dimensions and alignment within existing channel by adding benches ○ Addition of wood to bank and bed structures ○ Plantings to increase shade, stabilize banks, and provide source of woody debris
Aesthetics (secondary goal)	○ Use natural materials, when possible ○ Use riprap with natural appearance ○ Choke riprap with sediment and plant with live stakes or tubelings ○ Plantings

4.0 OUTFALL RETROFIT INVESTIGATION

During the field assessment outfalls were inspected and evaluated for retrofit opportunities. Outfall naming conventions were carried over from the USACE 2004 report. Due to the developed nature of the region surrounding Quantico Creek the majority of outfalls discharge in the immediate vicinity of the channel from storm drain or culvert conveyances. The proximity of residential and transportation land uses to the creek limit the opportunities for shortening the pipes in order to provide stormwater management opportunities before the confluence with Quantico Creek. Because of this, the main goal of reducing flooding in the town of Dumfries will be difficult to achieve with outfall retrofits. There are a limited number of outfalls that do present opportunities for stormwater quality management and possibly a reduction or delay in the contributing drainage area hydrograph. The secondary goal of reducing stream erosion could be achieved by the following practices depending on existing conditions and constraints: outfall/bank stabilization, scour holes, drop structures, and step pool conveyances. A table summarizing the existing features and potential treatments of each outfall are listed in ***Appendix C***.

5.0 ADDITIONAL STUDIES AND INVESTIGATIONS

Additional studies and investigations are recommended to develop a proposed design for the Quantico Creek study site.

Additional studies and investigations include:

- Topographic survey
- Environmental Constraints Identification/Delineation
- Historic Aerial Photographs
- Geomorphic Assessment and Analysis
- Hydrology and Hydraulics
- Design Discharge
- Sediment Transport Analysis

6.0 LONG-TERM MAINTENANCE

A Monitoring and Maintenance Plan (MMP) should be developed specifically for the proposed design. The primary focus of the MMP is to maximize the effectiveness and potential for success of proposed restoration measures. A secondary focus of the MMP is to provide a basis for determining the conditions of success and general effectiveness of the proposed efforts to be applied to future projects. The MMP typically includes criteria for success which are based on the project goals and design. Elements of monitoring can include assessing the stability and functioning of the design and structures and vegetation evaluation.

The monitoring schedule continues at least 5 years after construction, as typically is required by the USACE Nationwide Permit No. 27 and the corresponding Virginia Department of Environmental Quality Certification Letter. The first monitoring event should be conducted during the first growing season following the completion of the proposed work. The second yearly monitoring event should be scheduled approximately six months from the first and would generally occur in the fall. Monitoring years two

through five should target dates within a week or two of the Year one effort. Monitoring can be concluded at the end of the fifth year if the Town confirms that the restoration goals have been met. A report should be submitted after each monitoring event to fully document the findings.

Maintenance of the stream restoration site will be performed on an as-needed basis as determined through the monitoring effort. If plantings are installed and well-established during the fall season, watering should not be necessary. If plantings are installed during the spring season they should be watered weekly for 6 months following installation. Invasive species shall be evaluated and controlled with frequent removal by hand and/or application of mulch and herbicide.

Long-term management is relevant after it has been established that the site has met project goals and is self-sustaining. The proposed stream design and plantings should be chosen to require minimal long-term maintenance for success. The Quantico Creek study site should be assessed after a large storm event (5-year recurrence interval or higher) to visually detect any issues that may have resulted from the high discharge.

7.0 ESTIMATED RESTORATION COSTS

Estimated restoration costs will be addressed following a review of this assessment with the Town of Dumfries.

8.0 REFERENCES

U.S. Army Corps of Engineers. 2004. *Stream Restoration and Stormwater Management Study for Quantico Creek*.

U.S. Department of Agriculture, Natural Resource Conservation Service. 2002. *Quantico Creek Stream Assessment*.

