PRINCE WILLIAM COUNTY, VA
DEPARTMENT OF PUBLIC WORKS

Bull Run Watershed Study

Appendices

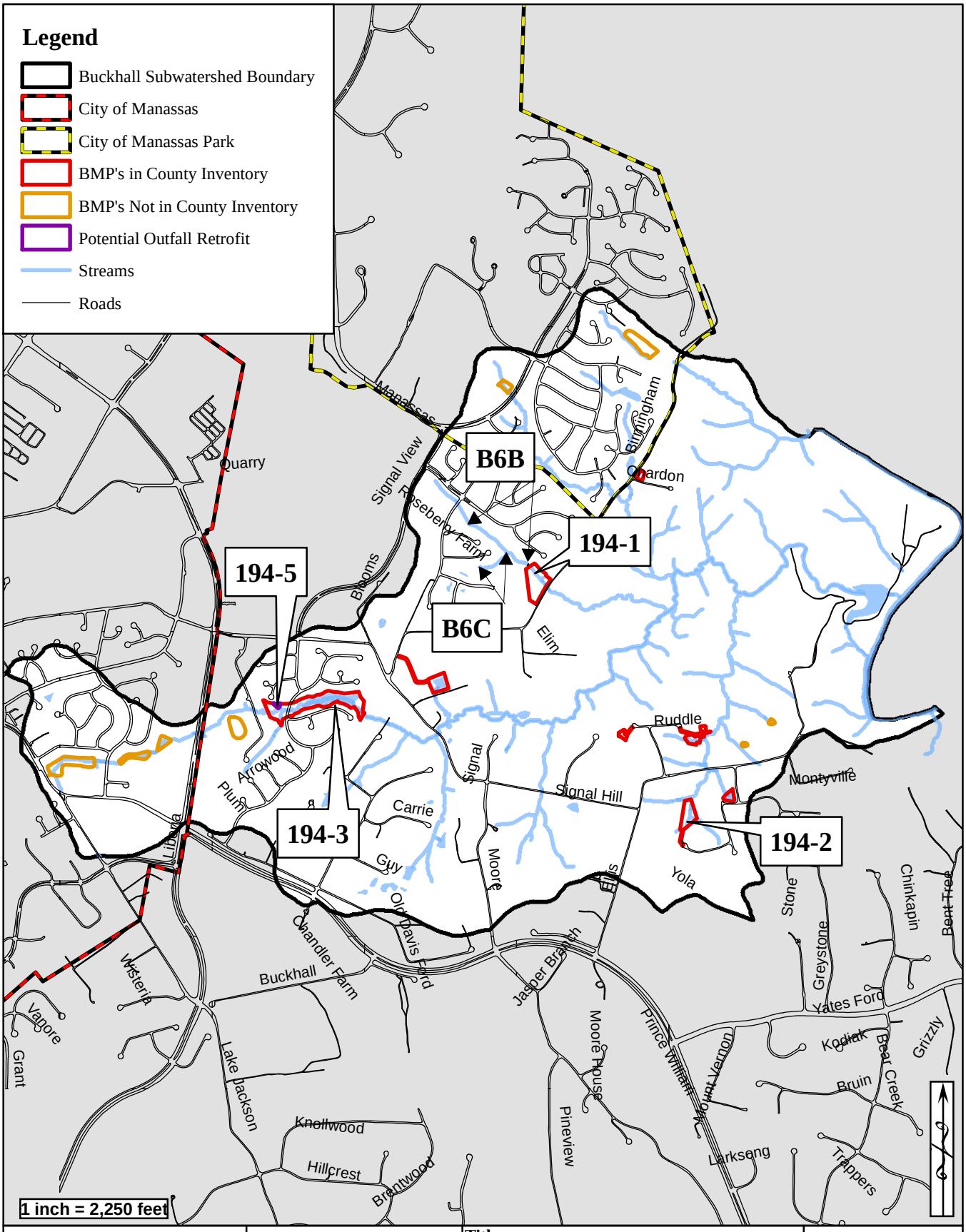
March 2010

Whitman, Requardt & Associates, LLP
Engineers • Architects • Planners
9030 Stony Point Parkway, Suite 220
Richmond, Virginia 23235

Appendix A –

Conceptual Design Narratives

Buckhall (194) Subwatershed



	Source:	Title:	Figure:
	Prince William County GIS	Recommended Project Map Buckhall (194) Subwatershed	A1

Project: Buckhall 194-1 Water Quality Retrofit and B6 Stream Stabilization

Watershed:	**Bull Run**
Subwatershed Name:	**Buckhall**
Subwatershed Code:	**194**
Site ID:	**194-1 and B6B & B6C**
County Facility ID:	**416**
Type:	**Water Quality Retrofit and Stream Stabilization**
Size or Length:	**1.33 acre Stormwater Facility** **1,786 lf stream**
Drainage Area:	**112 acres**
GPIN/Owner:	**7895-69-7044 / Roseberry Community Assoc.** **7895-68-8652 /Birchwood Manassas Associates LLC.**
Neighborhood/Address:	**2098 Roseberry/7813 Roseberry Farm Drive**
GPS Coordinates:	**77º 25' 58.218" W** **38º 45' 8.962" N**
SWM Ranking:	**5**
Stream Ranking	**1**

Location: This project is located to the southeast of Signal Station Drive and Roseberry Farm Drive.

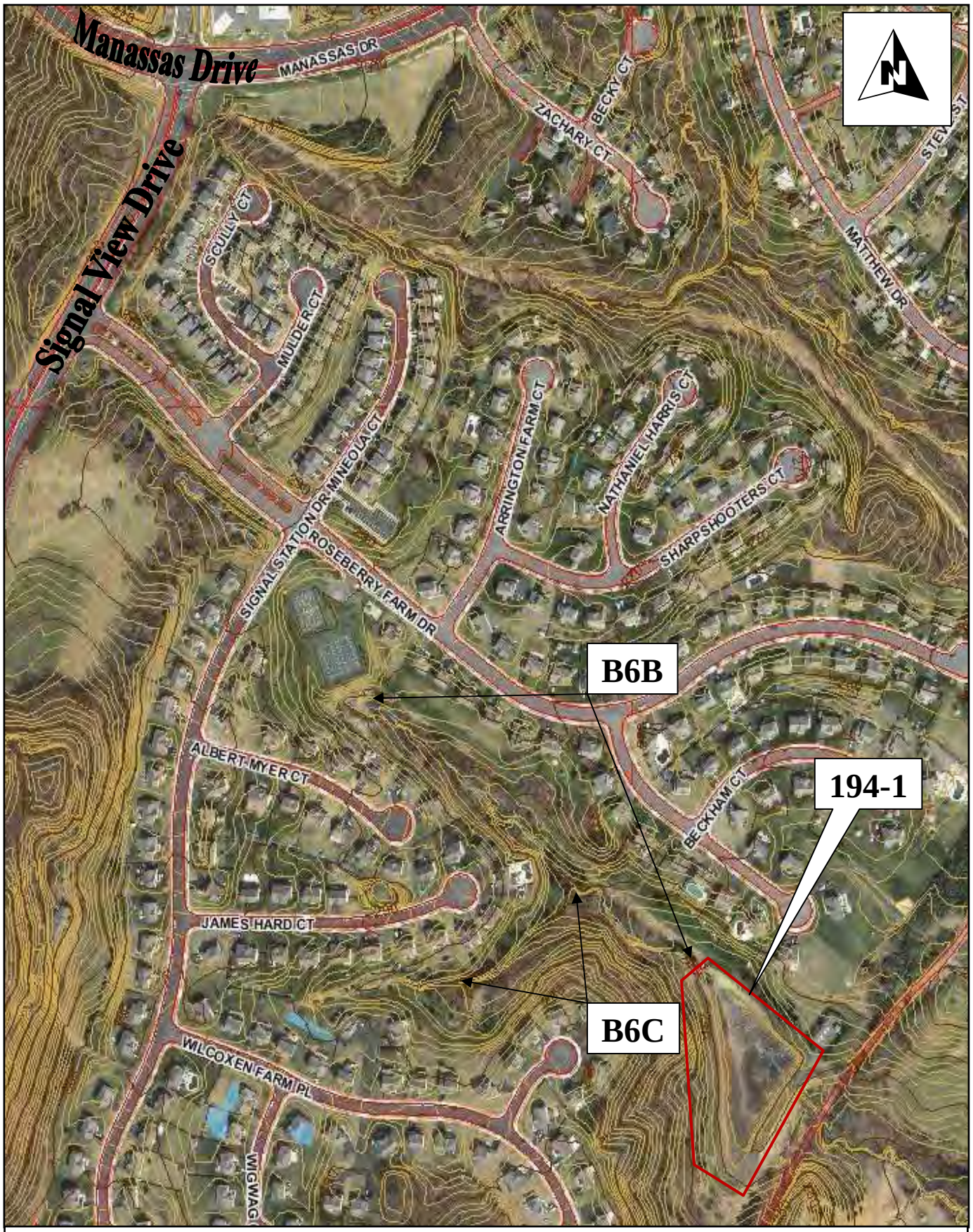
Problem Description: This dry basin was built in 2002 on a perennial stream with a drainage area of 112 acres. Due to a clogged low flow orifice it is functioning as a wetland. It lacks a forebay and sediment from the stream has accumulated in the basin. The facility has a HOA trail around it. Due to the triangular shape, the flows short circuit between the inflow and the 72 inch riser. Two severe head cuts (B6B-H2 and B6C- H2) are actively eroding the upstream channels. A head cut (B6C-H2) in reach B6C has incised four to five feet and is encroaching upon an upstream sanitary utility. Reach B6C is in fair condition and Reach B6B is in good condition. A large tree fall is generating a moderate obstruction (B6B-O1) resulting in bank erosion.

Project Description: The large watershed size, perennial flow, and large stormwater facility size makes this site well suited for a conversion to a stormwater wetland. This project would address the stormwater facility, stream buffer, and head cuts as a single project. The stormwater facility would be graded to create marsh, berms, and micro-pools. A forebay will be installed to help manage sediment from the perennial stream. The head cuts in the streams would be stabilized with stone structures. The obstruction would be removed to prevent additional bank erosion. A management plan would be developed to help the HOA properly maintain the stream buffers, monitor stream condition, and maintain the stormwater facility.

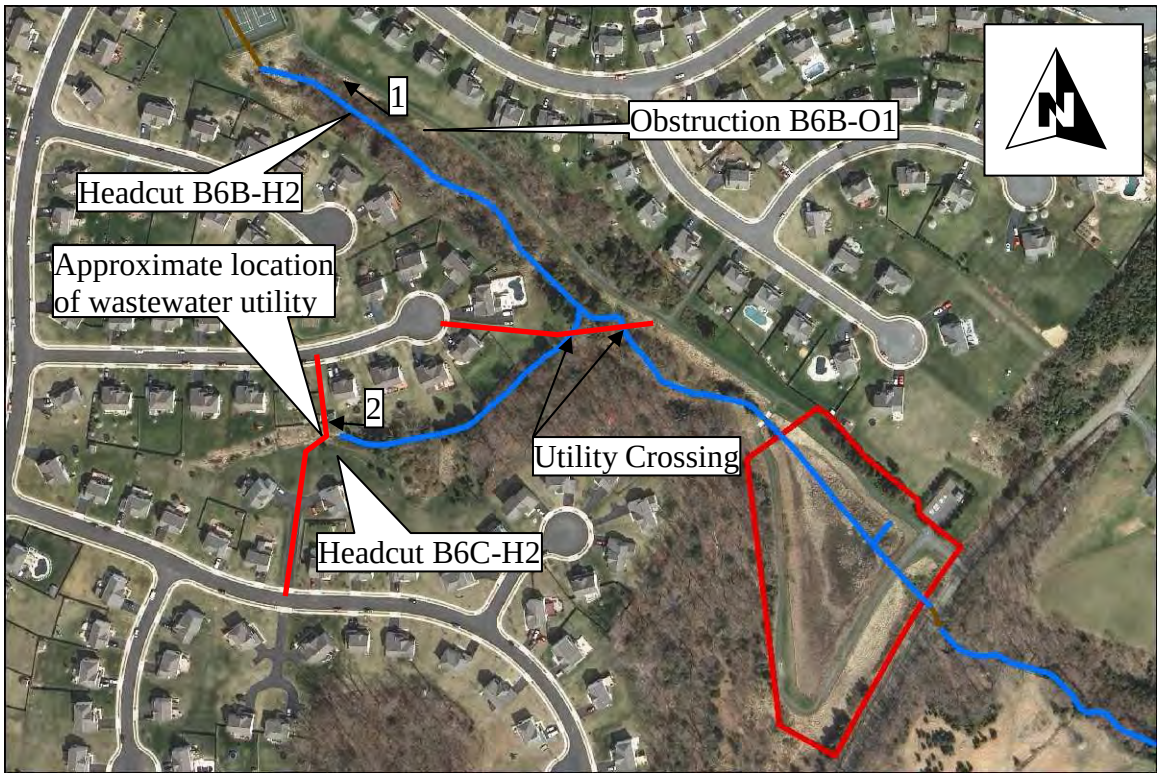
Potential Benefits: The stormwater facility retrofit would provide for improved water quality control, as well as wildlife habitat in the stormwater wetland. Based on proposed DCR standards the retrofit would increase phosphorous removal from less than 30% to greater than 50%. The sedimentation in the stormwater facility would be minimized by the stabilization of the upstream channels. Providing the HOA an integrated plan to manage the streams and stormwater facility on its property will improve overall habitat and water quality functions.

Design Considerations: Construction access to reach B6 and site 194-1 would be from a HOA recreational trail. Headcut B6C-H2 is in an open area that can be accessed through a utility easement upstream from the failing area. Clearing of mature trees in the riparian buffer is necessary to access the failing areas.

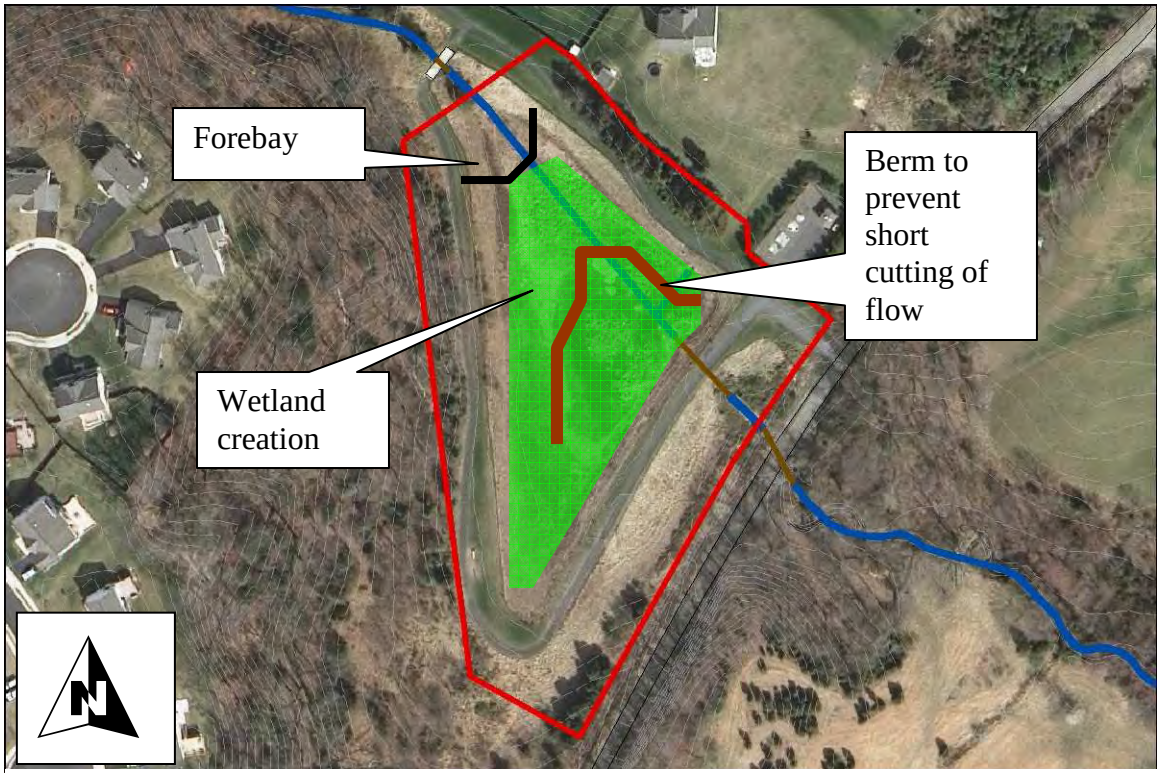
Cost Estimate: The estimated cost for this retrofit is approximately $182,000 or $8,200 per imperious acre.



Watershed: Buckhall
Site ID #: 194-1
BMP #: 416
ADC Map (25th edition): Map 9, page 14, grid coordinate K9



Existing Condition: B6 and BMP 194-1 study area



Conceptual Plan: Existing dry basin would be converted to wetland

Photo 1: Headcut B6B-H2 would be stabilized

Photo 2: Headcut B6C-H2 would be stabilized

Project: Buckhall 194-2 Stormwater Facility Improvements and Stream Stabilization

Watershed:	**Bull Run**
Subwatershed Name:	**Buckhall**
Subwatershed Code:	**194**
Site ID:	**194-2**
County Facility ID:	**77**
Type:	**Stormwater Facility Improvements**
Size:	**0.26 acres**
Drainage Area:	**50 acres**
GPIN/Owner:	**7995-04-3443/Lucas Lendford & Marilyn**
Neighborhood/Address:	**2858 Montyville SFD/7278 Yola Lane**
GPS Coordinates:	**77º 25' 20.57"W**
	38º 44' 25.275"N
SWM Ranking:	**7**

Location: The recommended stormwater facility improvement is located east of Ellis Road and South of Signal Hill Road on residential property.

Problem Description: Approximately 50 acres of drainage discharges into the existing stormwater facility. The drainage area consists primarily of large wooded residential lots with minimal impervious area. A perennial stream is conveyed through a 30" CMP driveway culvert into the facility. There is no riser structure in the stormwater facility and the outlet is a 21" CMP pipe. The emergency spillway seems to be high and not accessed often. The facility itself appears to be in good condition. The smaller outlet pipe results in detention within the basin, but has resulted in significant erosion of the receiving channel. There appears to be minimal scour protection in the receiving stream. The County inventory indicates that this facility was constructed in 1992. This design is similar to many facilities constructed in large lot residential areas with minimal impervious surfaces. Other similar stormwater facilities may also be resulting in stream instability.

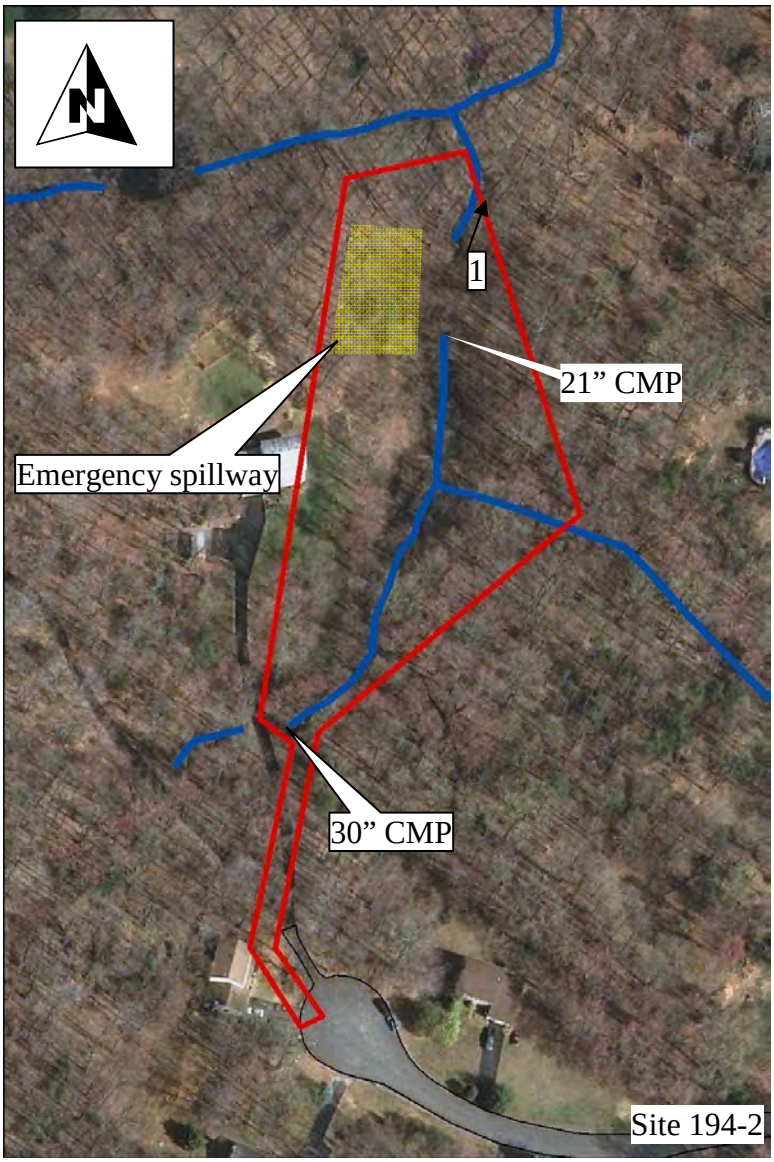
Project Description: A detailed investigation of the stormwater facility is recommended, including the design of an outlet structure, the water quality volume needed to treat the impervious runoff, and the height of the emergency spillway. The riser design should provide a non-erosive draw down velocity. Stabilization of the receiving channel is also recommended. The County may consider a field evaluation of all stormwater facilities of similar design to determine if stream de-stabilization is a problem common to this older design.

Potential Benefits: The addition of a riser structure would ensure the appropriate draw down time for the detention basin and reduce the velocities and erosive flows to the receiving channel. Reconnecting the emergency spillway to the basin will allow the basin to function as designed and protect the integrity of the receiving channel.

Design Considerations: There is a permanent easement around the access road and stormwater facility. Minimal clearing would be needed for access to the site. Access to the stream for stabilization would require clearing. Consider providing stormwater treatment adjacent to road and elimination of this facility.

Cost Estimate: The estimated total costs for this project are approximately $33,000.

Watershed: Buckhall
Site ID #: 194-2
PWC BMP #: 77
ADC Map (25th edition): Map 10, page 15, grid coordinate B10, 11



Existing Condition

Photo 1: Scour and erosion is evident downstream of BMP outlet

Project: Buckhall 194-3 Stormwater Facility Improvements

Watershed:	**Bull Run**
Subwatershed Name:	**Buckhall**
Subwatershed Code:	**194**
Site ID:	**194-3**
County Facility ID:	**106**
Type:	**Stormwater Facility Improvements**
Size:	**8.1 acre stormwater facility**
Drainage Area:	**289 acres**
GPIN/Owner:	**7895-46-3433 & 7894-46-4445/ Arrowhead Homeowners Assoc.**
Neighborhood/Address:	**2100 Arrowwood/8013Folkstone Road**
GPS Coordinates:	**77º 26' 35.629"W**
	38º 44' 44.584"N
SWM Ranking:	**8**

Location: This site is located to the southeast of Liberia Avenue and Signal Hill Road on the Arrowhead Homeowner Association property.

Problem Description: This facility was constructed in 1992 as a dry basin; however, it is functioning as a stormwater wetland system. The basin is located on a perennial stream with a drainage area of 289 acres. The basin is covered with wetland vegetation and has a well defined, relatively small low flow channel. The basin is generally functioning well from a water quality standpoint. However, recent sediment accumulation is evident in the lower portion, possibly due to recent construction immediately upstream of the facility. In addition to the stream, there are four stormwater inlets into the basin with the following sizes: 48", 30", 15", and 18" pipe. The outlet structure is a 15" RCP pipe without a riser structure. The inflow volume to the stormwater facility greatly exceeds the capacity of the outlet pipe. The emergency spillway appears stable, and is less than 2 feet above the invert of the outlet pipe. The 30" inlet does not have a well designed connection to the stormwater facility and has a 30 inch head cut which needs stabilization. The current design appears to provide quantity and quality control for smaller storm events, but rainfall over about 1 inch per hour would result in flows discharging through the emergency spillway. Larger storm events do not appear to have storage within the facility.

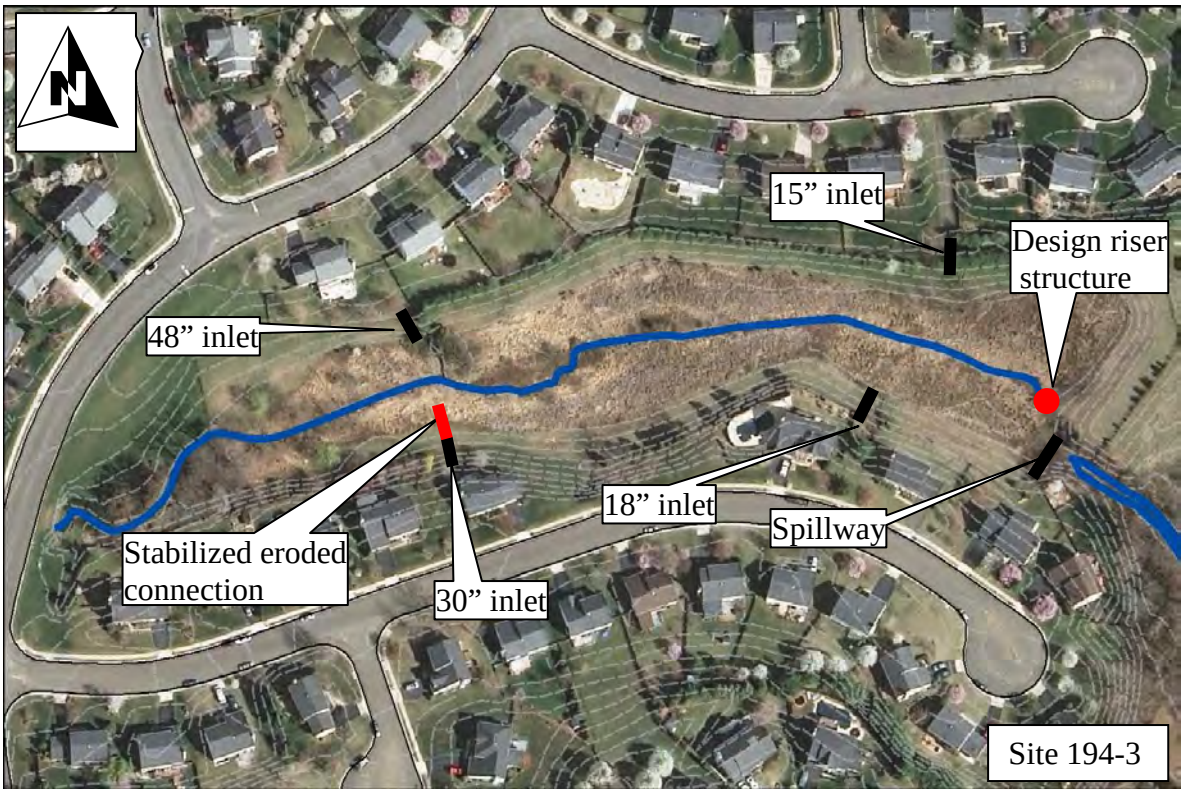
Project Description: Despite its original design as a dry basin, this facility is functioning as a stormwater wetland, providing water quality and quantity controls for storm events less than approximately 1 inch. The improvements would start with a hydrology/hydraulic study to determine the level of treatment currently provided. The improvements to the stormwater facility would include the design of a riser structure and removal of sediment near the outlet. The head cut from the 30" inlet pipe would be stabilized. Minor maintenance would be performed at the other inlets and on the emergency spillway, such as removal of trees and debris.

Potential Benefits: The addition of a riser structure will allow proper dewatering of the stormwater facility and protect the integrity of the basin and the receiving channel. The stabilization of the headcut at the inlet pipe will reduce the sediment load to the facility.

Design Considerations: The stormwater facility is located on HOA property, with several points of access, allowing for ease of construction.

Cost Estimate: The estimated total cost for this project is approximately $70,000, which includes a new riser, removal of accumulated sediment, inlet stabilization, and hydrology study.

Watershed: Buckhall
Site ID #: 194-3
PWC BMP #: 106
ADC Map (25th edition): Map 9, page 14, grid coordinate J10, 11



Conceptual Plan: Install riser structures and stabilize eroding inlet

Photo 1: 15” Outlet Pipe

Project: Buckhall 194-5 Outfall Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Buckhall**
Subwatershed Code:	**194**
Site ID:	**194-5**
County Facility ID:	**NA**
Type:	**Outfall Retrofit**
Size:	**2,180 sf**
Drainage Area:	**8 acres**
GPIN/Owner:	**7895-36-5811/ Arrowhead HOA**
Neighborhood/Address:	**2100 Arrowood/9700 Manassas Forge Road**
GPS Coordinates:	**77º 26' 45.452"W 38º 44' 43.773"N**
Outfall Ranking:	**5**

Location: The recommended outfall retrofit site is located southeast of Liberia Avenue and Signal Hill Road on HOA property.

Problem Description: The drainage from the Arrowhead residential neighborhood is discharging into the receiving channel without any water quality or quantity control. Approximately 8 acres of 25% impervious surface drains from two outfalls (B1-P8 and B1-P9).

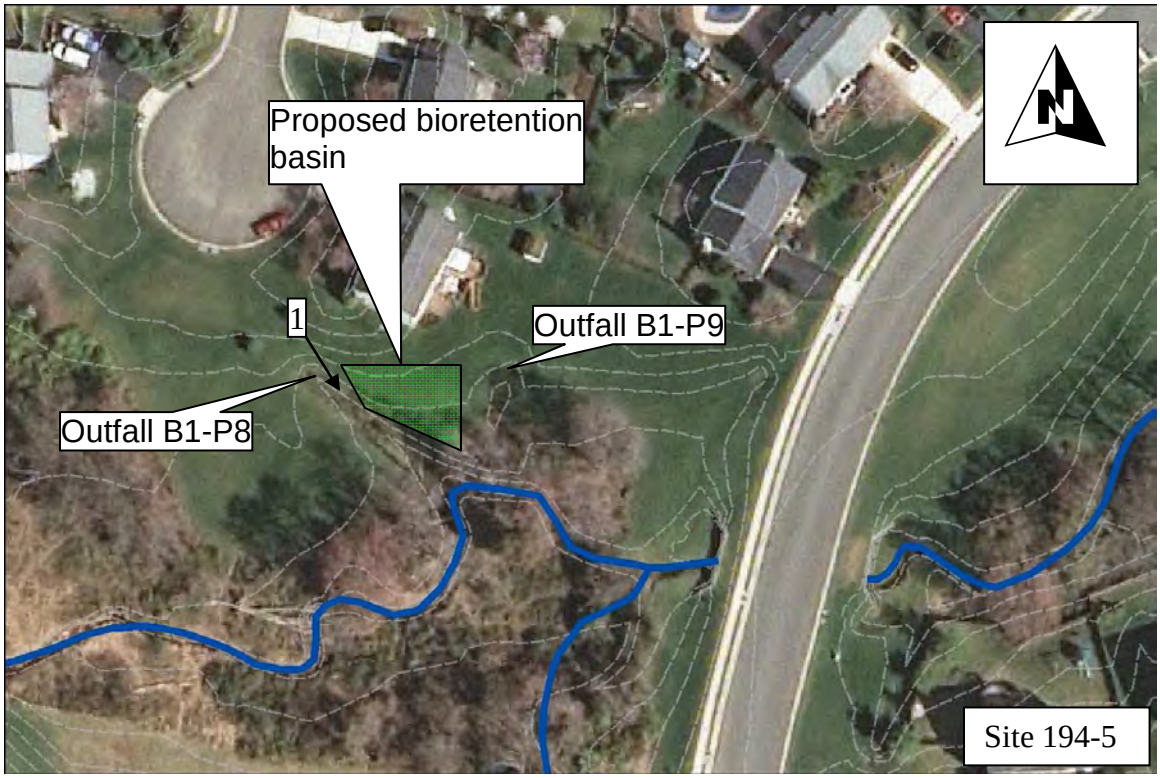
Project Description: The open space between the two outfalls could be retrofitted to provide quality control while higher flows could be diverted through the existing ditches to protect the basin. A bioretention basin is recommended because of the pollutant removal efficiency and the constraints of the site. The available 2,100 sf of open space near the two outfalls would almost accommodate a 2,180 sf basin as would be required under current DCR standards.

Potential Benefits: The current outfalls have no water quantity or quality controls. Based on proposed DCR standards, the bioretention basin would provide 55-90% reduction in total phosphorous loads, and 40-80% reduction in volume. This would help protect the quality and integrity of the receiving channel and treat runoff from eight acres of residential land not currently being treated.

Design Considerations: Access to the retrofit site would be easily accomplished off of Manassas Forge Drive or Barnwood Road (cul-de-sac). Stockpile and staging area is available on the property, however a temporary construction easement may be required from the adjacent property owner. Invasive species in the adjacent riparian buffer may impact a stormwater facility constructed adjacent to it. A fence would not be required since the maximum ponding depth of a bioretention basin is 6 inches.

Cost Estimate: The estimated total cost to design and construct the proposed bioretention facility would be approximately $55,000 or $28,000 per impervious acre.

Watershed: Buckhall
Site ID #: 194-5
ADC Map (25th edition): Map 9, page 14, grid coordinate J11



Conceptual Plan

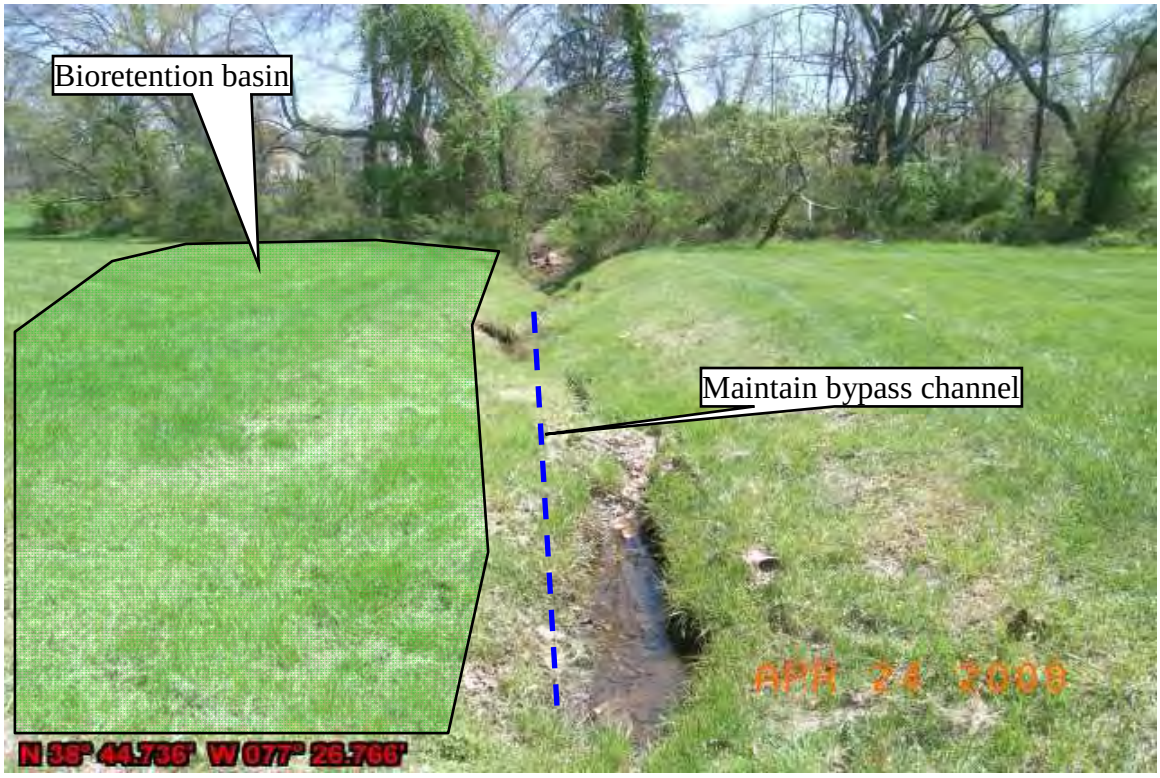
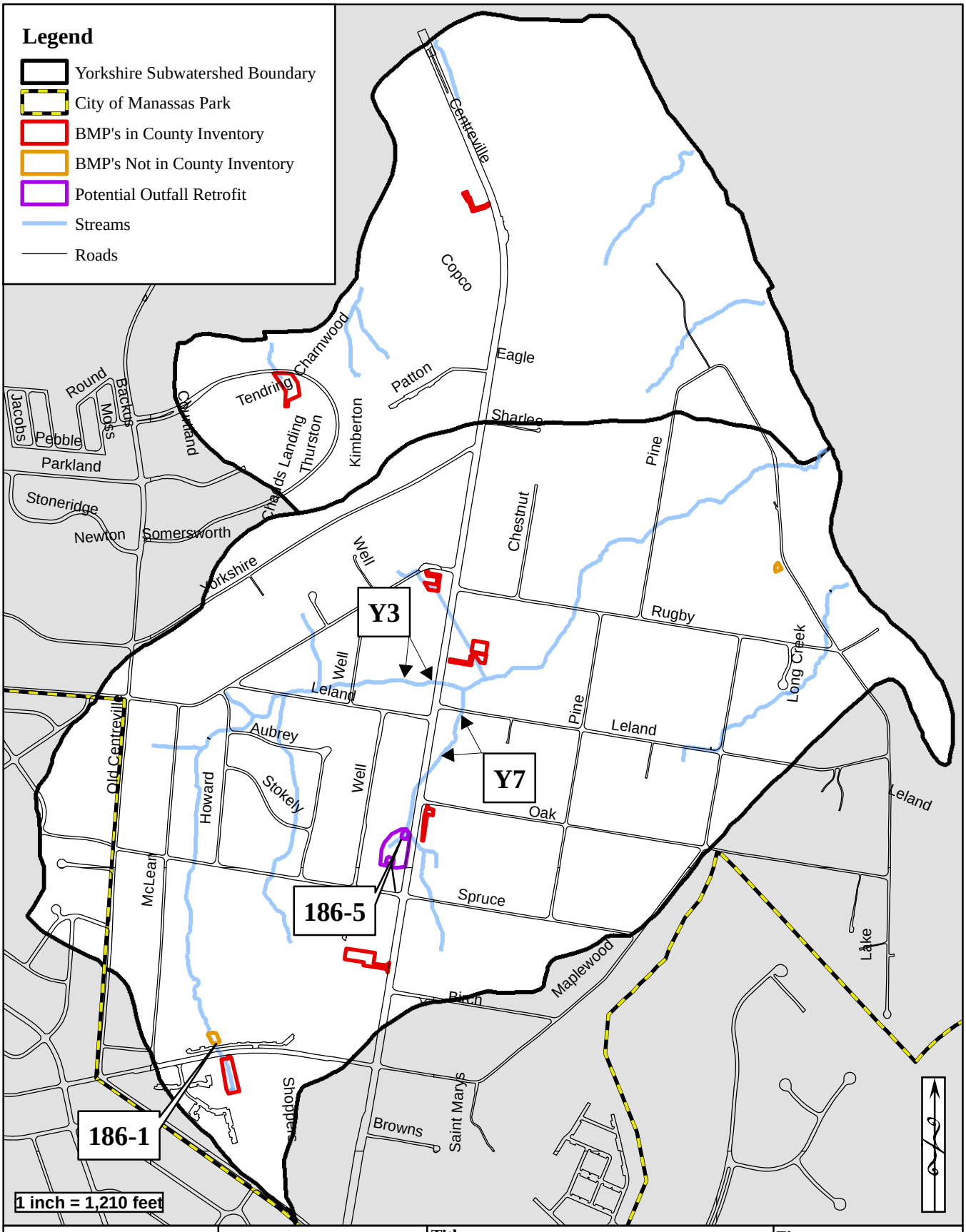


Photo 1: Proposed location for bioretention basin

Appendix B

Conceptual Design Narratives

Yorkshire (186 & 100) Subwatershed



	Source:	Title:	Figure :
WR&A	Prince William County GIS	Recommended Project Map Yorkshire (186 & 100) Subwatershed	B1

Project: Yorkshire 186-1 Stormwater Facility Water Quality Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Yorkshire**
Subwatershed Code:	**186**
Site ID:	**186-1**
County Facility ID:	**Not in Inventory**
Type:	**Stormwater Facility Retrofit**
Size:	**5,450 s.f.**
Drainage Area:	**3 acres**
GPIN/Owner:	**7896-08-6255 / Maplewood Drive Assoc.**
Neighborhood/Address:	**4341 Apartments-Income Approach/8470 Maplewood Drive**
GPS Coordinates:	**77º 27' 21.52"W**
	38º 46' 44.821"N
SWM Ranking:	**3**

Location: This site is located in the northwest quadrant of the intersection of Peakwood Court and Maplewood Drive. The site is located on Maplewood Drive Association property, surrounded by a multi-family apartment complex.

Problem Description: This facility, which is not in the County inventory, does not appear to be maintained and is ponded for long durations. The ponded dry basin supports a wetland plant community, despite the relatively small drainage area. Approximately 3 acres of highly impervious area discharges into the existing dry detention basin. The basin is currently not fenced and the low flow dewatering structure (solid PVC pipe) is not functioning. The low flow orifice on the riser structure is approximately 2 feet off of the bottom of the basin, with no other way to dewater the site, resulting in a ponding depth of 2 feet. There are two inlet pipes into the basin that are approximately 50% blocked with sediment. A 54" pipe ties into the outlet structure, which discharges into the receiving channel. The receiving channel appears to be in good condition.

Project Description: This site would be re-designed as a constructed wetland. In addition, a revised riser structure is recommended. The addition of a fence is recommended due to the ponding depth and the location of the stormwater facility in a residential area. To the extent possible, the water quality retrofit would preserve the existing mature wetland trees.