APPENDIX A:
SITE MAP

TOWN OF DUMFRIES
PRINCE WILLIAM COUNTY, VA

QUANTICO CREEK
ASSESSMENT

INDEX MAP

April, 2013

Cut Sheet

McCormick Taylor
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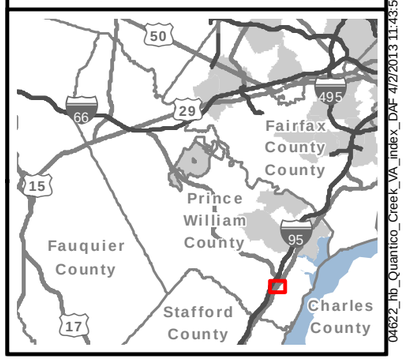

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TOWN OF DUMFRIES
PRINCE WILLIAM COUNTY, VA

QUANTICO CREEK ASSESSMENT

SITE MAP

April, 2013

- Outfall
- Start Reach
- End Reach
- Large Woody Debris
- Unstable Bank
- Exposed Utility
- Bar (est.)
- Bench (est.)

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Appendix A
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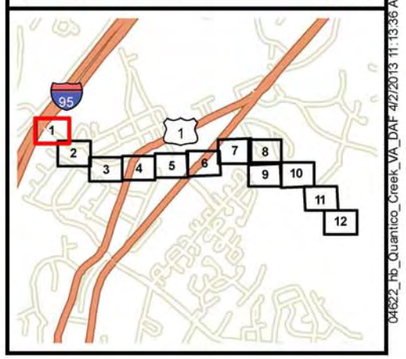

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TOWN OF DUMFRIES
PRINCE WILLIAM COUNTY, VA

QUANTICO CREEK ASSESSMENT

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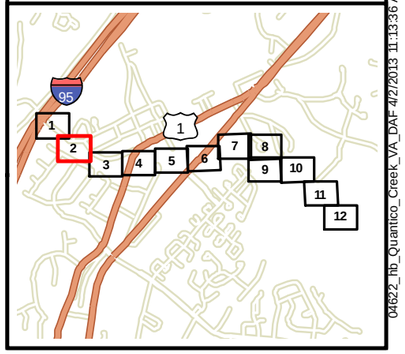

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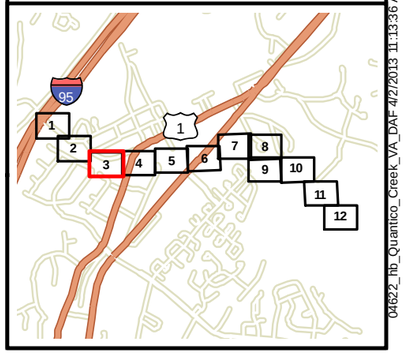

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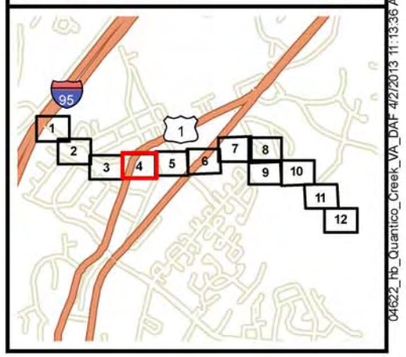

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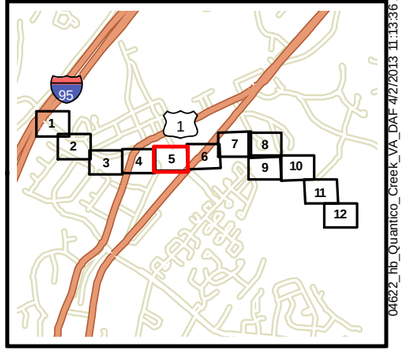

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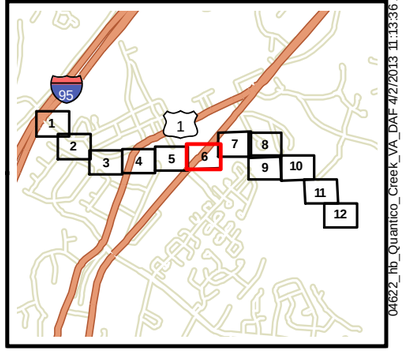