Potential Benefits: Based on current DCR standards, the created wetland would provide 20% phosphorous reduction. Based on proposed DCR standards, the created wetland would provide 50-75% phosphorous removal. The addition of a forebay at each inlet pipe will provide an area for the sediment in the influent flows to settle out. The integration of a low flow channel and high marsh area will provide a flow path for smaller storm events while allowing the accommodation for higher events. The addition of a fence will serve as a safety measure and protect the integrity of the stormwater facility.

Design Considerations: Construction access and staging area could easily be achieved from the surrounding parking lots.

Cost Estimate: The estimated total cost for this retrofit would be approximately $43,000, or about $18,000 per acre of impervious surface treated.

Watershed: Yorkshire
Site ID #: 186-1
PWC BMP #: Not In Inventory
ADC Map (25th edition): Map 9, page 14, grid coordinate G4

Conceptual Plan: Culvert dry basin design to constructed wetland

Photo 1: Dry basin is ponded, supporting a wetland community

Project: Yorkshire 186-5 Outfall Retrofit and Y1B Stream Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Yorkshire**
Subwatershed Code:	**186**
Site ID:	**186-5**
County Facility ID:	**NA**
Type:	**Outfall Retrofit** **Stream Buffer Enhancement**
Drainage Area:	**6 acres**
GPIN/Owner:	**7897-20-1510, 7897-20-1203,** **7897-20-1621, 7897-20-1930/** **Trustees Emmanuel Baptist Church**
Neighborhood/Address:	**4011 Manassas Park/7010 Centreville Road**
SWM Ranking:	**6**
Stream Ranking:	**3**

Location: The outfall retrofit site is located in the north-west quadrant of the intersection of Centerville Road and Spruce Street on the property of Emmanuel Baptist Church School.

Problem Description: The runoff to the stream is currently untreated for water quality or quantity. Approximately 6 acres (about 50% impervious cover) drains through the site. There is one outlet pipe on site that discharges directly into the existing stream. The parking lot drainage sheet flows over the lawn and into the stream. Additional untreated off site runoff discharges at Y1-P1. In addition runoff from Centerville Rd. discharges into a swale that also enters into the stream. The existing stream banks and bed are unstable and eroding, resulting in a reach condition assessment of fair. Invasive species and mowing the riparian buffer are decreasing the water quality and ecology of the channel. However, groundwater supplies the stream with strong base flow which supports aquatic species including caddisflies.

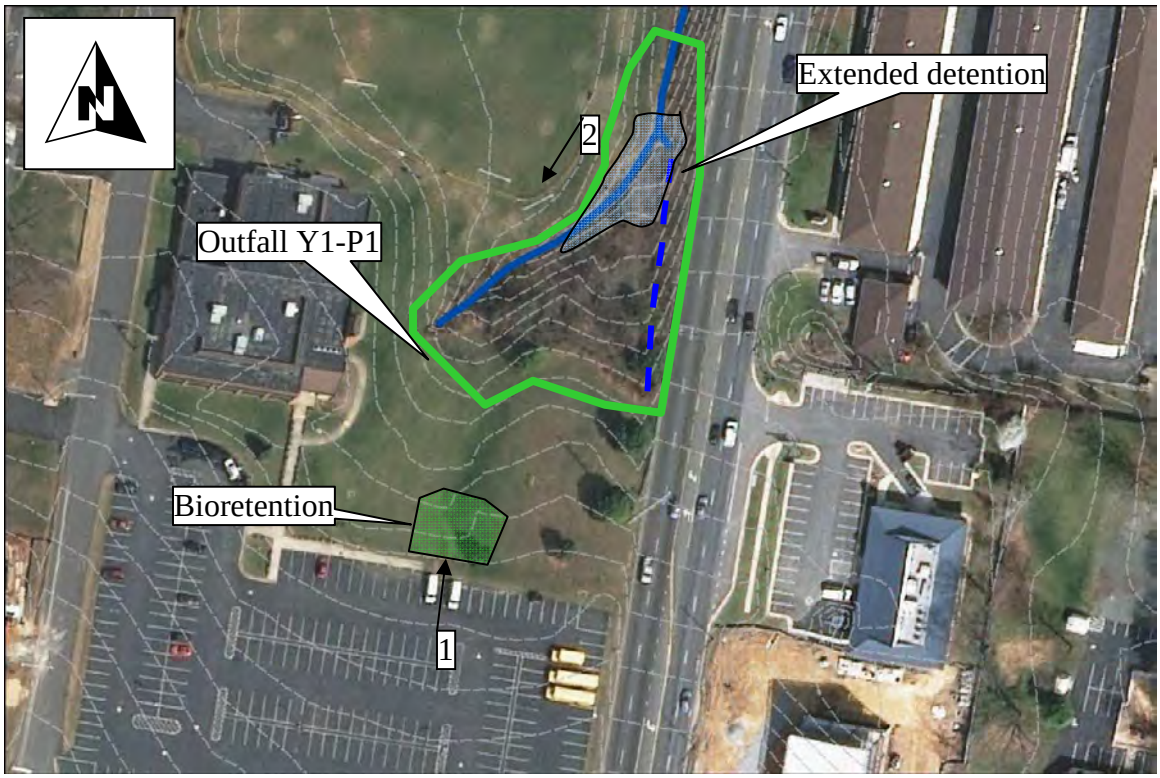
Project Description: A 2180 sf bioretention basin is recommended to treat the runoff from the church school parking lot. A 3180 sf enhanced extended detention basin is recommended at the intersection of the swale and the channel from the outfall pipe. There appears to be sufficient space available to accommodate these facilities. A riparian buffer management plan would be developed to assist the church school in maintaining these facilities, as well as the riparian buffer.

Potential Benefits: The project would provide water quality treatment for approximately 6 acres of impervious surface at the headwater of a stream. Based on proposed DCR standards, the bioretention basin would provide a 50%-90% total phosphorus removal rate and an enhanced extended basin would provide 15% reduction. The project would also provide partial quantity control and improve stream conditions. Enhancement of a riparian buffer throughout the length of the study reach would improve the stability and integrity of the stream. The facility could be used in educational programs with the church school.

Design Considerations and Constraints: Construction access and staging would be easily accomplished from the parking lot. The downstream extent is limited by vegetation management in an overhead power line easement and the discharge from a 48 inch pipe under Centerville Road. In addition, a fenced recreational field is to the northwest of the project area limiting buffer width. Basin size may be limited by grading considerations.

Cost Estimate: This project has two distinct elements: the proposed bioretention basin to treat the parking lot run-off, and the extended wetland treatment basin. The bioretention basin is estimated to cost approximately $65,000 while the extended wetland basin would cost approximately $36,000. The average cost per acre of impervious surface would be $25,000.

Watershed: Yorkshire
Site ID #: 186-5
ADC Map (25th edition): Map 9, page 14, grid coordinate H3, 4



Conceptual Plan: Bioretention basin is proposed to replace current efforts to treat parking lot runoff

Photo 1: Bioretention basin is proposed to replace current efforts to treat parking lot runoff

Photo 2: Buffer management plan could improve streamside maintenance practices

Project: Yorkshire Y7 Stream Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Yorkshire**
Subwatershed Code:	**186**
Site ID:	**Y7**
County Facility ID:	**NA**
Type:	**Stream Enhancement**
Length:	**489'**
GPIN/Owner:	**7897-21-5701, 7897-21-5712 /**
	Vargas Fernando R & Graciela, 7897-21-6127 / Auroras LLC.
Neighborhood/Address:	**4011 Manassas Park/7805 Centreville Road**
GPS Coordinates:	**77º 26' 54.229" W**
	38º 47' 11.108" N
Stream Ranking:	**6**

Location: This project is located in the south eastern quadrant of Leland Road and Centerville Road. This reach flows through commercial property.

Problem Description: This reach is hidden in a steep valley between commercial properties where it is out of sight of adjacent landowners and the public, which leads to a lack of concern and maintenance. This stream reach scored as fair condition, with a particularly low channel bed stability score and aquatic habitat score. The channel has two significant head cuts (Y7-H1 & Y7-H2) with 2 or more feet of channel bed incision. This reach has one of the largest dump sites in the study (Y7-T1), composed of automotive debris, furniture, appliances, and paper/ plastics. There are two outfalls (Y7-P2 & Y7-P1) which require stabilization or maintenance. There is no stormwater control upstream of this reach.

Project Description: The proposed work along this reach would be to stabilize the channel bed, particularly at the two head cuts, addressing any outfall stabilization, and removing the debris dump. The narrow stream valley and existing riparian buffer limits the extent of restoration that could be performed. The work would focus primarily on stabilization. Given it's location between commercial properties, management of the riparian buffer and adjacent land should be addressed. This project would benefit from the recommended improvements upstream at Site 186-5 which will provide stormwater quantity and quality controls.

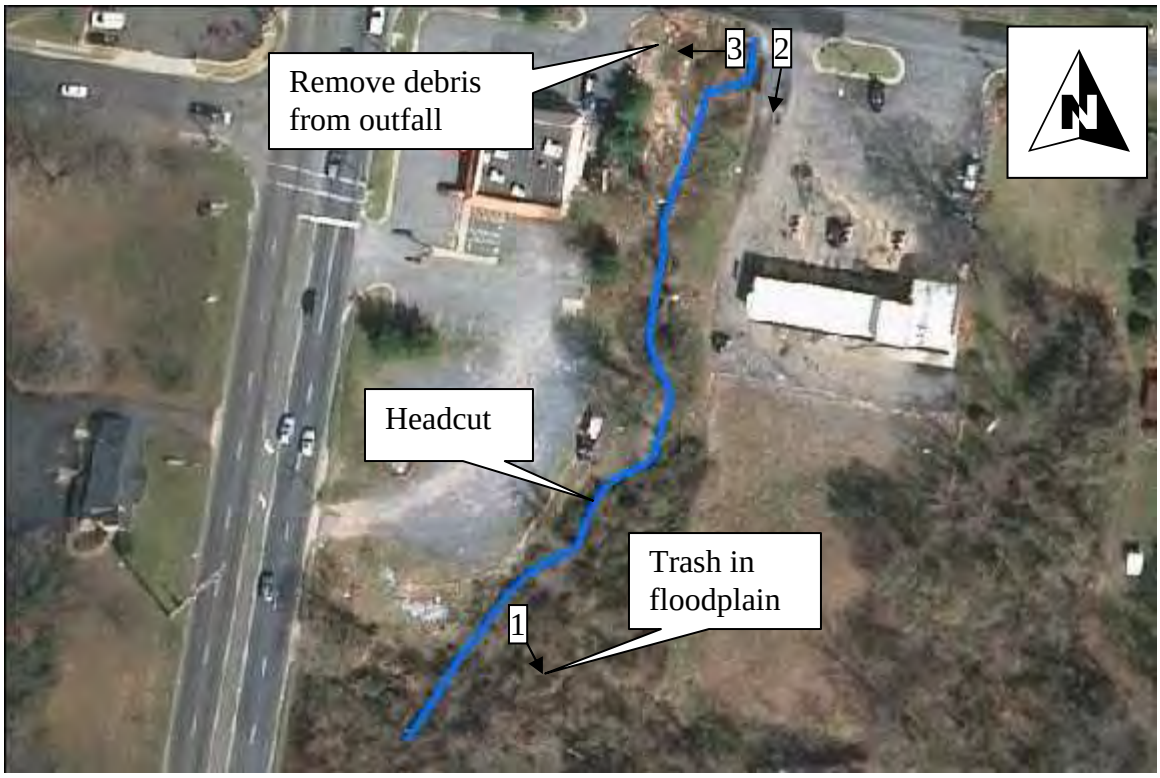
Potential Benefits: This stream project would raise awareness of the adjacent land owners, and prevent future degradation and dumping. Stabilization of the two significant head cuts would reduce sediment load, and prevent down cutting and channel migration. Trash removal would improve the riparian vegetation growth, increase aesthetics, and prevent impacts to downstream reaches.

Design Considerations: Construction access could be achieved through the commercial properties and with minimal tree clearing within the riparian buffer. Agreements should be established with the local businesses concerning the management of the buffer and adjacent land. Signage or fencing should be considered to stop future dumping activity.

Cost Estimate: The cost for stabilization of headcuts and outfalls, riparian improvements, and litter removal was estimated to be $20,000. For this relatively short project, the costs would be approximately $102 per linear foot.

Watershed: Yorkshire
Site ID #: Y7
ADC Map (25th edition): Map 9, page 14, grid coordinate H3

N
W E
S



Conceptual Plan:

Photo 1: Remove debris from dump Y7-T1

Photo 2: Stabilize headcut Y7-H1

Photo 3: Remove sediments and debris from outfall Y7-P2

Project: Yorkshire Y3 Stream Stabilization / Riparian Buffer Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Yorkshire**
Subwatershed Code:	**186**
Site ID:	**Y3**
County Facility ID:	**NA**
Type:	**Stream Stabilization**
Length:	**161 linear feet**
GPIN/Owner:	**7897-21-1860, 7897-21-2867 / Gentry V & Imogene F** **7897-21-4358 /Custer George D & Lola Mae**
Neighborhood/Address:	**4011 Manassas Park/7618 Centreville Road**
GPS Coordinates:	**77º 26' 58.729" W** **38º 47' 15.577" N**
Stream Ranking:	**10**

Location: This project is located to the north of Leland Road, between Centerville Road and Well Street on commercial property.

Problem Description: The stream condition assessment score for the entire reach was good, but there is a cluster of issues which warrant repair along the lower 165 feet. The riparian buffer upstream of Centerville Road has been cleared of trees and shrubs. An exposed utility crossing (Y3-U1) has created a large scour pool causing stream bank slumping downstream of the utility crossing. Ditch (Y3-D1) has been filled with woody debris restricting the drainage to the receiving channel.

Project Description: The project would stabilize a utility crossing, address bank erosion, and enhance the riparian zone. The condition of the utility crossing and scour pool would be evaluated and a stabilized grade control provided to prevent damage to the utility and excessive scour. The eroded banks would be stabilized and a riparian vegetation plan developed to control invasives and plant woody species.

Potential Benefits: The project would help to stabilize the utility crossing, reducing scour and allowing for fish passage during base flows. The project would help to enhance the riparian buffer zone. Buffers are a natural boundary used for maintaining stream water quality and aquatic habitat. Enhancing the buffer will help to reduce water temperature, increase filtering, and decrease erosion and sedimentation.

Design Considerations: Construction access could be achieved through an utility easement located within the project area. Since the riparian buffer has been removed, tree clearing will be minimal. Scour pool stabilization on downstream side of utility crossing and ditch Y3-D1 can be combined into one project. Commercial space adjacent to the project area is cleared.

Cost Estimate: This relatively short project would cost approximately $22,000 or $131 per linear foot.

Watershed: Yorkshire
Site ID #: Y3
ADC Map (25th edition): Map 9, page 14, grid coordinate H3

Conceptual Plan: Stabilize stream at utility crossing and establish buffer

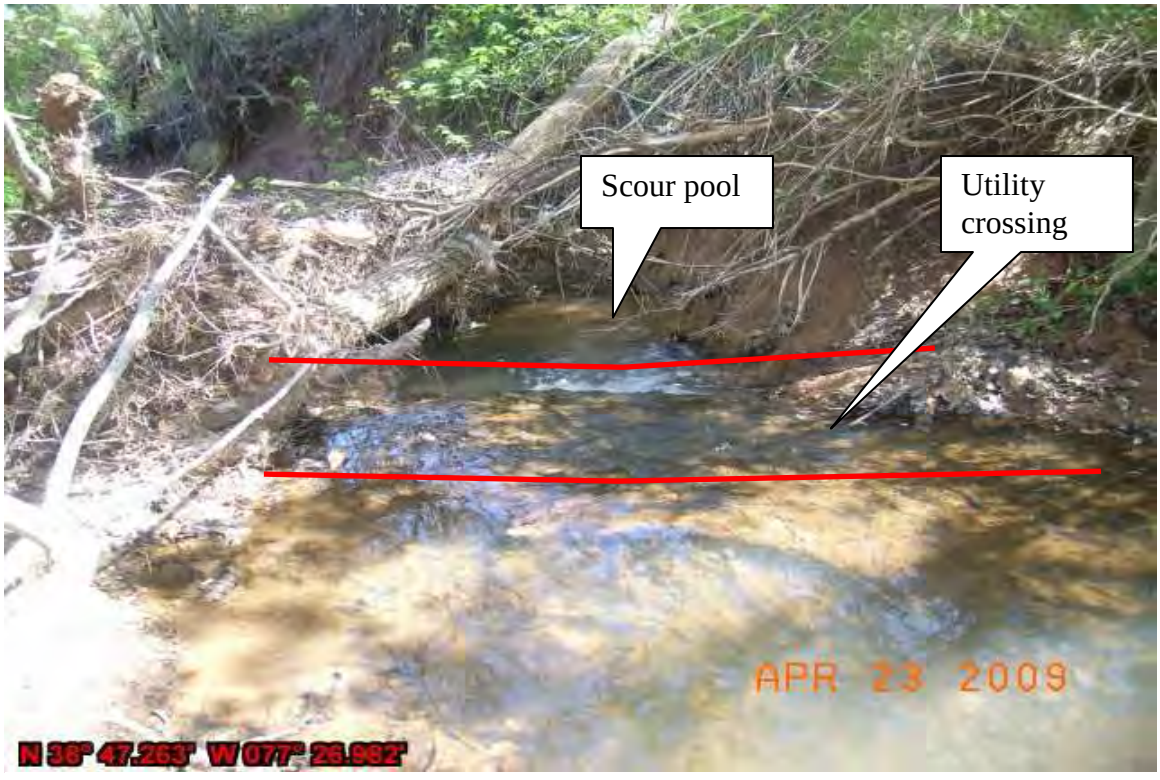


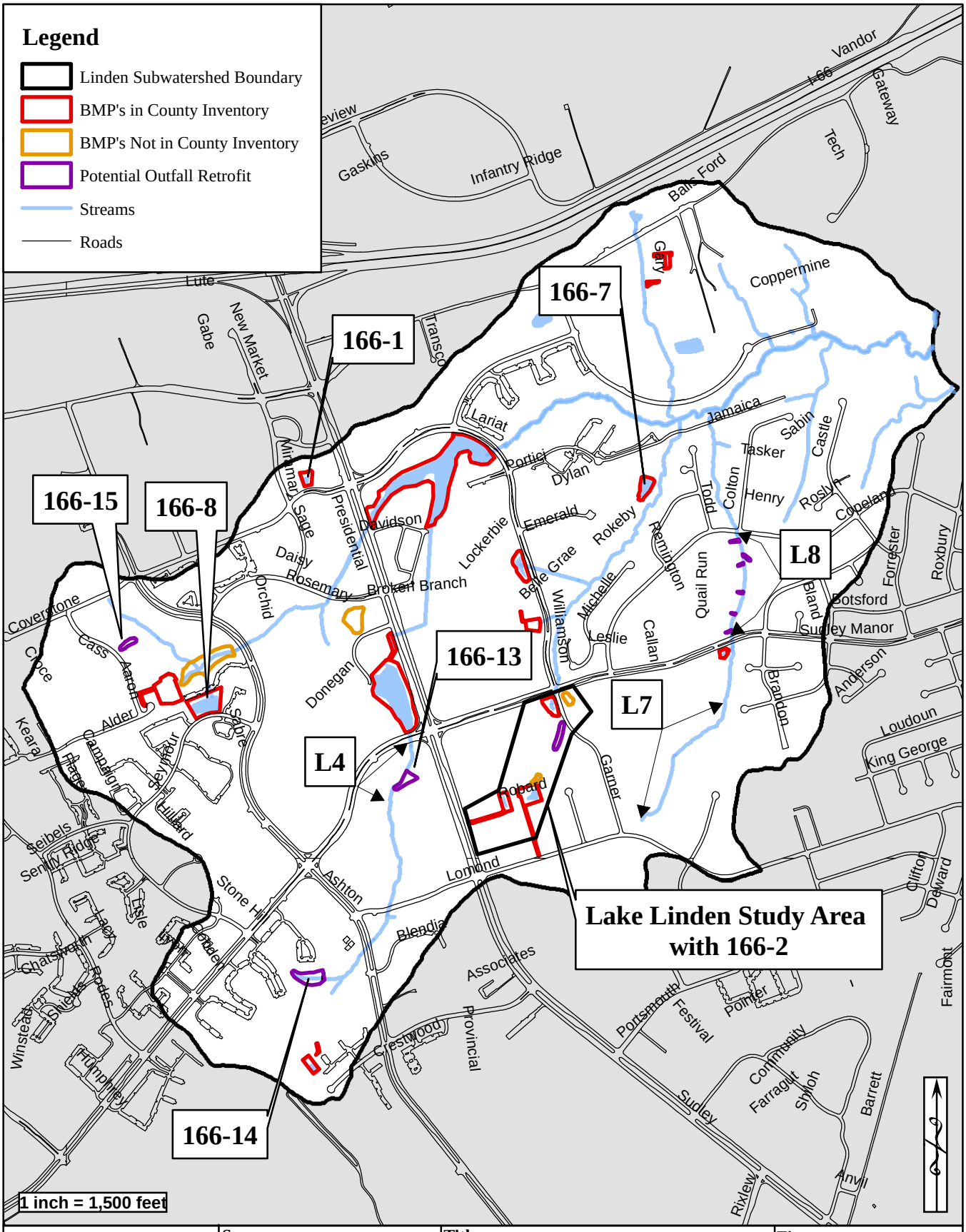
Photo 1: Utility crossing scour on downstream side

Photo 2: Re-establish buffer with woody vegetation

Appendix C

Conceptual Design Narratives

Linden (166) Subwatershed



	Source:	Title:	Figure:
THE SEAL OF PRINCE WILLIAM COUNTY VA. WR&A	Prince William County GIS	Recommended Project Map Linden (166) Subwatershed	C1

Project: Linden 166-1 Stormwater Facility Safety Improvements

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-1**
County Facility ID:	**5233**
Type:	**Safety Improvement**
Size:	**4,325 sf**
Drainage Area:	**4 acres**
GPIN/Owner:	**7697-24-5209 / E&A Southeast LTD**
Neighborhood/Address:	**4311 Shopping Centers-Income Approach/7461 Coverstone Drive**
GPS Coordinates:	**77º 31' 7.291"W**
	38º 47' 42.718"N
SWM Ranking:	**1**

Location: This project is located in the northwest quadrant of the intersection of Sudley Road and Coverstone Drive on commercial property in an intensely developed commercial area.