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McCormick Taylor
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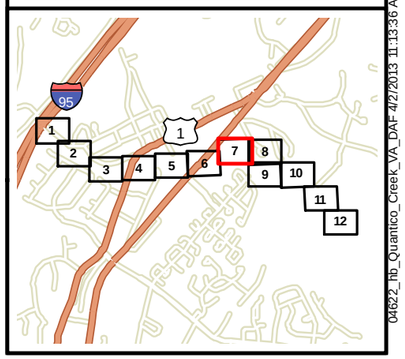

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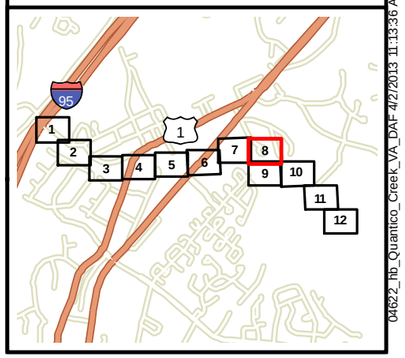

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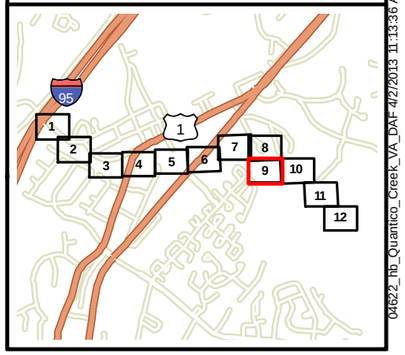

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Appendix A
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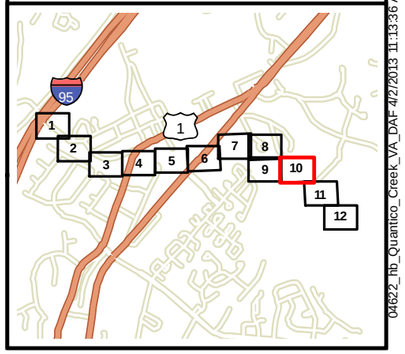

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TOWN OF DUMFRIES
PRINCE WILLIAM COUNTY, VA

QUANTICO CREEK ASSESSMENT

SITE MAP

April, 2013

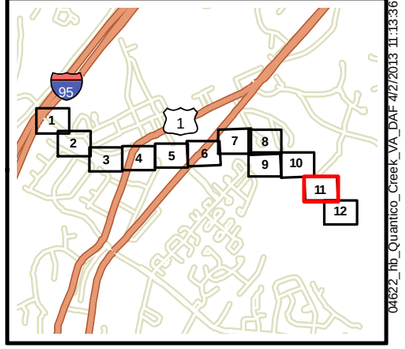
- Outfall
- Start Reach
- End Reach
- Large Woody Debris
- Unstable Bank
- Exposed Utility
- Bar (est.)
- Bench (est.)

McCormick Taylor
Engineers & Planners Since 1946

Appendix A
Sheet: 11 of 12

N

0 50 100 Feet



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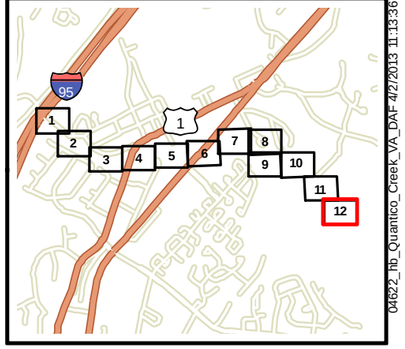
Appendix A
Sheet: 12 of 12

N

0 50 100 Feet



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APPENDIX B:
PHOTOGRAPHS

Quantico Creek
Appendix B: Photographs

Reach 1: Typical channel and gravel bar formation

Reach 1: Left bank instability

Reach 1: Right bank instability

Reach 1: Bar formation, bank instability, and woody debris

Quantico Creek
Appendix B: Photographs

Reach 1: Outfall P

Reach 2: Outfall R

Reach 2: Outfall O and bamboo

Reach 2: Outfall N and woody debris

Quantico Creek
Appendix B: Photographs

Reach 2: Outfall K

Reach 2: Outfall M and undercut tree

Reach 2: Outfall L

Reach 2: Outfall New 2

Quantico Creek
Appendix B: Photographs

Reach 2: Outfall J at confluence


Reach 2: Fence along top of bank

Reach 2: Exposed utility pipe


Reach 2: Left bank instability and fallen fence

Quantico Creek
Appendix B: Photographs

Reach 2: Outfall S and debris in left bank

Reach 2: Right bank instability

Reach 2: Typical channel upstream of Outfall ? with bars, gravel substrate, and riffles