Problem Description: Approximately 4 acres of highly impervious drainage discharges into the stormwater facility. Instead of the 36 inch riser reported in the county's stormwater facility inventory, field inspection identified a 12" PCV pipe that is filled with stone. The riser is clearly undersized and there is no emergency spillway. It is enclosed by a fence that is damaged and has not been maintained. There are rack lines along the southern fence line and erosion on the southern berm; indicating that the facility is actively over topping. In addition the road downstream of the berm is damaged from the apparent overtopping. Upon discussion with an employee in the area it was discovered the facility had overtopped at least once within 4 months of the inspection. Maintenance is poor in part due to lack of equipment access into the facility.

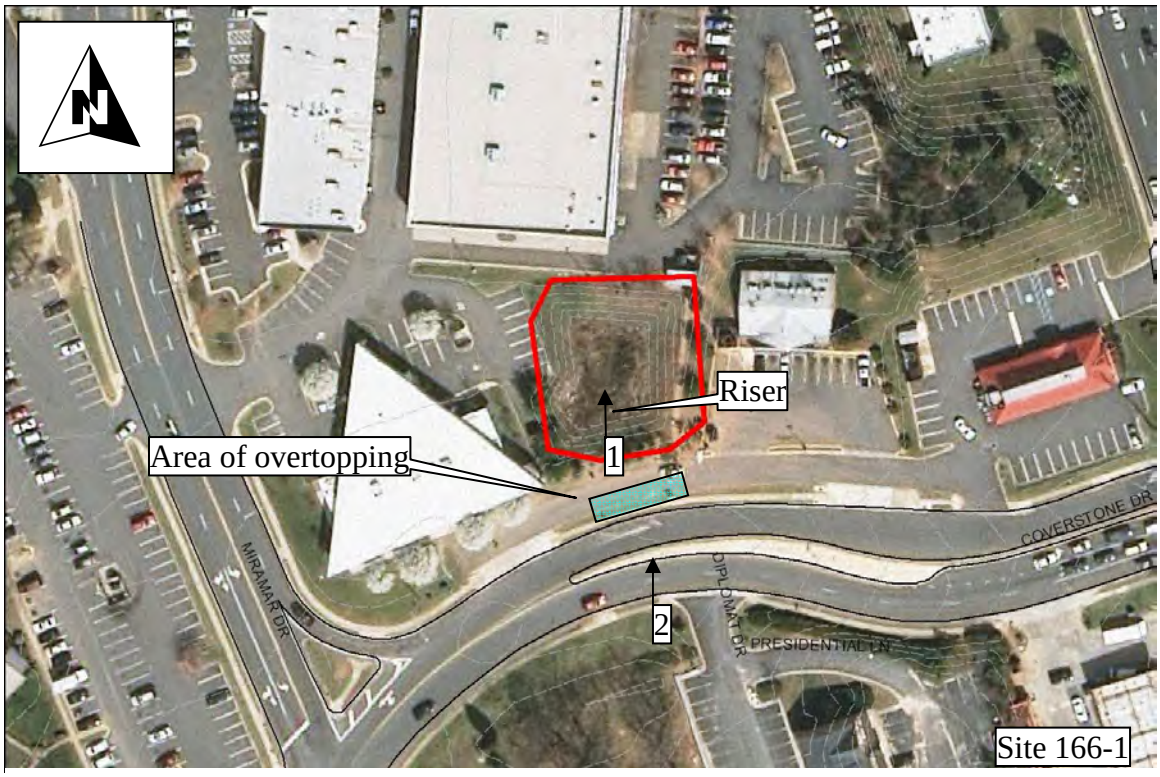
Project Description: The design of this facility would include an evaluation of the drainage area, required water quantity and quality volume, the design of an adequate rise structure, and an evaluation of the damaged berm. The design would provide an emergency spillway or riser sufficiently sized to act as the emergency spillway. Equipment access would be graded into the steep side slope to insure that the basin could be properly mowed and maintained.

Potential Benefits: This stormwater facility is the most deficient observed in this study. Addressing the immediate safety issues is the primary benefit of this project. The re-design would improve the ability to maintain the site. There would not be significant improvements in water quantity or quality controls.

Design Considerations: Construction access and staging area can easily be achieved through any of the surrounding parking lots. The design should address the lack of equipment access down the steep slopes, which is one reason this facility probably has not been properly maintained.

Cost Estimate: This existing facility needs to be re-designed and re-built at an estimated cost of approximately $90,000. Most of the associated costs would be related to providing an adequate riser and grading to provide access for maintenance.

Watershed: Linden
Site ID #: 166-1
PWC BMP #: 5233
ADC Map (25th edition): Map 8, page 13, grid coordinate H1, 2



Existing Conditions

Photo 1: Showing lack of maintenance and inadequate riser

Photo 2: Erosion along backside of berm

Project: Linden 166-2 Stormwater Management Study

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-2 Lake Linden Study**
County Facility ID:	**5007, 99, and 5331**
Type:	**Stormwater Management Study**
Size:	**7,348 (5007), 14,672 (99), 3,175 (5331) sf**
Drainage Area:	**72 acres**
GPIN/Owner:	**7697-50-0740/ Brighton Commons HOA, 7697-51-3830 and 7697-51-4002/ PWC Board of Supervisors, 7697-41-6415/ Princeton LLC, 7697-51-7373/Trustees Hope Lutheran Church Missouri Synod.**
	Neighborhood/Address: 4339 Adult Assisted Living Fac./7750 Gardner Drive
GPS Coordinates:	**77º 30' 32.704"W**
	38º 47' 14.189"N
BMP Ranking:	**2**

Location: The proposed study area is located in the southeast quadrant of the intersection of Sudley Rd. and Sudley Manor Dr. on multiple parcels.

Problem Description: The study area includes a series of stormwater facilities that appear to be either undersized or not functioning to the full design capacity. Three of the facilities are included in the Prince William County inventory (5007, 166-6, & 166-3) and two existing facilities were identified during field inspections (166-2 & 166-5). Facility 166-6 appears to be well maintained, however the riser structure appears to be of inadequate size (less than 18 inches). Stormwater facility 166-3 is well maintained, but has a manually operated shut off valve. Facility 166-2 appears to be inadequately sized and is one of the most deficient facilities inspected within this study. Stormwater facility 166-5 appears abandoned and may no longer receive flow. All five facilities are in close proximity to each other, and are located at the headwaters of a stream.

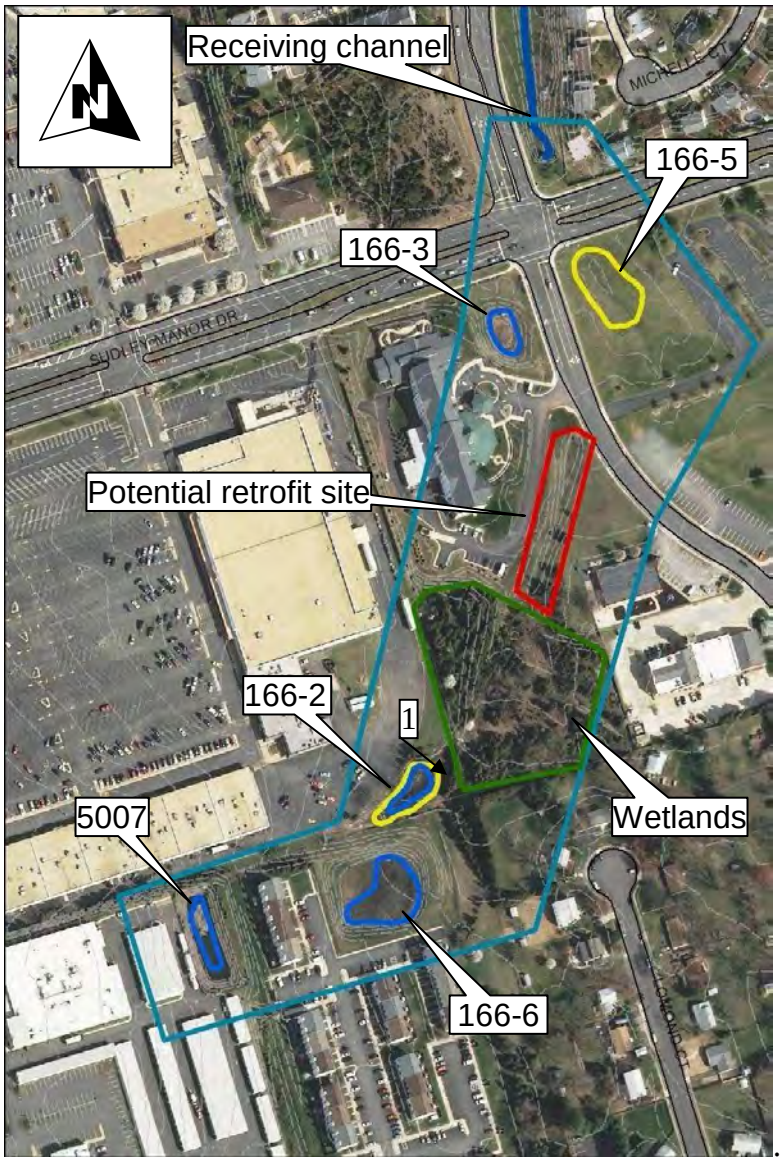
Project Description: A full water quality and quantity evaluation is recommended for this intensely developed area. The study should include an evaluation of the existing stormwater facilities, including how they perform for water both quality and quantity. The study would identify the optimal design approach to correct deficiencies with facility 166-2, address the riser in 166-6, as well as the protection of existing wetlands, and possibly redevelopment of facility 166-5.

Potential Benefits: This study would provide an understanding of how these stormwater facilities are functioning as a network. Implementation of the recommendations would improve the water quality and the integrity of the receiving channel and wetland. Addressing the deficiencies of multiple stormwater facilities may provide opportunities to realize a more holistic design solution than if each facility was individually addressed.

Design Considerations: There are multiple land owners in the study area. Construction access to individual stormwater facilities is easily available and there are multiple locations for stockpile and staging areas during construction.

Cost Estimate: A construction cost estimate was not developed for the facilities within this study. The study would identify the most effective approach to resolving deficiencies identified at several facilities. The estimated $100,000 cost would be for survey, planning, and design services.

Watershed: Linden
Site ID #: 166-2, 166-3, 166-5, 166-6
PWC BMP #: 5331, 99, 5007
ADC Map (25th edition): Map 8, page 13, grid coordinate J3



Proposed study area includes five existing BMPS, wetlands, and potential retrofits sites

Photo 1: BMP 166-2 is a poorly functioning stormwater facility

Project: Linden 166-7 Stormwater Facility Water Quality Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-7**
County Facility ID:	**91**
Type:	**Stormwater Facility Water Quality Retrofit**
Size:	**0.45 acres**
Drainage Area:	**13 acres**
GPIN/Owner:	**7697-64-0507/Stonington Community Assoc. Inc**
Neighborhood/Address:	**2313 Stonington-Sudley Artery TH/7371 Emerald Drive**
GPS Coordinates:	**77º 30' 20.258"W 38º 47' 41.615"N**
SWM Ranking:	**4**

Location: The recommended stormwater facility retrofit site is located south of Jamaica Lane in the Paradise Ridge apartment complex and is owned by Stonington Community Association, Inc.

Problem Description: This dry basin was constructed in 2004 and drains approximately 13 acres of multi-family residential development. The basin appears to be routinely ponded. The low flow orifice is an 8 inch PVC pipe which is not connected to the 81 inch main riser but discharges to the receiving channel through a separate outfall. The PVC pipe is not set low enough to drain the basin and it clogs easily. One 30 inch inlet is eroding and under cutting by 2 feet. One of the inlets has a short flow path to the outlet. Shallow bedrock could be contributing to the observed ponding.

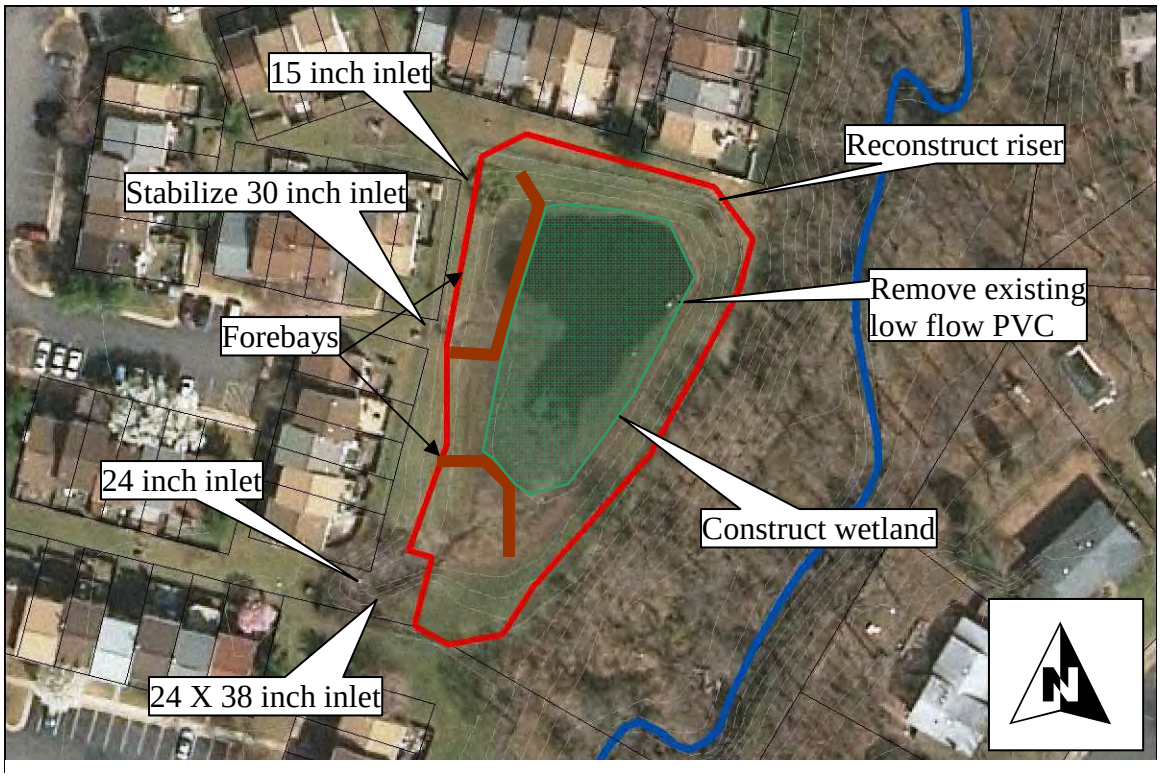
Project Description: This stormwater facility is not functioning as a dry basin, and water quality control could be achieved by retrofitting the existing facility. The retrofit would include stabilizing the inlets and providing forebays to contain sedimentation, excavation of a wetland and low flow channel in the basin, and improving the riser and low flow outlet. The existing ponding and baseflow from one of the inlets indicates that this facility is capable of supporting wetland vegetation. The wetland would be designed with low and high marsh, and micropools at the riser and near the forebays. Based on 2 feet of excavation to create a stormwater wetland, the facility would have sufficient area to exceed current DCR standards.

Potential Benefits: Based on proposed DCR standards, the conversion from the dry basin to a stormwater constructed wetland will increase pollutant removal from less than 30% to 50-75%. A well designed constructed wetland would provide better habitat, water quality control, and mosquito control than the currently ponded dry basin.

Design Considerations: The stormwater facility is located on community property, but access through townhomes is limited. Staging and stock pile areas would probably be limited. Shallow bedrock may be present and limit excavation.

Cost Estimate: The estimated total cost for this dry pond retrofit would be approximately $70,000 or $8,200 per impervious surface.

Watershed: Linden
Site ID #: 166-7
PWC BMP #: 91
ADC Map (25th edition): Map 8, page 13, grid coordinate J1 and K1



Conceptual Plan

Photo 1: Low flow orifice for dry basin is clogged and not connected to riser

Project: Linden 166-8 Stormwater Facility Water Quality Investigation and Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-8**
County Facility ID:	**492**
Type:	**Water Quality Investigation and Retrofit**
Size:	**76,472 s.f.**
Drainage Area:	**48 acres**
GPIN/Owner:	**7697-11-8874 & 7697-11-2353/ Paradise Homeowner Assocs.**
Neighborhood/Address:	**2320 Paridise F-Stanley Martin TH/7689 Staunton CL**
GPS Coordinates:	**77º 31' 21.212"W**
	38º 47' 18.419"N
SWM Ranking:	**9**

Location: The recommended water quality investigation site is located off of Seymour Road between Winfield Loop and Monitor Court. It is on private property in a multi-family apartment complex.

Problem Description: Built in 2000, the existing 76,472 s.f. stormwater facility is a retention basin which drains approximately 48 acres of high density residential development. The water quality of the pond appears to be poor with high nutrient and algal concentrations. This facility has steep sides which limits vegetation management and a depth of 5-6 feet. The facility may become stratified during the summer, resulting in low dissolved oxygen and the release of nutrients from bottom sediments. The 108 inch riser structure has a flat debris screen that accumulates a lager amount of trash and debris.

Project Description: The project investigation would evaluate the water quality of the retention basin, and determine if adding mechanical aeration to induce mixing and increase dissolved oxygen levels is warranted. Water quality would be monitored from spring to fall, including nutrients and dissolved oxygen levels near the surface and at the bottom. If aeration is warranted by low oxygen level and/ or high algal populations, various types of aeration designs will be compared. Possible modifications to be evaluated for the riser structure would include a new debris rack and modifications to provide detention.

Potential Benefits: This facility is located at the headwaters for a major tributary to Linden Lake. The addition of an aerator would improve the water quality of the retention basin. The removal of trash and debris would improve the function of the basin to its full design capacity.

Design Considerations: The ability to improve operation of the facility is limited by freeboard.

Cost Estimate: This project includes an improved trash rack and two aerators. The total project costs are estimated at approximately $26,000. There would be long-term operation and maintenance costs associated with the aerators.

Watershed: Linden
Site ID #: 166-8
PWC BMP #: 492
ADC Map (25th edition): Map 8, page 13, grid coordinate G3

Existing Conditions

Photo 1: Existing 108 inch riser with flat debris grate

Project: Linden 166-13 Outfall Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-13**
County Facility ID:	**NA**
Type:	**Outfall Retrofit**
Size:	**17,000 s.f.**
Drainage Area:	**4 acres**
GPIN/Owner:	**7697-302206/ Costco Wholesale Corp.**
Neighborhood/Address:	**4013 Sudley/10701 Sudley Manor Drive**
GPS Coordinates:	**77º 30' 53.695"W 38º 47' 9.987"N**
Outfall Ranking:	**1**

Location: The recommended outfall retrofit site is located in the south-west quadrant of Sudley Manor Dr. and Sudley Rd. on a parcel owned by Costco Wholesale Corp.

Problem Description: The drainage from a 30 inch outfall (L4-P6) does not have an adequate outfall channel to the receiving stream, resulting in ponding, scour, and erosion. The outfall drains approximately 4 acres of surrounding commercial properties. The runoff from the outfall is being partially diverted in to an adjacent wetland.