Reach 2: Typical channel downstream of Outfall ? lacking riffles and bars and with sand substrate

Quantico Creek
Appendix B: Photographs

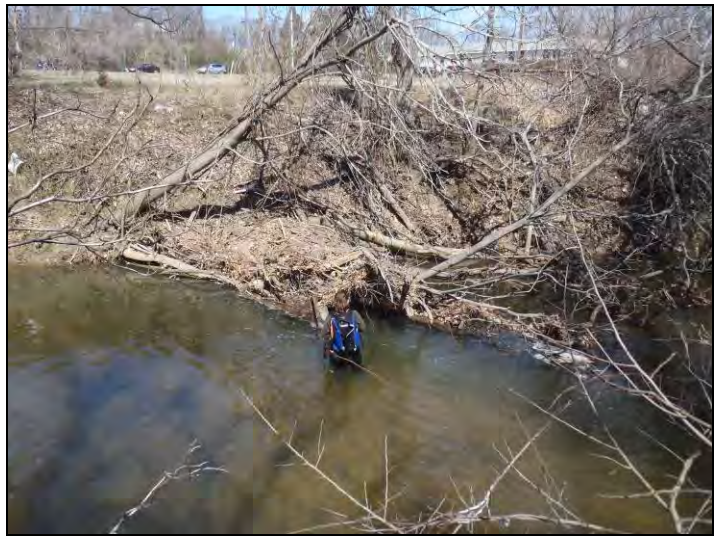
Reach 2: Grouted riprap and infrastructure at top of left bank

Reach 2: Left bank failure and lack of riparian vegetation

Reach 3: Grade control under bridge and bar formation

Reach 3: Mid-channel bar with woody debris along riffle

Quantico Creek
Appendix B: Photographs



Reach 3: Left bank failure and lack of riparian Vegetation

Reach 3: Typical channel without bench

Reach 3: Typical channel with bench

Reach 3: Secondary channel along bench

Quantico Creek
Appendix B: Photographs

Reach 3: Left bank instability

Reach 3: Left bank instability and lack of riparian vegetation near baseball field

Reach 3: Outfall F

Reach 4: Outfall New 3 drop structure (without lid)