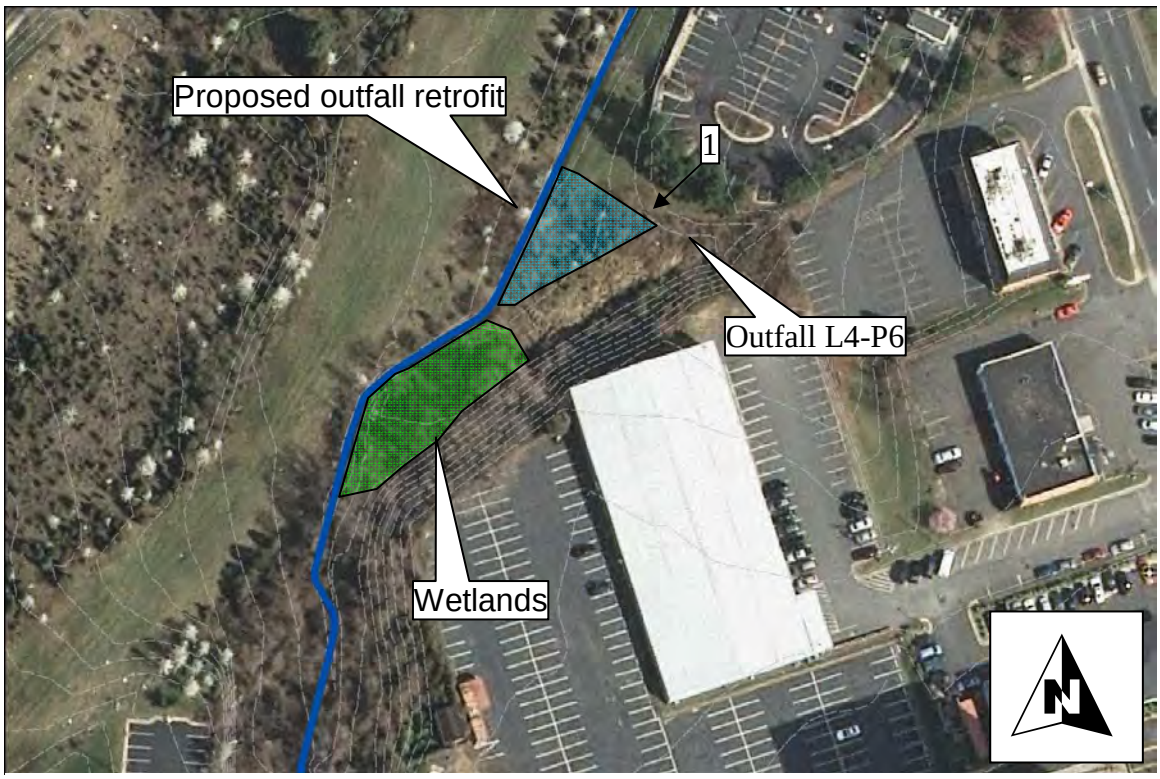
Project Description: The outfall requires an adequate channel to the receiving stream. The drainage area to the outfall is too small to support a created wetland, but would support a bioretention basin. Based on the 4 acre drainage area, a 3,200 sf bioretention facility would be required to provide water quality treatment. There is sufficient open land (0.4 acres) to provide area for an off-line bioretention basin. Higher storm flows would be diverted through a stabilized channel to the receiving channel.

Potential Benefits: The current outfall has no treatment for quantity or quality. The proposed bioretention facility would provide water quality treatment for the first flush while diverting higher storm flows. Under proposed DCR standards, a bioretention basin would reduce phosphorus concentrations 55-90% and runoff volume by 40-80%.

Design Considerations: Construction access to the site can easily be achieved through any of the several adjacent parking lots. The potential hydrological impact to the adjacent wetland should be considered in any retrofit of the outfall. Ideally, maintaining some flow to the wetland would be incorporated in to the retrofit design.

Cost Estimate: The estimated total cost to retrofit this outfall with a bioretention facility is approximately $88,000 or approximately $35,000 per impervious acre. The cost per acre is slightly above the average for this study of $31,000 per impervious acre.

Watershed: Linden
Site ID #: 166-13
ADC Map (25th edition): Map 8, page 13, grid coordinate H3



Conceptual Plan

Photo 1: Outfall without adequate channel creating erosion

Project: Linden 166-14 Outfall Retrofit / L2 Stream Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-14**
County Facility ID:	**NA**
Type:	**Outfall Retrofit** **Stream Enhancement**
Size and Length:	**Proposed Stormwater Facility 11,200 s.f. /** **134 l.f. of stream**
Drainage Area:	**28.6 acres**
GPIN/Owner:	**7696-28-1861,7697-38-0186/** **Paradise Ridge Assoc. LTD** **Partnership, 7697-28-4908/** **PWC Park Authority**
Neighborhood/Address:	**4341 Apartments-Income Approach/10879 Gambril Drive**
GPS Coordinates:	**77º 31' 7.362"W** **38º 46' 48.785"N**
Stream Ranking:	**4**
Outfall Ranking:	**3**

Location: The project site is located in the southwestern quadrant of Sudley Manor Drive and Ashton Avenue. The outfall retrofit is on multifamily complex property and stream is in Rosemont Lewis Park.

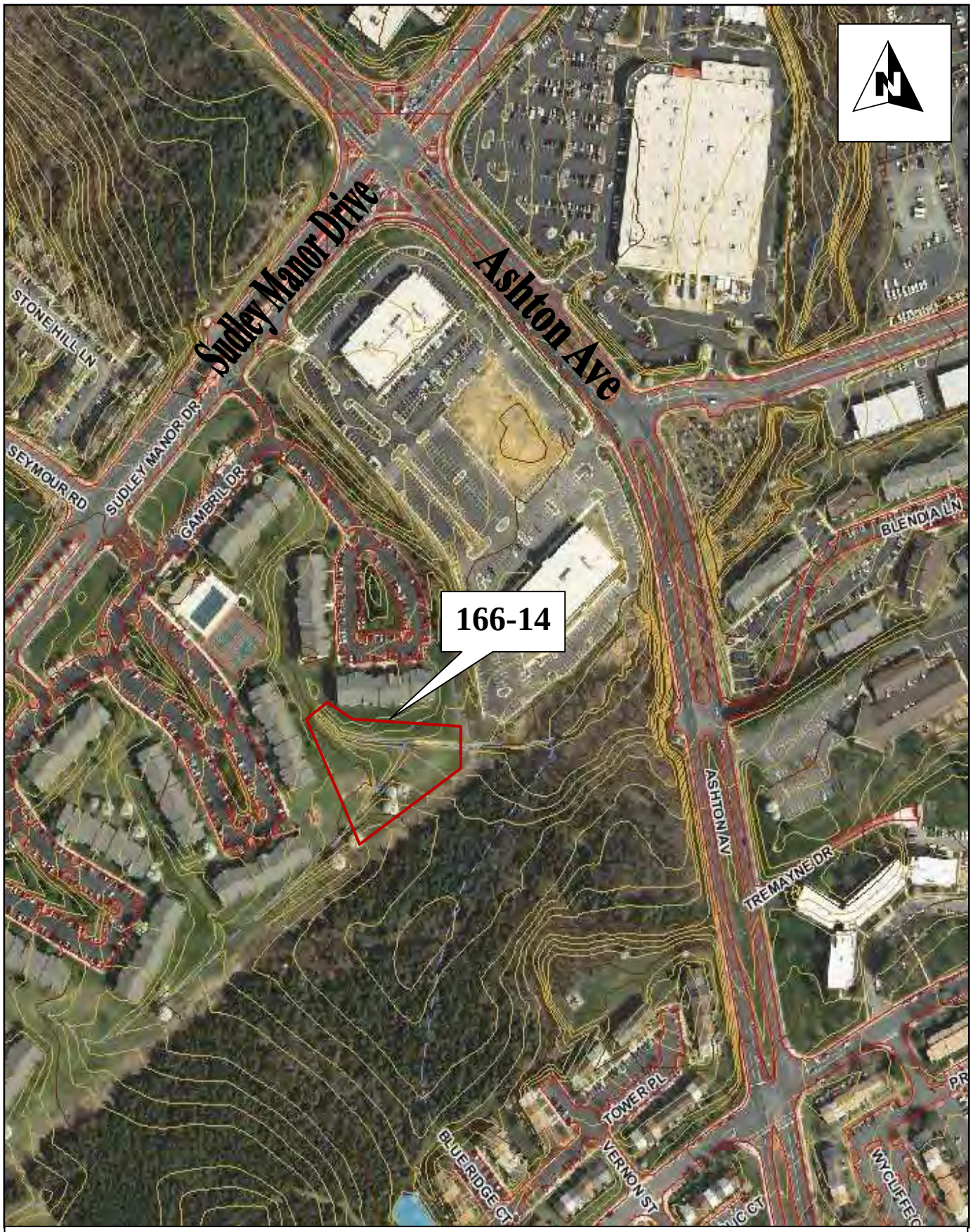
Problem Description: Approximately 28.6 acres of drainage from the apartment complex runs through two swales in an area of common property. The drainage area appears to be approximately 35% impervious without water quality or quantity control. At the confluence of the two swales, the flows run into a 134 foot paved channel, then in to a section of riprapped channel, and eventually flowing to the receiving channel within the park. The stream within the park is in fair condition. Two head cuts are actively down cutting and will eventually migrate upstream to the paved channel. L2-H1 is a moderate head cut and L2-H2 is a severe head cut with over two feet of incision. Outfall L2-P2 is blocked by accumulated sediment.

Project Description: The project would provide water quality controls as well as reducing the excessive velocities which are causing channel incision at the head cuts, and the need for the concrete and riprapped channels. Flow from the swales would be routed through a bioretention basin to provide detention and provide some quantity control for the first flush of each storm event. A riparian buffer would be installed along the channel. The 134 feet of concrete and riprap channel would be removed and reconstructed with more natural materials. The headcuts would be stabilized to prevent future incision of the channel. The blocked outfall pipe would be improved. A management plan would be provide to the owner.

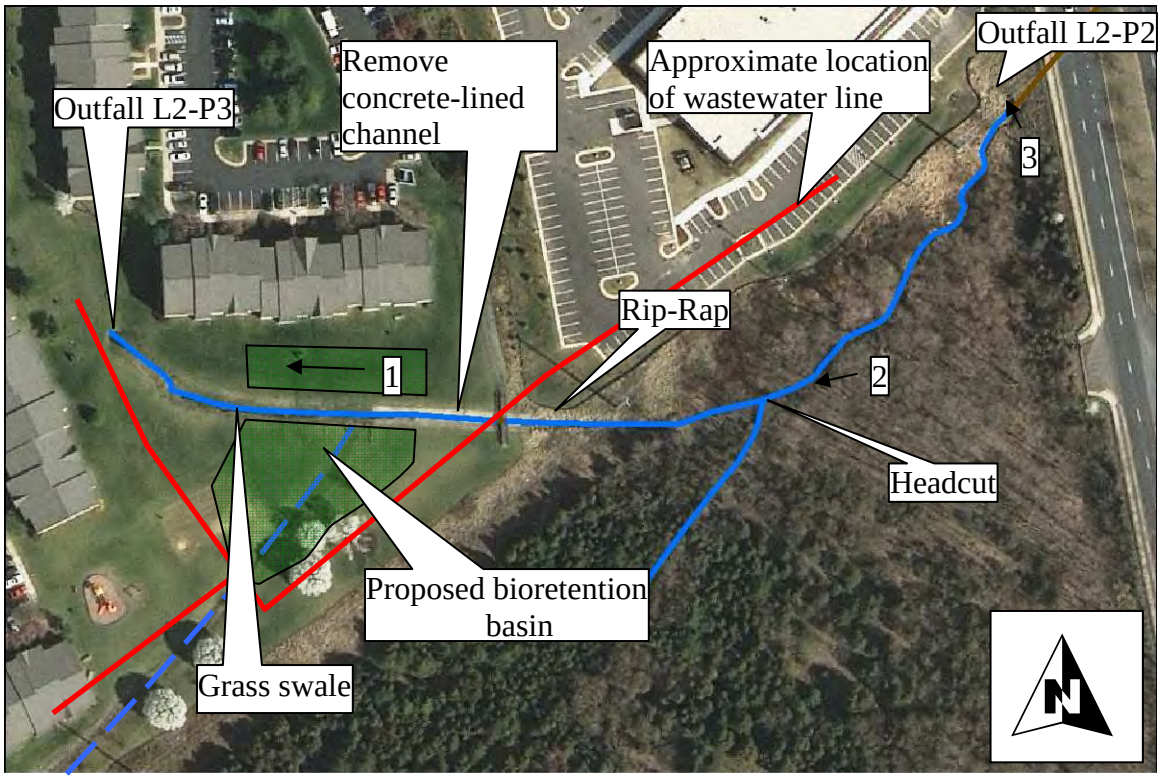
Potential Benefits: Combining outfall retrofits for water quality with channel reconstruction and stabilization will improve the stability and quality of this headwater stream system. The bioretention facility would provide 50-90% total pollutant removal and 40-80% reduction in runoff volume.

Design Considerations: Construction access to the retrofit site could be achieved through adjacent parking lots. The site is an open lawn so no clearing would be required. Access to the headcuts in the stream in the park would require clearing. Informative signs would educate residents and inform them of the county efforts to protect the watershed.

Cost Estimate: The estimated total cost would be $178,000 including stream stabilization.



Watershed: Linden
Site ID #: 166-14
ADC Map (25th edition): Map 8, page 13, grid coordinate H4



Conceptual Plan

Photo 1: Drainage swale in common property would be converted to water quality BMP

Photo 2: Headcut L2-H2 would be stabilized

Photo 3: Outfall L2-P2 would be cleaned out

Project: Linden 166-15 Outfall Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**166-15**
County Facility ID:	**NA**
Type:	**Outfall Retrofit**
Size:	**1,980 sf**
Drainage Area:	**23 acres**
GPIN/Owner:	**7697-02-7245/ PWC Park Authority**
Neighborhood/Address:	**2331 Jacksons Ridge Artery Condos/7625 Aaron Lane**
GPS Coordinates:	**77º 31' 32.624"W 38º 47' 34.8"N**
Outfall Ranking:	**4**

Location: The recommended outfall retrofit site is located southeast of the intersection of Coverstone Dr. and Aaron Lane in Ellis Barron Park.

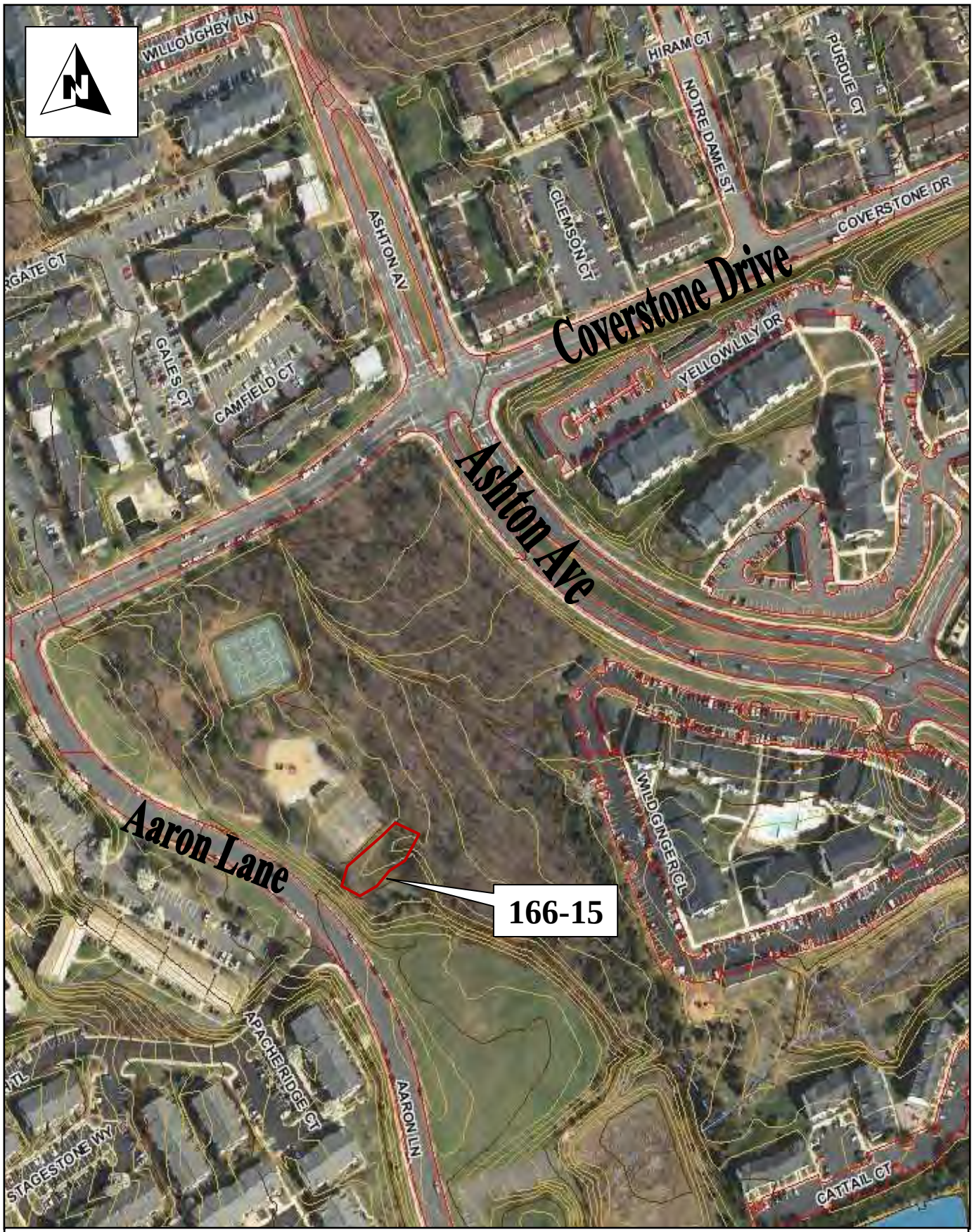
Problem Description: Based on existing topographic mapping, the 21 inch outfall (L5-P4) conveys drainage from approximately 23 acres of highly impervious multi-family apartments. The discharge is directed through a swale that leads to the receiving channel. Other than the swale there were no other water quality measures. The outfall has minor erosion along the headwall.

Project Description: The proposed outfall retrofit would provide treatment of the first flush in an off-line bioretention basin with the high flows diverted through the existing swale. Based on the outfall size, the actual drainage area may be closer to 6 acres. Assuming the smaller drainage area, the bioretention area would need to be 1980 sf to meet state standards. The estimated required stormwater facility size would just fit the available open space. As a bioretention site it would not require a fence to exclude park visitors.

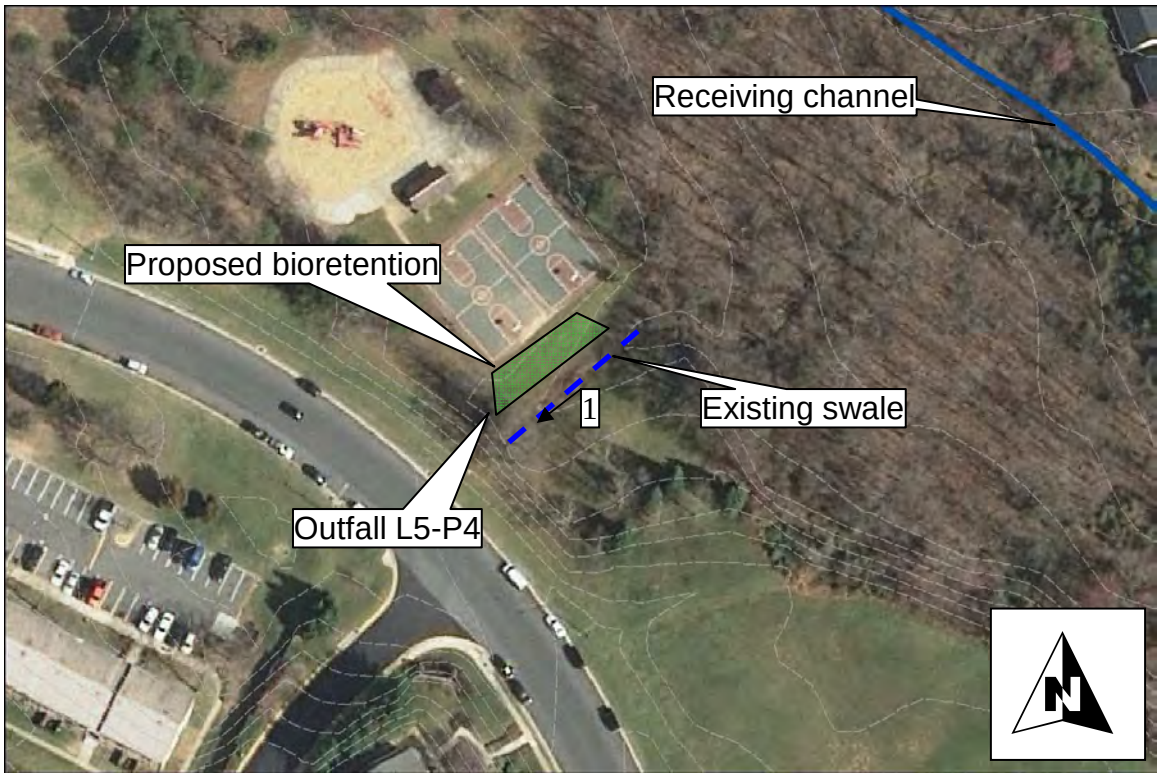
Potential Benefits: The basin would provide water quality measures for the currently untreated drainage. Treating the first flush would reduce flows and velocities and improve the water quality of the receiving channel, protecting the integrity of the stream. Based on proposed DCR standards, the bioretention site would provide a 55-90% reduction in phosphorous and 40-80% reduction in volume. This would be an ideal location for a water quality retrofit since it is located in a public park. Informative signs would educate park goers and inform them of the county efforts to protect the watershed.

Design Considerations: The actual drainage area needs to be confirmed in the field to determine proper sizing of this project. The available open space may become a limiting factor for this project if the drainage area is larger than 6 acres. Access to the site can easily be achieved through the parking lot for the park. The area for the bioretention basin is clear; preparation of the site for construction would be minimal.