Quantico Creek
Appendix B: Photographs

Reach 4: Outfall New 3

Reach 4: Outfalls AA and AB


Reach 4: Outfall E


Reach 4: Typical channel

Quantico Creek
Appendix B: Photographs

Reach 4: Saplings on right floodplain

Reach 4: Parking lot to top of left bank, greenbrier on right bank

Reach 4: Pipe crossing stream

Reach 4: Infrastructure to top of left bank

Quantico Creek
Appendix B: Photographs

Beaver dam on tributary west of Fraley Blvd

Backwater from Beaver dam

APPENDIX C:
OUTFALL SUMMARY

Quantico Creek
Appendix C: Outfall Summary

Outfall Designation	Outfall Invert To Stream WSEL (vertical ft)	Outfall To Stream (horizontal ft)	Baseflow Present?	Potential Tree Impacts (low, medium, high)	Potential Utility Impacts (low, medium, high)	Existing Outfall Type	Existing Outfall Protection	Outfall Stable in Existing Conditions?	Barriers to Pipe Removal	Recommended Treatment	Other Comments
P	*20'	*300'	Yes	medium	low	3' base Trapezoidal Concrete Flume	None	No	NA	Step Pool	V-notch channel with 10' sides at confluence with stream
Q	3'	0	Yes	low	low	32" Conc PP/Culvert	Rip Rap on Bank	No, scour present	Mine Rd	Engineered Scour Hole	Last 4' of pipe seperating
O	10'	70'	Yes	low	low	18" Conc PP*, to channel	Rip Rap in Channel	No, channel bank erosion, scour hole	Residential	Add Rip Rap Thoughout And Scour Hole	Invasives: Bamboo
N	4'	1'	Yes	low	low	48" CMP, PP	Rip Rap	Yes	Residential	Remove 10' of pipe, construct EW, add rip rap, line/replace pipe	Smells bad
R	4'	11'	Yes	low	low	42" RCP EW	Grouted Rip Rap	Yes	Residential	None	
S	6'	0'	No	medium	low	18" RCP,PP	None	Yes	Residential	None	Appears to be abandonned in place
M	9'	4'	Yes	medium	low	12" RCP, HW	Conc. Cantilevered Apron	No	Residential	Remove 10' of pipe reconstruct EW, add step pool/scour hole	Entire HW structure and several trees threatened by undercut banks
T	10'	50'	No	high	low	24" Conc.,ES, to channel	Rip Rap	No	Mine Rd	Step Pool	Outfall Structure Stable, channel stream confluence degraded
L	6'	3'	No	medium	low	24" HPDE, PP	Rip Rap	Yes	15' from fence	None	
K	6'	1'	Yes	high	low	18" CMP, PP	None	No	Residential	Divert outfall around tree, add rip rap	Adjacent to abanndoned CMP
U	7'	40'	Yes	high	low	18" Conc PP, to channel	Recent Rip Rap to channel bed	No	Mine Rd	Channel stabilizaiton/step pool	Channel is highly incised with head cuts and scour at confluence
J	20'	130'	Yes	high	low	60" CMP, conc HW, to channel	Rip Rap apron	No	Residential	Step Pool	Channel begins with stable rip rap apron but has several 4' vertical head cuts, some flow over bed rock. Channel at confluence highly incised w/ 12' high banks
V	15'	45'	No	low	high	18" RCP, PP	Bridge abutment rip rap	Yes	Bridge/Commecail	Investigate/clean pipe	Appears to be abandonned in place or clogged
I	30'	10'	No, backwater	medium	high (Bridge/OHW)	18" RCP	Rip Rap	Yes	Bridge /US 1	Clean Pipe	Obvious oil sheen in backwatered pipe
H	15'	25'	Yes	low	high (Bridge/OHW)	32" Conc PP	Bridge abutment rip rap	Yes	Bridge/US 1	None	10' from utility pole, 10' from brige. Immediately below OHW
W	10'	15'	No	High	high(OHW)	15" Conc ES	None	Yes	Bridge/Commecail	Clean Pipe	Pipe over 50% filled with sediment
X	12'	200'	Yes	high	low	24" Conc.,ES, to channel	None	Yes	Main St	SWM Facility	Ex channel flow through wooded area (possibly wetland?). Should divert overland toward police station for treatement
Y	10'	170'	No	high	low	24" Conc.,ES, to channel	Rip Rap in channel	Yes	Main St	SWM Facility	Min. Add rip rap/stabalize confluence. May provide SWM oppurtunity similar to or combined with 'X'
YY	3'	5'	Yes	low	low	8" Conc EW	Rip Rap	Yes	Commercail	None	New Outfall since Army Corps Study, smal and stable
G	NA	NA	Yes	high	low	Stream	none	No	NO PIPE	Stream Stablilization	This is a confluence of two channels. Recommend in stream stabilization in conjunction with any Quantico Creek work
"NEW 3"	4'	12'	No	low	low	Unkwn. Size, HW	none	No	Brand new SD infrastructure upstream	Remove Sediment, Add scour hole. Stabalize upstream?	New inlet discharges to approx 15' drop structure than to small pipe and HW. HW covered in at least 4' sediment. Cant see pipe.
F	15'	75'	Yes	high	high(OHW)	10" DI, to channel	none	No	None	Add Rip Rap at Confluence	Scour Hole and undercutting at confluence
AA	<0'	0'	?	None	high (sewer)	>48"	?	?	Industrial	None	pipe is 95% submerged in Quantico Creek
AB	3'	7'	No	None	high(sewer)	double 24" conc HW	Rip Rap	Yes	Industrial	None	1' form large sewer line passing transveresly in front of outfall
E	15'	140'	Yes	high	high(sewer0	21" Conc. HW, to channel	None	Yes	Old Triangle Rd	SWM Facility	Stable at outfall structure, channel is incised with several headcuts. Possible to do SWM though confined by trees and sewer line.

*PP = Projecting Pipe