Cost Estimate: The retrofitting of bioretention at this outfall would cost an estimated $61,000 or approximately $20,000 per impervious acre, well below the average cost for this study of $31,000 per impervious acre.



Watershed: Linden
Site ID #: 166-15
ADC Map (25th edition): Map 8, page 1, grid coordinate F2 and G2



Conceptual Plan for Outfall Retrofit

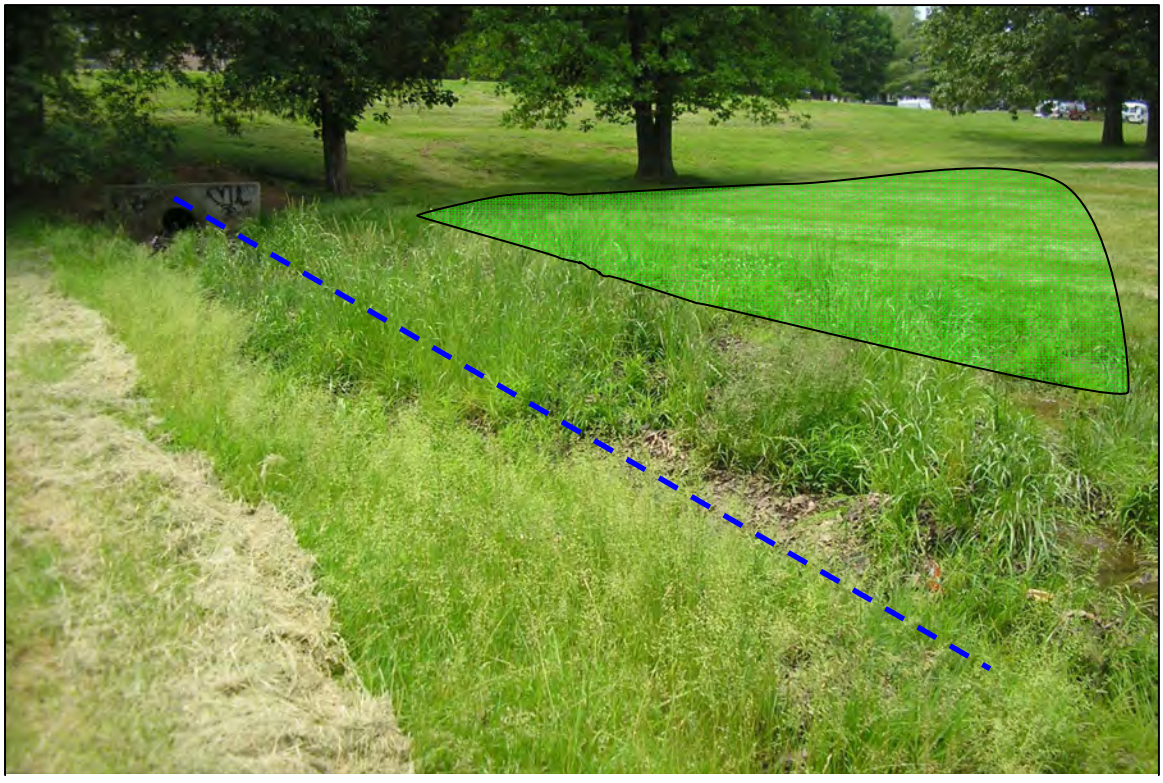


Photo 1: Proposed location for bioretention basin to treat drainage

Project: Linden L8 Buffer Enhancement and Water Quality Retrofit

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**L8**
County Facility ID:	**NA**
Type:	**Buffer Enhancement and Water Quality Retrofit**
Length:	**1,137'**
GPIN/Owner:	**7697-73-4102 / Sudley Place Townhouse Association**
Neighborhood/Address:	**2301 Sudley Village TH/7660 Quail Run Lane**
GPS Position:	**77º 30' 6.786" W 38º 47' 30.81" N**
Stream Ranking:	**4**

Location: This project is located between Copeland Drive and Sudley Manor Drive on the property of Sudley Place Townhouse Association.

Problem Description: The stream is in fair condition. The channel does not require stabilization, but does lack a woody riparian buffer. The HOA mows the riparian buffer adjacent to the stream channel. The existing channel is lined with riprap which has limited incision and erosion. Maintaining the riparian buffer decreases the water quality and ecology for the channel. A lack of riparian buffer decreases water quality and increases stream temperature. Seven outfalls (L8-P3 to L8-P8) flow indirectly through ditches into the stream without water quality control.

Project Description: This project includes establishment of a woody riparian buffer, improving water quality through retrofitting existing outfall ditches, and providing the HOA with a management plan for the stream buffer. The buffer will be composed of large canopy trees with landscaped clusters of native shrubs**.** The seven stormwater outfall ditches will be converted to water quality swales which will provide velocity attenuation and water quality improvements. A detailed management plan and education/outreach program would be developed for both the Association and the residents.

Potential Benefits: Buffers are a natural boundary used for maintaining stream water quality and aquatic habitat. Vegetating the buffer will lower water temperature, increase filtering, decrease erosion and sedimentation, and decrease the velocity of surface run off to the channel. Retrofits of the outfall ditches will enhance water quality and reduce the velocity of stormwater entering the stream.

Design Considerations: The openness of reach L8 allows for easy construction access. When installing a buffer, especially within a common area, safety becomes a concern. Maintaining sightlines within the buffer by using trees that can be limbed up and shrubs which can be trimmed will address safety concerns. The existing riprap and turf would not be removed to minimize disturbance to the stream.

Cost Estimate: This project would install riparian buffer and retrofit outfalls at an estimated total cost of $133,000. The project extends over 1,l37 linear feet of channel for cost of $117 per linear foot. The cost of the water quality swale retrofit represents approximately 60% of the total costs.

Watershed: Linden
Site ID #: L8
ADC Map (25th edition): Map 8, page 13, grid coordinate K2

Conceptual Plan: Establish riparian buffer and retrofit water quality swales

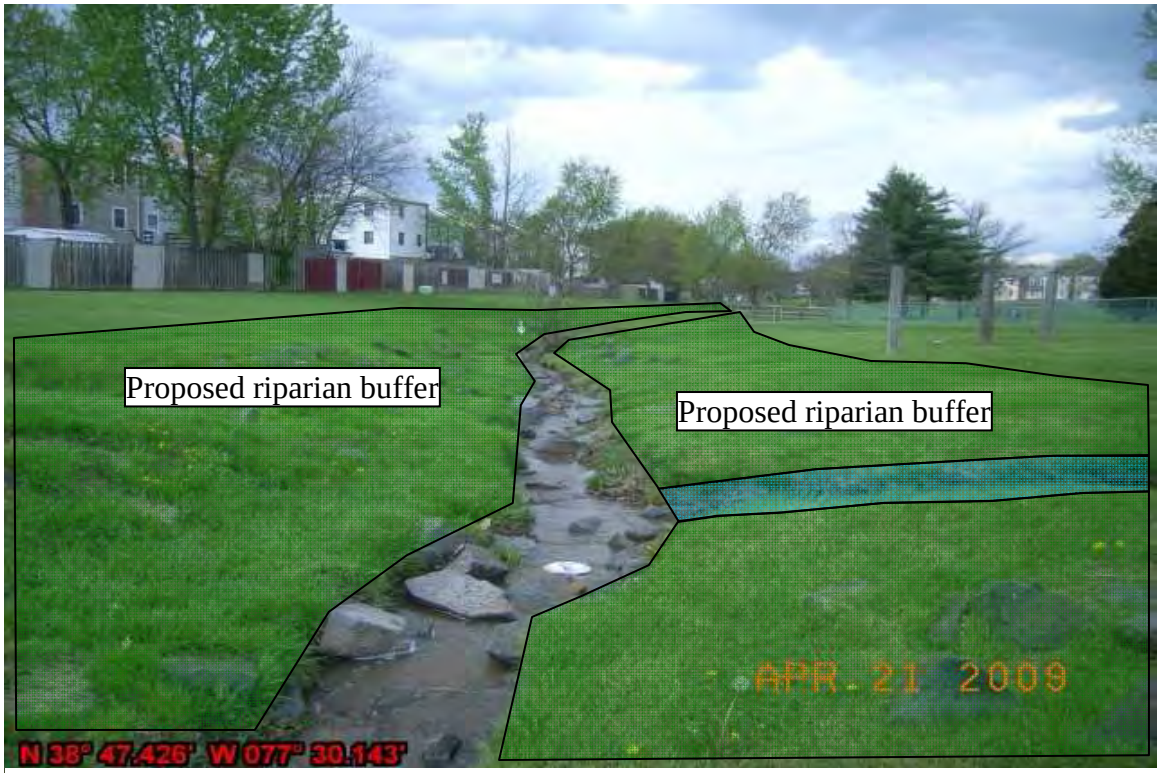


Photo 1: Existing conditions with proposed buffer width

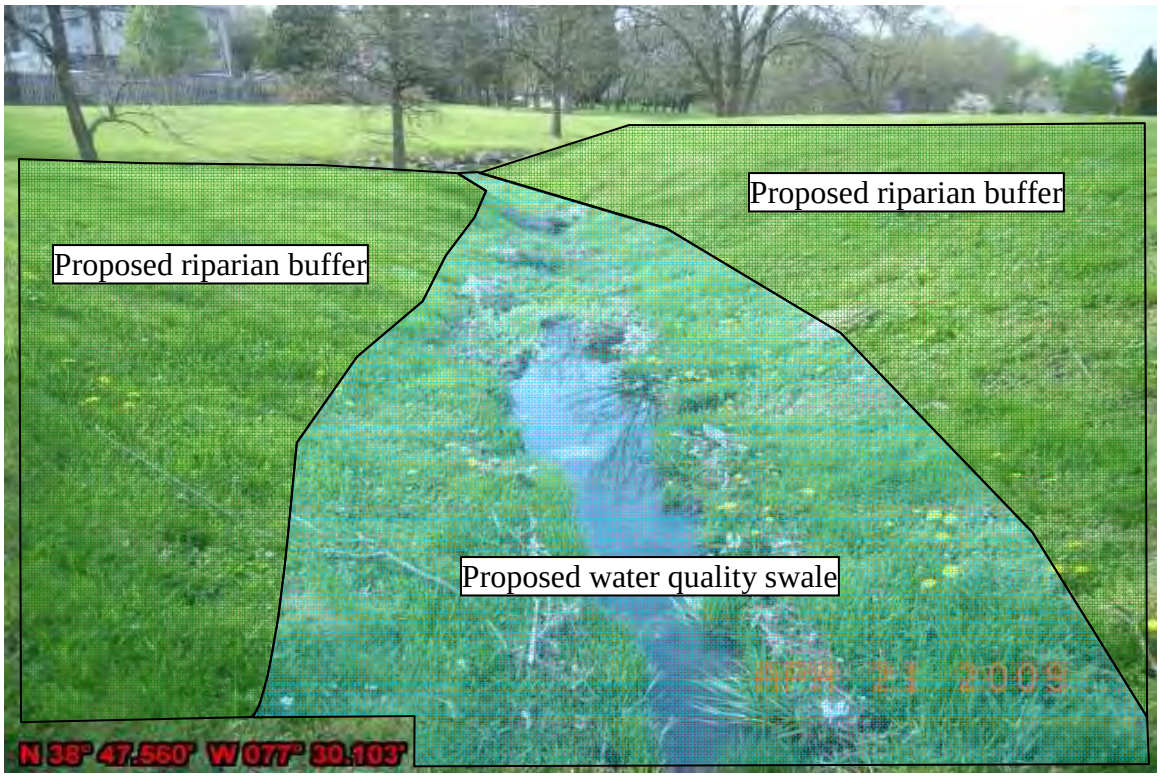


Photo 2: Existing outfall ditch to be converted to water quality swale.

Photo 3: Lower end of channel increases in slope

Project: Linden L7 Riparian Buffer and Wetland Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**L7**
County Facility ID:	**NA**
Type:	**Buffer and Wetland Enhancement**
Length:	**550'**
GPIN/Owner:	**7697-61-1627, 7697-71-5726 / PWC School Board**
Neighborhood/Address:	**2409 Sudley, Sudley Manor/7716 Brandon Way**
GPS Coordinates:	**77º 30' 16.698"W 38º 47' 12.55" N**
Stream Ranking:	**5**

Location: The project is located between Sudley Manor Drive and Lomond Drive. This project is within Prince William County School Board property at Sinclair Elementary School.

Problem Description: The school board mows the recreational/athletic fields, including the riparian buffer, adjacent to the stream channel. Outfall L7-P1 has an unidentified effluent discharge entering into the stream. The stream within this area is in fair condition. The stream flows under a roadway between recreational fields through a plastic culvert (L7-P2). This pipe is crushed and stream flow has jumped out of its original channel and cut a new channel around the pipe. Water quality and aquatic habitat are limited within the reach. Aquatic habitat throughout the reach is degraded, providing limited habitat for benthic community diversity.

Project Description: This project would enhance the 550 linear feet of stream corridor through the school property. A woody buffer which is compatible with the adjacent recreational fields would be designed and planted. Educational signage would be installed. A Riparian Buffer Management plan would be developed to guide school maintenance crews in proper management of the buffer. The crushed culvert pipe should be replaced. A large wetland area is present adjacent to the stream, in what appears to be the foot print of a basin or pond. This wetland should be evaluated for opportunities to improve its water quality and habitat functions. Possible improvements include wetland tree and shrub plantings, excavation of shallow marsh zones or micro-pools, and installation of nesting boxes.

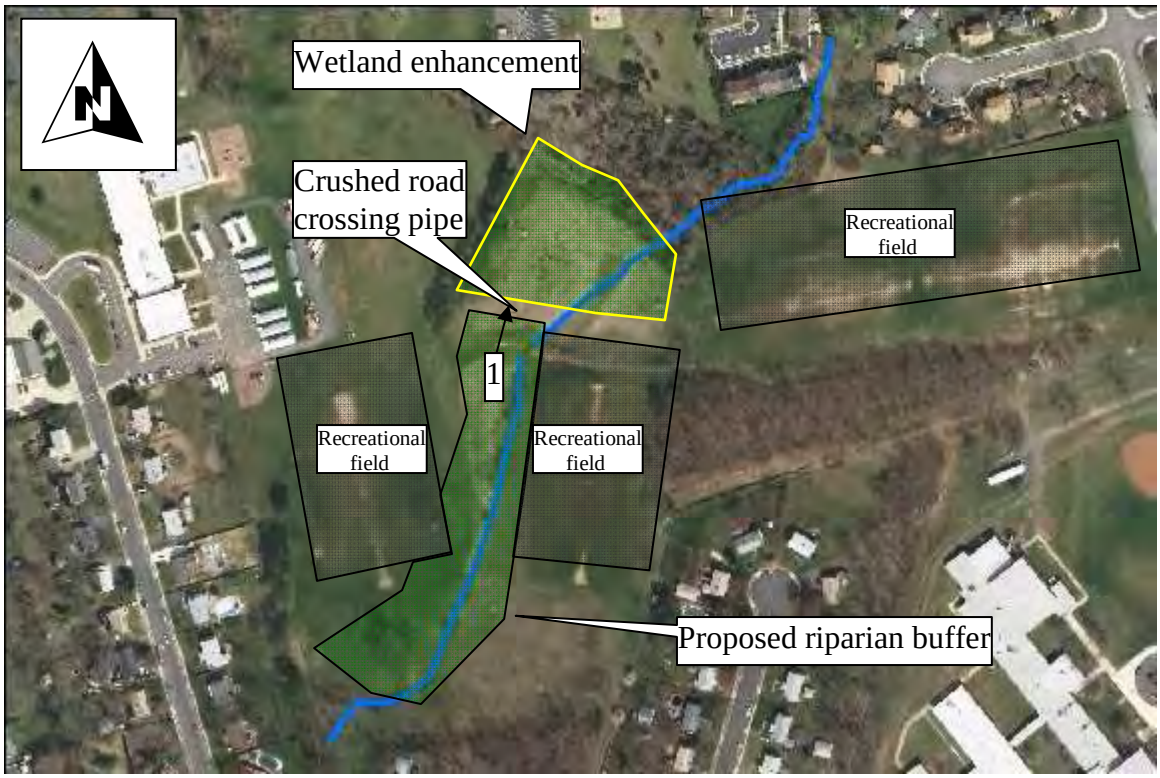
Potential Benefits: The project would help to enhance the riparian stream buffer. Buffers are a natural boundary used for maintaining stream water quality and aquatic habitat. Increasing the buffer width will help reduce water temperature, increase filtering, decrease erosion and sedimentation, and decrease the velocity of surface runoff to the channel. The source of the unidentified effluent discharge would be identified and corrective action taken. Replacement of outfall pipe will reduce erosion and flooding, and will provide access to recreational fields.

Design Considerations: The project could be developed as an outdoor educational facility focused on water quality, streams, and wetlands. Compatibility with elementary school age students and concerns over public safety should be incorporated into the plan. A portion of the riparian buffer plantings should be designed to allow the students to participate. Access for construction would be through the school property.

Cost Estimate: This project was estimated to have a total cost of $55,000, or $47 per linear foot. The primary focus is re-establishment of a riparian buffer which is a relatively low cost enhancement.

Watershed: Linden
Site ID #: L7
ADC Map (25th edition): Map 8, page 13, grid coordinate K3

N
W E
S



Conceptual Plan: Buffer management and road crossing pipe replacement

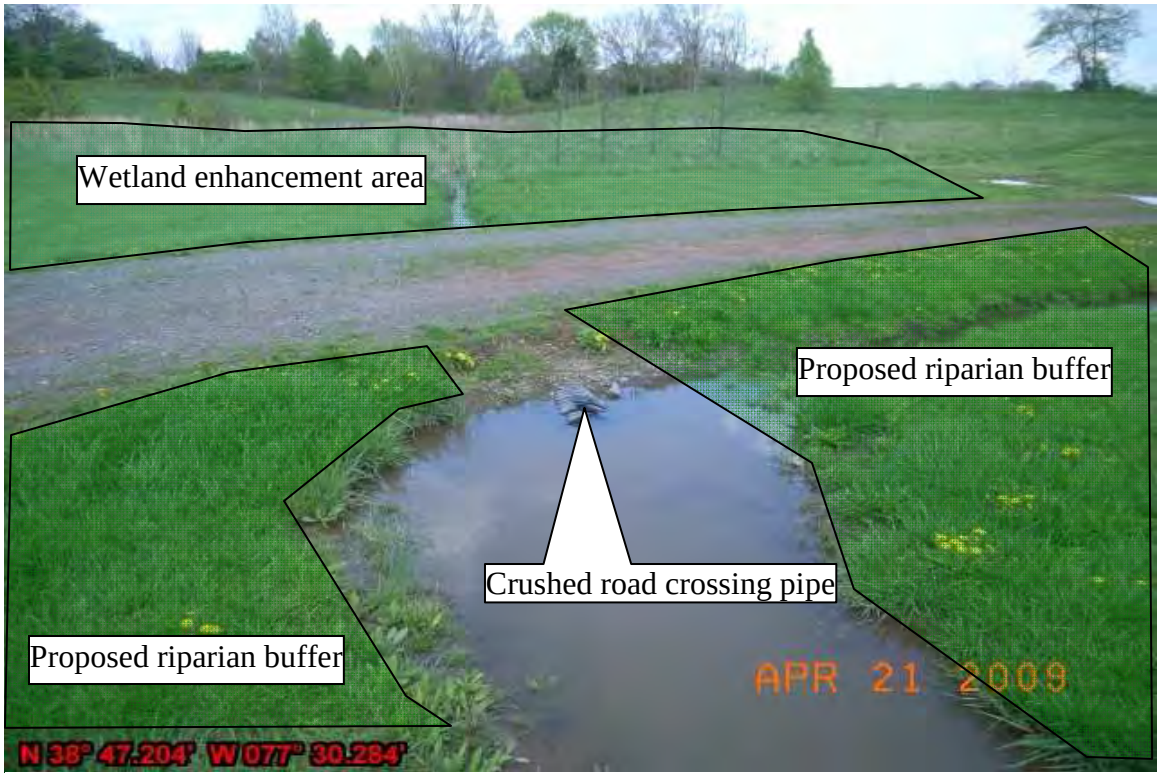


Photo 1: Replacement of crushed pipe

Project: Linden L4 Stream Restoration / Riparian Buffer Enhancement

Watershed:	**Bull Run**
Subwatershed Name:	**Linden**
Subwatershed Code:	**166**
Site ID:	**L4**
County Facility ID:	**NA**
Type:	**Stream Restoration and Riparian Buffer Enhancement**
Length:	**421'**
GPIN/Owner:	**7697-30-2206 /** **Costco Wholesale Corp.**
Neighborhood/Address:	**4013 Sudley/10701 Sudley Manor Drive**
GPS Coordinates:	**77º 30' 53.78" W** **38º47' 11.241" N**
Stream Ranking:	**7**

Location: This project is located in the southwestern quadrant of Sudley Road and Sudley Manor Drive. This reach flows north through commercial property currently owned by Costco Wholesale Corporation.

Problem Description: This stream reach is a concrete trapezoidal channel, scoring poor on the stream condition assessments. Recent construction has installed a box culvert in the middle of the reach. Riprap installed during the new construction is unstable on the upstream side of the box culvert. Commercial property owners mow the riparian buffer zone adjacent to the channel. Outfall L4-P6 does not have an adequate outfall channel to the receiving stream. Channelization removed the natural stream characteristics resulting in poor water quality and aquatic habitat.

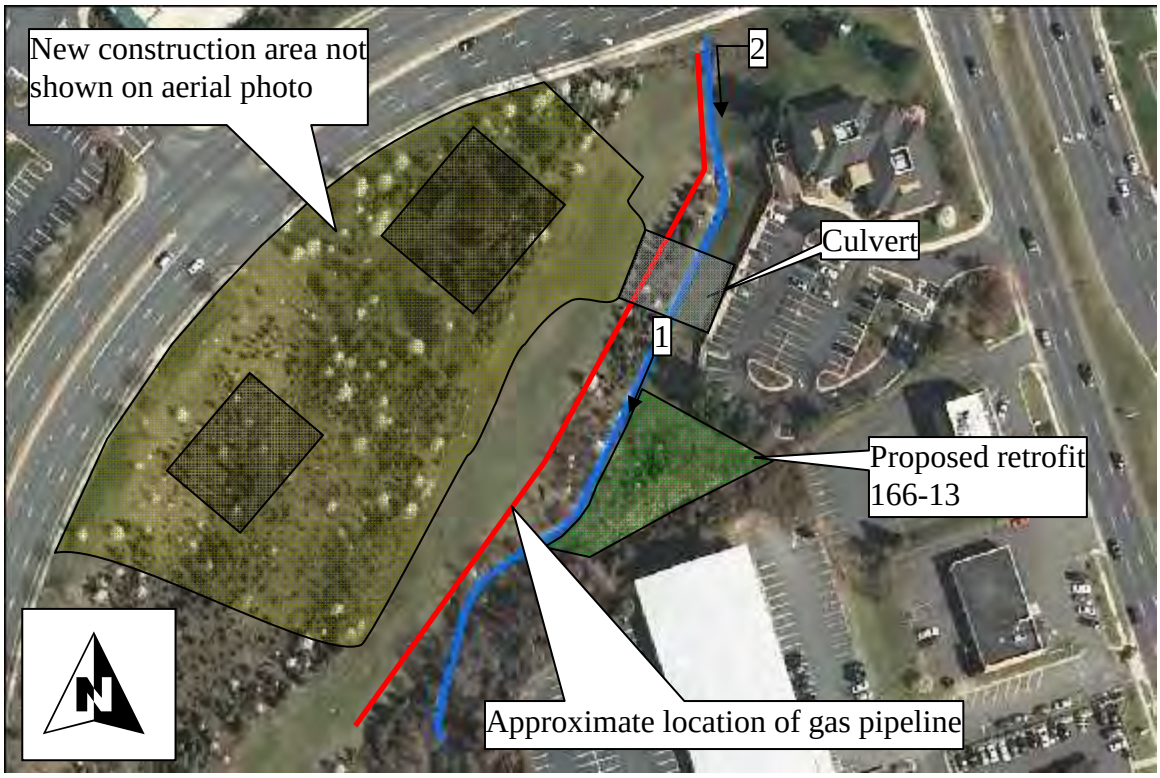
Project Description: This project would include removal of the concrete channel, installation of a riparian buffer, and providing a connection to the proposed L4 Outfall Retrofit. This project also addresses the existing failing riprap stabilization at the culvert. Removal of the concrete channel and constructing a natural riffle pool system will improve the water quality and aquatic habitat.

Potential Benefits: Returning the stream to its natural characteristics will increase the integrity and aquatic habitat for the watershed. The project would help to enhance the riparian stream buffer, reduce velocity, and increase aquatic habitat. Buffers are a natural boundary used for maintaining stream water quality and aquatic habitat. Vegetating the buffer will lower water temperature, increase filtering, decrease erosion and sedimentation, and decrease the velocity of surface run off.

Design Considerations: Channel stabilization is necessary to keep the stream from migrating into the gas pipeline on the left side of the stream. The project could be combined with outfall L4 retrofit. Construction access would be from adjacent commercial properties.

Cost Estimate: The total estimated cost for this project is $130,631, or $327 per linear foot. This cost is well above the average costs for stream-related projects in this study. The higher costs are due to the removal of the existing concrete channel and creation of a new natural channel bed.

Watershed: Linden
Site ID #: L4
ADC Map (25th edition): Map 8, page 13, grid coordinate H3



Existing Condition

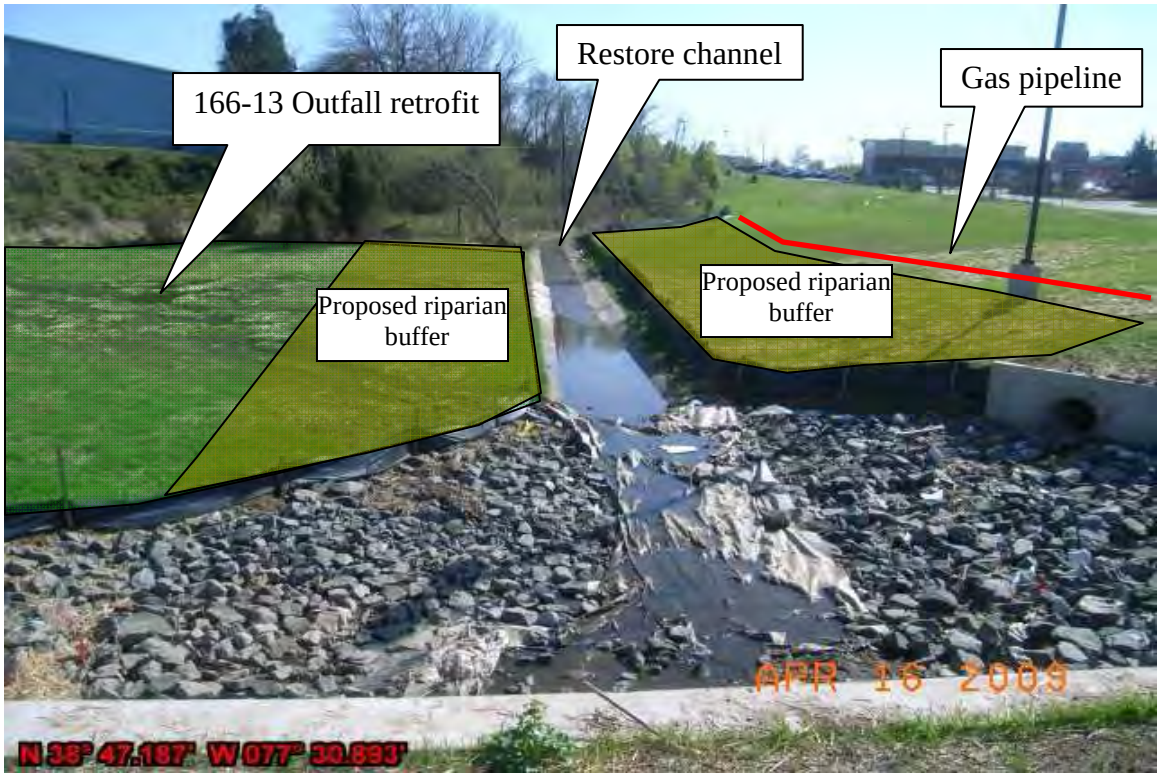


Photo 1: Remove concrete channel and add buffer

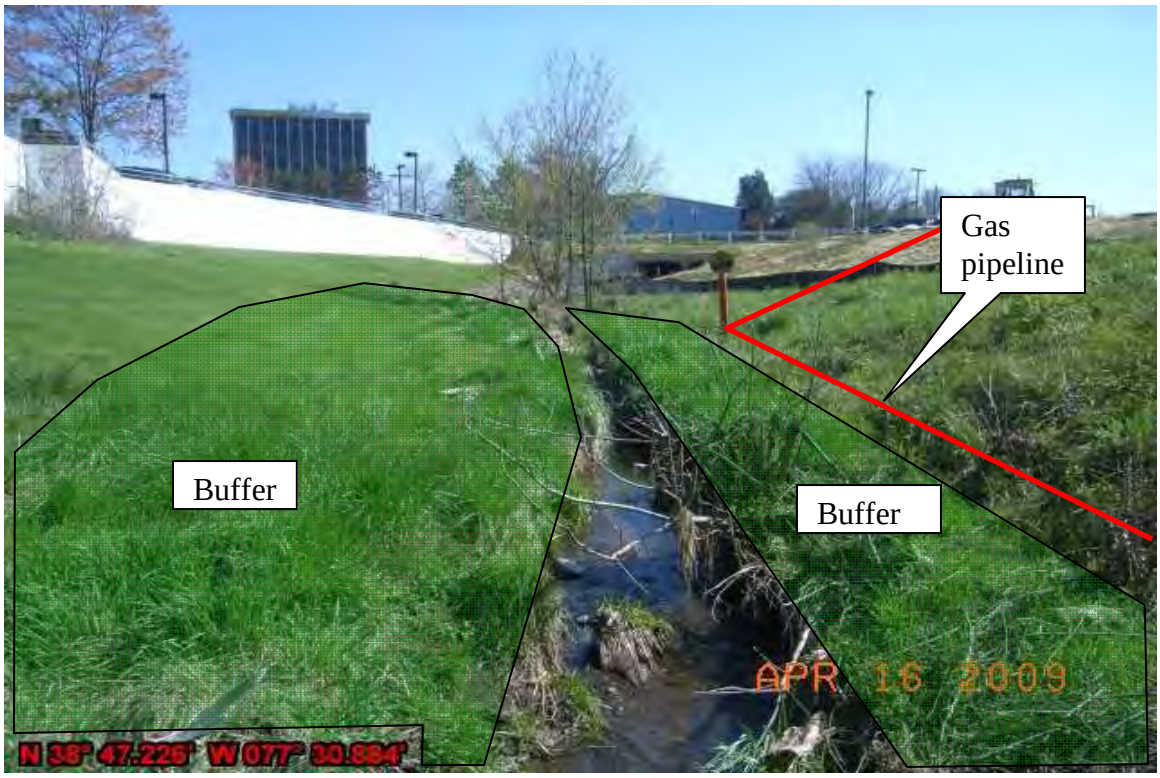


Photo 2: Downstream of recently constructed bridge with proposed buffer.

Appendix D

Drainage Calculations for Stormwater Conceptual Designs

OUTFALL DRAINAGE AREAS

Site ID	Measured Area, ac	Pipe Size, in	*Pipe Capacity, cfs	Drainage area based on pipe capacity, ac	Drainage area used, ac	Drainage area used, sf
166-15	23	21	22	6.07	6.07	264291
166-13	4	30	58	16.00	4.00	174240
166-14	28.6	n/a	n/a	n/a	28.60	1245816
186-1	3	24	32	8.83	3.00	130680
186-2	2.5	n/a	n/a	n/a	2.50	108900
186-2	3.5	30	58	16.00	3.50	152460
194-5		24	32	8.83		
		18	22	6.07		
	8	n/a	n/a	14.89	8.00	348480

* Assumptions: full flow capacity, 2% slope,Tc=10min., I(10)=5.18 in/hr, C=0.7

** Areas combined for total area

*** Drainage is divide into drainage from parkinglot and drainage from road & discharge from pipe

Bioretention Outfall Retrofits

Site ID	Drainage Area, ac	Drainage Area, sf	Percent Impervious	Approximate Impervious Area, sf	*Area required for Bioretention (50% removal), sf	Area Available, sf
166-15	6.07	264291	30	79287	1980	1980
166-13	4.00	174240	75	130680	3270	17000
166-14	28.60	1245816	35	436036	10900	11200
186-5	2.50	108900	80	87120	2180	2700
194-5	8.00	348480	25	87120	2180	2100

* Required area is 2.5% of the Impervious Drainage Area

Enhanced Extended Detention Basin Outfall Retrofits

Site ID	Drainage Area, ac	Percent Impervious	Approximate Impervious Area, ac	Required Water Quality Volume (WQV), cf.	2 x WQV, cf	**Area required for Enhanced Extended Detention Basin (50% removal), sf	Area Available, sf
186-5	3.50	50	1.8	3176	6353	3180	3180
186-1	3.00	80	2.4	4356	8712	4360	5450

** Required Area is based on an assumed depth of 2'

BMP WATER QUALITY RETROFITS

Site ID	Drainage area to BMP, ac	Percent Impervious	Approximate Impervious Area, ac	Area of Basin Footprint, ac	*WQV Required for Drainage Area, ac.ft.	**Assumed Water Quality Volume Provided, ac.ft.	Currently Meets Requirements
166-7	13	65	8.45	0.45	0.35	0.45	Meets
194-2	50	10	5.00	0.26	0.21	0.26	Meets
194-1	112	20	22.40	1.33	0.93	1.33	Meets

* WQV based on 0.5"/ac of impervious acre of drainage
** Based on an assumed 1 time the water quality volume provided for the impervious draniage and the existing water quality volume is equal to 1' deep x the existing footprint of the basin.
*** Based on an average depth of 2 feet excavation to create wetland system

Site ID	***Additional Volume Provided, ac.ft.	Retrofit Treatment Capacity, ac	Meets Current Requirements
166-7	0.45	10.8	Exceeds
194-2	0.26	6.24	Exceeds
194-1	1.33	31.92	Exceeds

Appendix E

Stream Assessment Data Forms

Lower Bull Run Rapid Stream Assessement Technique (RSAT) Score Matrix

Evaluation Category	Field Characteristics	Excellent	Good	Fair	Poor
Channel Stability Vertical stability of channel, particularly incision	General Narrative	Vertically stable channel, no recent signs of incision	Predominately stable channel with few, limited areas of incision or deposition	20-60% of channel with signs of deposition or incision including mid-channel bars, head cuts, and/or exposed pipes	>60% of channel with signs of deposition or incision including mid-channel bars, head cuts, and/or exposed pipes
	Channel Type	U shaped (Class B) stream with cobble / boulder substrate	B Channel or C Channel in gravel, sand and fine sediment	Trapezoidal Channel (Class F)	V-shaped channel, gully formation (Class G)
	Incision / Degradation	Channel vertically stable, grade control provided by bedrock or boulders	Few, small headcuts present, down cutting limited	Several headcuts evident, down cutting prevalent but less than 2 feet	Large headcuts and severe (>2') down cutting evident
	Deposition / Aggradation	Point bars stable, pavement of gravel, pools well developed	Point bars enlarging, no mid-channel or other bars	bars and deltas common, pools full of sediment, some sediment on banks	Deep deposits of unconsolidated sand dominate channel and are common on banks
	Exposed Pipes	None	Top of pipes exposed in streambed	Pipes exposed above streambed undercutting pipes by <12 inches	Streambed >1 foot below bottom of exposed pipes
	Point range	**20 18**	**16 14 12**	**10 8 6**	**4 2 0**
Bank Stability Horizontal stability of stream	General Narrative	Nearly all banks are stable, less than 5% unstable	Most banks are stable with small areas (5-30%) showing signs of slumping or erosion	Many banks (30-60%) are unstable with slumping and erosion common	Most banks (>60%) are unstable, evidence of erosion common
	Bank Slumping	Rare and small	Infrequent or small	Common or large	Abundant and large
	Bank Height above channel	< 2 feet (3 feet for larger streams)	2-3 feet (3-4 feet for larger streams)	3-4 feet above (5-7 feet for larger streams)	>4 feet above (7+ feet for larger streams)
	Bank angle	<45%, point bar and outside bends stable	45-60%, outside bend steep	60-90%, near vertical on both banks	Unstable undercuts common (>90% slope)
	Bank Material	Bedrock, boulder, (non-erodible)	Cobble, gravel, and /or clay; slightly erodible material	Sand and silt, some clay and gravel,erodible layers	Silt and sand, or otherwise highly erodible
	Tree Falls (don't include if not forested)	0-1 per 1,000, usually small and partially healed	2-3 recent, tree falls per 1,000	4-5 recent large tree falls per 1,000	>6 recent, large tree falls per 1,000
	Vegetation	90% covered with dense vegetation or root mass	70-90% covered with vegetation and/or roots	50-70 % covered; most outside bends eroding	<50% covered; bare soil predominant
	Point range	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**
Riparian Habitat Condition of buffer	General Narrative	Wide, forested buffer providing optimal shading of stream	Moderately to wide buffer with woody vegetation, providing stream shading.	Moderate width buffer lacking woody vegetation, which provides some shade	Narrow buffer lacking vegetation, which is heavily distrubed and provides no shade
	Average width of vegetative buffer	>50+ feet	25-50 feet	10-25 feet	<10 feet
	Dominant Buffer Type	Mature Trees	Shrubs / Saplings	Non-woody vegetation	Lawn or no vegetation
	Shading	>60%	30-60%	10-30%	<10
	Point range	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**

Lower Bull Run Rapid Stream Assessement Technique (RSAT) Score Matrix

Evaluation Category	Field Characteristics	Excellent	Good	Fair	Poor
Water Quality Long-term level of pollutants as reflect by benthos and other readily observable signs	General Narrative	Diverse community of pollution intolerant taxa with minimal evidence of pollution	Moderately diverse community with some evidence of pollution	Poor diversity, dominated by pollution tolerant taxa with evidence of pollution common	Severely degraded benthic community with abundant evidence of pollution
	Benthic Community Composition (dominate taxa)	**Pollution sensitive taxa** Dominated by stoneflies, mayflies, cased caddisflies, dobsonfly, water penny, riffle beetle, right handed snails	**Somewhat pollution sensitive** Dragonfly, damselfly, cranefly, alderfly, beetle larvae, hydroscidae caddisfly, scud, clams	**Pollution Tolerant Taxa** Midges, blackfly, left handed snails, leeches, aquatic worms	**Very Pollution Tolerant Taxa** Midges, Leeches and aquatic worms or none
	Diversity of pollution sensitive taxa	4+ taxa	2-3 taxa	1 taxa	None
	Proportion of Pollution Sensitive Individuals	>32% pollution sensitive individuals	16-32 % Pollution sensitive Individuals	<16% pollution sensitive individuals	Few or No pollution sensitive individuals
	Litter / Floatables	No litter in channel, minimal along banks	Some litter along banks and in channel	Litter common along bank and in channel	Active dumping in channel and along banks
	Substrate Fouling	<20% fouling, primarily algae	20-50% of substrate covered primarily with algae	50-75% of substrate; includes sewage fungi, acid drainage	75%+ of substrate covered with algae, or any amount of sewage fungi, oil, pollutants
	Odors (sewage, oil, etc.)	None	Slight odor	Moderate odor	Strong odor
	Point range	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**
Aquatic Habitat Physical structure of pools and riffles within stream	General Narrative	Diverse habitat consisting of deep and shallow pools, with riffles with clean substrate	Most of aquatic habitat only slightly degraded, typically with increased sediment	Aquatic habitat limited to small riffles and pools	Much of the habitat has been eliminated by pass modifications, remaining habitat degraded
	Channel Modification (Riprap, concrete or channelized)	Less than 5% of channel modified	Limited areas (5-20%) of channel modified	20-60% of channel modified	Most (>60%) of the channel has been modified
	Riffle Substrate Type	Cobble, boulder, gravel abundant	Cobble, gravel, and sand predominate	Gravel and sand predominate	Sand and finer predominate
	Riffle Embeddeness	Riffle substrate surrounded by <25% fine sediment	Riffle substrate surrounded by 25-50% fine sediment	Riffle substrate surrounded by 50-75% fine sediment	Riffle substrate surrounded by >75% fine sediment or totally absent
	Pools	>24 inch deep	18-24 inch deep	12-18 inch deep	<12 deep
	Fish Cover	Abundant > 75% pools	25 - 75% of pools	present < 25% of pools	Absent
	Point range	**7 6**	**5 4**	**3 2**	**1 0**

Rapid Stream Assessment Field Form

WRA WO: _____ Date: _____

Staff: _____

Watershed: Bull Run Watershed / Subwatershed Watershed # _____

Site ID: _____

Evaluation Category	Field Characteristics	Excellent		Good			Fair			Poor		
Channel Stability	**Point range**	**20**	**18**	**16**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**
	Channel Shape											
	Down Cutting / Degradation											
	Deposition / Aggradation											
	Exposed Pipes											
Average												
Bank Stability	**Point range**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Bank slumping											
	Bank height above channel											
	Bank angle											
	Bank material											
	Tree falls											
	Vegetation											
Average												
Riparian Habitat	**Point range**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Average width of vegetative buffer											
	Dominant Buffer Type											
	Shading											
Average												
Water Quality	**Point range**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Benthic Community Composition											
	Diversity of pollution sensitive taxa											
	Abundance of Pollution Sensitive Individuals											
	Litter/Floatables											
	Substrate Fouling											
	Odors											
Average												
Aquatic Habitat	**Point range**	**7**	**6**	**5**		**4**	**3**		**2**		**1**	**0**
	Channel modification											
	Riffle substrate type											
	Riffle embeddeness											
	Pools											
	Fish cover											
Average												

Evaluation Category	Field Characteristics	Excellent			Good			Fair			Poor		
Channel Stability	General Narrative	Vertically stable channel, no recent signs of down cutting			Predominately stable channel with few, limited areas of down cutting or deposition			20-60% of channel with signs of deposition or down cutting including mid-channel bars, headcuts, and/or undercut pipes			>60% of channel with signs of deposition or down cutting including mid-channel bars, headcuts, and/or undercut pipes		
Vertical Stability of channel, particularly degradation	Channel Shape	U shaped (Class B) stream			B Channel or C Channel in gravel, sand and fine sediment			Trapezoidal Channel (Class F)			V-shaped channel, gully formation (Class G)		
	Down Cutting / Degradation	Channel vertically stable, grade control provided by bedrock or boulders			Few, small headcuts present, down cutting limited			Several headcuts evident, down cutting prevalent but less than 2 feet			Large headcuts and severe (>2') down cutting evident		
	Deposition / Aggradation	Point bars stable, pavement of gravel, pools well developed			Point bars enlarging, no mid-channel or other bars			bars and deltas common, pools full of sediment, some sediment on banks			Deep deposits of unconsolidated sand dominate channel and are common on banks		
	Exposed Pipes	None			Top of pipes exposed in streambed			Pipes exposed above streambed undercutting pipes by <12 inches			Streambed >1 foot below bottom of exposed pipes		
	Point range		**20**	**18**	**16**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**

Characteristic	**Score**
Channel Shape	
Degradation	
Aggradation	
Exposed Pipes	
Average	

Notes:

Evaluation Category	Field Characteristics	Excellent			Good			Fair			Poor		
Bank Stability	General Narrative	Nearly all banks are stable, less than 5% unstable			Most banks are stable with small areas (5-30%) showing signs of slumping or erosion			Many banks (30-60%) are unstable with slumping and erosion common			Most banks (>60%) are unstable, evidence of erosion common		
	Bank Slumping	Rare and small			Infrequent or small			Common or large			Abundant and large		
Horizontal Stability of stream, particularly in outside bends	Bank Height above channel	< 2 feet (3 feet for larger streams)			2-3 feet (3-4 feet for larger streams)			3-4 feet above (5-7 feet for larger streams)			>4 feet above (7+ feet for larger streams)		
	Bank angle	<45%, point bar and outside bends stable			45-60%, outside bend steep			60-90%, near vertical on both banks			Unstable undercuts common (>90% slope)		
	Bank Material	Bedrock, boulder, (non-erodible)			Cobble, gravel, and /or clay; slightly erodible material			Sand and silt, some clay and gravel,erodible layers			Silt and sand, or otherwise highly erodible		
	Tree Falls (don't include if not forested)	0-1 per 1,000, usually small and partially healed			2-3 recent, tree falls per 1,000			4-5 recent large tree falls per 1,000			>6 recent, large tree falls per 1,000		
	Vegetation	90% covered with dense vegetation or root mass			70-90% covered with vegetation and/or roots			50-70 % covered; most outside bends eroding			<50% covered; bare soil predominant		
	Point range		**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

Characteristic	**Score**
Bank Slumping	
Bank Height	
Bank Angle	
Bank Material	
Tree Falls	
Vegetation	
Average	

Notes:

Evaluation Category	Field Characteristics	Excellent			Good			Fair			Poor		
Riparian Habitat	General Narrative	Wide, forested buffer providing optimal shading of stream			Moderately to wide buffer with woody vegetation, providing stream shading.			Moderate width buffer lacking woody vegetation, which provides some shade			Narrow buffer lacking vegetation, which is heavily distrubed and provides no shade		
Horizontal Stability of stream, particularly in outside bends	Average width of vegetative buffer	>50+ feet			25-50 feet			10-25 feet			<10 feet		
	Dominant Buffer Type	Mature Trees			Shrubs / Saplings			Non-woody vegetation			Lawn or no vegetation		
	Shading	>60%			30-60%			10-30%			<10		
	Point range		**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

Characteristic	**Score**
Width	
Buffer Type	
Shading	
Average	

Notes:

Average Width of Vegetative Buffer - In general, the wider the buffer the better habitat it provides and the more functions it provides to the stream system. Some methods use a 100 foot buffer as excellent, however, in an urban watershed buffers tend to be narrower so the widths for each class were reduced.

Dominant Buffer Type - A forested riparian area is the dominant type under normal conditions. However, in urban watersheds many buffers are dominated by shrubs or grasses which still provide some habitat functions to the stream.

Shading is optimal between 20 and 95%. Headwater stream are more often heavily shaded, while wider streams are less shaded. Shading can be provided by any type of vegetation - trees, shrubs, vines or herbs and grasses.

Density of the vegetation was not included, however it can be used to assign points within a class. A heavily vegetated shrub buffer should score higher than a lightly vegetated shrub buffer

Evaluation Category	Field Characteristics	Excellent			Good			Fair			Poor		
Water Quality	General Narrative	Diverse community of pollution intolerant taxa with minimal evidence of pollution			Moderately diverse community with some evidence of pollution			Poor diversity, dominated by pollution tolerant taxa with evidence of pollution common			Severely degraded benthic community with abundant evidence of pollution		
	Benthic Community Composition (dominate taxa)	**Pollution sensitive taxa** Dominated by stoneflies, mayflies, cased caddisflies, dobsonfly, water penny, riffle beetle, right handed snails			**Somewhat pollution sensitive** Dragonfly, damselfly, cranefly, alderfly, beetle larvae, hydroscidae caddisfly, scud, clams			**Pollution Tolerant Taxa** Midges, blackfly, left handed snails, leeches, aquatic worms			**Very Pollution Tolerant Taxa** Midges, Leeches and aquatic worms or none		
long-term level of pollutants as reflect by benthos and other readily observable signs - litter, fouling, odors	Diversity of pollution sensitive taxa	4+ taxa			2-3 taxa			1 taxa			0		
	Proportion of Pollution Sensitive Individuals	>32% pollution sensitive individuals			16-32 % Pollution sensitive Individuals			<16% pollution sensitive individuals			Few or No pollution sensitive individuals		
	Litter / Floatables	No litter in channel, minimal along banks			Some litter along banks and in channel			Litter common along bank and in channel			Active dumping in channel and along banks		
	Substrate Fouling	<20% fouling, primarily algae			20-50% of substrate covered primarily with algae			50-75% of substrate; includes sewage fungi, acid drainage			75%+ of substrate covered with algae, or any amount of sewage fungi, oil, pollutants		
	Odors (sewage, oil, etc.)	None			Slight odor			Moderate odor			Strong odor		
	Point range		**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

Characteristic	**Score**
Community	
Pollution Sensitive	
Abundance	
Litter	
Fouling	
Odor	
Average	

Notes:

Evaluation Category	Field Characteristics	Excellent		Good		Fair		Poor	
Aquatic Habitat Physical structures of pools and riffles within stream	General Narrative	Diverse habitat consisting of deep and shallow pools, with riffles with clean substrate		Most of aquatic habitat only slightly degraded, typically with increased sediment		Aquatic habitat limited to small riffles and pools		Much of the habitat has been eliminated by pass modifications, remaining habitat degraded	
	Channel Modification (Riprap, concrete or channelized)	Less than 5% of channel modified		Limited areas (5-20%) of channel modified		20-60% of channel modified		Most (>60%) of the channel has been modified	
	Riffle Substrate Type	Cobble, boulder, gravel abundant		Cobble, gravel, and sand predominate		Gravel and sand predominate		Sand and finer predominate	
	Riffle Embeddeness	Riffle substrate surrounded by <25% fine sediment		Riffle substrate surrounded by 25-50% fine sediment		Riffle substrate surrounded by 50-75% fine sediment		Riffle substrate surrounded by >75% fine sediment or totally absent	
	Pools	>24 inch deep		18-24 inch deep		12-18 inch deep		<12 deep	
	Fish Cover	Abundant > 75% pools		25 - 75% of pools		present < 25% of pools		Absent	
	Point range	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

Characteristic **Score**
Modifications
Riffle type
Embeddeness
Pools

Average

Notes:

Channel Modification - The amount of channel modification reflects past impacts on aquatic habitat

Riffle Substrate Type - A typical riffle in this region is gravel with some cobble and some sand. A decrease in larger particles in riffles is a typical sign of degradation due to sedimentation. Larger particles can also become scarcer as natural bed load transport is interrupted.

Riffle Embeddeness - The amount of fine particles fill the space between large particles increases as streams degrade. Embeddeness should be estimated visually over several riffles.

Pools - Stable streams have deep pools with cover (woody material, stable undercut banks), degradation results in filling of pools with fine sediment. Pool depth varies with stream flow. Depths are assumed to be during base flow in a typical summer, when pool depth is most critical. Scoring should be adjusted for extreme weather conditions (storm or drought) or other seasons.

Fish Cover-

Utility Form

WRA WO: _____ Date: _____

Staff: _____

Watershed: Bull Run

Subwatershed _____ Subwatershed # _____

Site ID: _____ (U=Utility)

Site ID = Reach ID Plus Feature ID

Type	Location	Material
Unknown	Left Bank	Conc. Pipe
Sanitary	Right Bank	Metal Pipe
Water	Bed	Clay Pipe
Other	Floodplain	Plastic
		Other

Exposed			Erosion	
Manhole	Pipe Dia.	_____	None	Joints Exposed
Along Bank	Length Exp.	_____	Minor	Pipe Aerial
Across Bed	Elev. above bed	_____	Moderate	Scour Pool DS
			Major	

Discharge	Color	Odor	Visual
None	None	None	None
Trickle	Clear	Sewage	Oils
Moderate	Cloudy	Oily	Floatables
Substantial	Brown	Musky	Litter
	Black/Grey	Fishy	Suds
	Green	Rotten Eggs	Sediment
	Yellow	Chlorine	Iron Flocculent

Retrofit / Repair Recommendations	Severity	
None	No discharge or erosion	0
Utility Repair	Minor Erosion/Slightly exposed	3
Discharge Investigation	Partially Exposed/Mod. Erosion	7
Bank Stabilization	Major Erosion/Obstruction/Pot. Failure	10
Bed Stabilization	Discharge Obvious	20
Fish Passage		

COMMENTS

Trash Dumping Form

WRA WO: _____ Date: _____
Staff: _____
Watershed: Bull Run
Subwatershed _____ Subwatershed # _____
Site ID: _____ (T=Trash)
Site ID = Reach ID Plus Feature ID

Type	Location	Material		Volume
Unknown	Left Bank	Plastic/Paper/Glass	Appliances	Less than Pickup
Residential	Right Bank	Lawn Debris	Oil / Asphalt	Pickup
Commencial	Channel	Food/Garbage	Construction	Dump Truck
Industrial	Floodplain	Furniture	Automotive	Many Loads

Removal Recommendations	Severity / Volume	
None	Small, inactive, outside of channel	1
Volunteers		
Contractor/County	Moderate, maybe active, not hazmat	5
Hazmat		
	Large, Active, Hazardous Materials	10

COMMENTS

WRA WO: _____ Date: _____
Staff: _____
Watershed: Bull Run
Subwatershed _____ Subwatershed # _____
Site ID: _____ (T=Trash)
Site ID = Reach ID Plus Feature ID

Type	Location	Material		Volume
Unknown	Left Bank	Plastic/Paper/Glass	Appliances	Less than Pickup
Residential	Right Bank	Lawn Debris	Oil / Asphalt	Pickup
Commencial	Channel	Food/Garbage	Construction	Dump Truck
Industrial	Floodplain	Furniture	Automotive	Many Loads

Removal Recommendations	Severity / Volume	
None	Small, inactive, outside of channel	1
Volunteers		
Contractor/County	Moderate, maybe active, not hazmat	5
Hazmat		
	Large, Active, Hazardous Materials	10

COMMENTS

Obstruction / Fish Barrier/Headcut Form

WRA WO: _____ Date: _____
Staff: _____
Watershed: Bull Run
Subwatershed _____ Subwatershed # _____
Site ID: _____ (B=barrier)
Site ID = Reach ID Plus Feature ID

Type	Headcut Height	Fish Barrier		Barrier Height
Fish Barrier	<0.5'	Dam	Too High	<0.5'
Flow Obstruction	1 '	Culvert	Too Shallow	1 '
Trees	2 '	Pipe	Too Fast	2 '
Debris	>2 '	Utility		>2 '
Headcut				

Restoration Recommendations	Severity	
None	Minor - <25% of channel blocked	3
Remove Flow Obstruction	<1' height	
Provide Fish Passage	Moderate - 50% channel blocked	5
Stabilize Headcut	1-2 foot height	
	Sever - >50% Channel blocked	10
	>2 foot height	

COMMENTS (Beaver dams, Tree falls are not fish blockages)

WRA WO: _____ Date: _____
Staff: _____
Watershed: Bull Run
Subwatershed _____ Subwatershed # _____
Site ID: _____ (B=barrier)
Site ID = Reach ID Plus Feature ID

Type	Headcut Height	Fish Barrier		Barrier Height
Fish Barrier	<0.5'	Dam	Too High	<0.5'
Flow Obstruction	1 '	Culvert	Too Shallow	1 '
Trees	2 '	Pipe	Too Fast	2 '
Debris	>2 '	Utility		>2 '
Headcut				

Restoration Recommendations	Severity	
None	Minor - <25% of channel blocked	3
Remove Flow Obstruction	<1' height	
Provide Fish Passage	Moderate - 50% channel blocked	5
Stabilize Headcut	1-2 foot height	
	Sever - >50% Channel blocked	10
	>2 foot height	

COMMENTS (Beaver dams, Tree falls are not fish blockages)

Outfall Form

WRA WO: _____ Date: _____

Staff: _____

Watershed: Bull Run

Subwatershed _____ SubWatershed # _____

Site ID: _____ (P=Pipe, D=Ditch)

Site ID = Reach ID Plus Feature ID

Type of Outfall	Location	Dist. From Channel
Unknown	Left Bank	_____ Ft
Stormwater	Right Bank	
Poss. Illicit	Head	
Stream Crossing	Floodplain	

Material	Shape	Number	Size		Erosion
Earthen Ditch	Trapezoid	Single	Pipe Dia. _____	Inches	None
Conc. Ditch	Circular	Double	Ditch Width _____	Feet	Minor
Conc. Pipe	Elliptical	Triple			Moderate
Metal Pipe					Major
Cor. Metal Pipe					
Plastic					
Other					

Dry Weather Flow	Color	Odor	Visual	Source
None	None	None	None	Unknown
Trickle	Clear	Sewage	Oils	Groundwater
Moderate	Cloudy	Oily	Floatables	Streamflow
Substantial	Brown	Musky	Litter	Sewage/illicit
	Black/Grey	Fishy	Suds	
	Green	Rotten Eggs	Sediment	
	Yellow	Chlorine	Iron Flocculent	

Retrofit / Repair Recommendations	Severity	
None	No discharge or erosion	0
Discharge Investigation	Minor Erosion / Minor Discharge	2
Stabilization	Moderate Erosion / Discharge	5
Repair to Pipe or Headwall	Major Erosion / Substaintial Discharge	7
Retrofit Stormwater Management	Immediate Repair / Investigation	10
Daylighting		

COMMENTS

Appendix F

Cost Estimates

COST ESTIMATION
Bull Run Watershed Study
Potential BMP Improvements and Retrofits

Watershed	Site ID	Study Ranking	Drainage Area, ac	Percent Impervious	Approximate Impervious Area, sf	Size of Site	Type of BMP
Buckhall (194)	194-1	4	112	20%	22.4	5800 sf	Retrofit
	194-2	7	50	10%	5.0		Repair
	194-3	8	289	20%	57.8	8 acres	Repair
Yorkshire (186 & 100)	186-1	3	3	80%	2.4	5450 sf	Retrofit
Linden (166)	166-1	1	4	85%	3.4	4325 sf	New /ReBuilt
	166-2	2	72	85%	61.2	na	Study
	166-7	4	13	65%	8.5	20412 sf	Retrofit
	166-8	9	49	80%	39.2	1.7 acres	Repair
			592		**199.9**		

CONSTRUCTION COSTS BASED CENTER FOR WATERSHED PROTECTION RESEARCH

Cost based on area of impervious surface treated

Type of BMP	Low Cost	Median Cost	High Cost
Pond Retrofit	$3,600	$11,100	$37,100
New Const. wetlands	$2,000	$2,900	$9,600
New Extended Detetion	$2,200	$3,800	$7,500

Watershed	Site ID	Low Cost	Median Cost	High Costs	Type of BMP
Buckhall (194)	194-1	$80,640	$248,640	$831,040	Pond Retrofit
	194-2	$11,000	$19,000	$37,500	New ExDet.
	194-3	na	na	na	Repair
Yorkshire (186 & 100)	186-1	$8,640	$26,640	$89,040	Pond Retrofit
Linden (166)	166-1	$6,800	$9,860	$32,640	New Wet.
	166-2	na	na	na	Study
	166-7	$30,420	$93,795	$313,495	Pond Retrofit
	166-8	na	na	na	Repair
	Totals	**$137,500**	**$397,935**	**$1,303,715**	

COSTS BASED ON UNIT COSTS FOR EACH FACILITY
(includes site specific costs)

Watershed	Site ID	Costs Const.	Design 30%	Contingency 20%	Total	WQ Retrofit $/Imp Acre
Buckhall (194)	194-1	$117,265	$35,180	$30,489	$182,933	$8,167
	194-2	$21,450	$6,435	$5,577	$33,462	
	194-3	$44,839	$13,452	$11,658	$69,949	
Yorkshire (186 & 100)	186-1	$27,770	$8,331	$7,220	$43,320	$18,050
Linden (166)	166-1	$57,369	$17,211	$14,916	$89,495	
	166-2	NA	$100,000		$100,000	
	166-7	$44,232	$13,270	$11,500	$69,001	$8,166
	166-8	$16,830	$5,049	$4,376	$26,255	
	Total	**$329,754**	**$198,926**	**$85,736**	**$614,417**	

Bull Run Watershed Study
Outfall Retrofits

Sizing Calculations for Each Outfall Retrofit

Watershed	ID Number	Site ID	Study Ranking	Drainage Area, ac	DA based on Pipe Size	DA used for Design	Percent Impervious	Approximate Impervious Area, ac	Size of Site
Buckhall (194)	B1	194-5	5	8.00	14.89	8.00	25%	2.00	1,800
Yorkshire	Y "H"	186-5	2	2.50		2.50	80%	2.00	2,100
(186 & 100)	Y "H"	186-5	2	3.50	16.00	3.50	50%	1.75	3,180
Linden	L4	166-13	1	4.00	16.00	4.00	75%	3.00	3,250
(166)	L2	166-14	3	28.60		28.60	35%	5.00	5,000
	L5	166-15	4	23.00	6.07	6.07	30%	1.82	2,000
				69.6		**52.7**		**15.6**	**17,330**

IP for 166-14 Reduced by 50%

Construction Costs based on Center for Watershed Protection Research
Cost per acre of Impervious Surface Treated

Type of BMP	Low Cost	Median Cost	High Cost
Bioretention	$19,900	$25,400	$41,750
Wetland	$2,000	$2,900	$9,600

Watershed	Site ID	Study Ranking	Type of BMP	Low Cost	Median Cost	High Costs
Buckhall (194)	194-5	5	Bioretention	$39,800	$50,800	$83,500
Yorkshire	186-5	2	Bioretention	$39,800	$50,800	$83,500
(186 & 100)	186-5	2	Wetland	$3,500	$5,075	$16,800
Linden	166-13	1	Bioretention	$59,700	$76,200	$125,250
(166)	166-14	3	Bioretention	$99,500	$127,000	$208,750
	166-15	4	Bioretention	$36,238	$46,253	$76,027
				$278,538	**$356,128**	**$593,827**

$22,871.26 Per IP Acre
Construction Costs Only

Costs based on Project Specific Construction Costs

Watershed	Site ID	Costs Const.	Design 30%	Contingency 20%	Total	Cost per Imp.Ac
Buckhall (194)	194-5	$35,400	$10,620	$9,204	$55,224	$27,612
Yorkshire	186-5	$40,910	$12,273	$10,637	$63,820	$31,910
(186 & 100)	186-5	$23,588	$7,077	$6,133	$36,798	$21,027
Linden	166-13	$56,608	$16,982	$14,718	$88,309	$35,324
(166)	166-14	$114,260	$34,278	$29,708	$178,246	$97,884
	166-15	$39,348	$11,804	$10,231	$61,383	$20,461
	Total	**$310,115**	**$93,035**	**$80,630**	**$483,780**	

includes stream stabilization

Average Cost
$19,916 Per IP Acre
Total Costs

Average Cost
$31,069 Per IP Acre
Total Costs

Costs based on Generalized Construction Costs per Unit Area of Construction
(excludes site specific costs)

Watershed	Site ID	Costs Const.	Design 30%	Contingency 20%	Total
Buckhall (194)	194-5	$35,400	$10,620	$9,204	$55,224
Yorkshire	186-5	$40,910	$12,273	$10,637	$63,820
(186 & 100)	186-5	$18,087	$5,426	$4,703	$28,215
Linden	166-13	$46,657	$13,997	$12,131	$72,785
(166)	166-14	$71,780	$21,534	$18,663	$111,976
	166-15	$28,712	$8,614	$7,465	$44,791
	Total	**$241,546**	**$72,464**	**$62,802**	**$376,811**

Average Cost
$15,513 Per IP Acre
Construction Costs

Average Cost
$24,200 Per IP Acre
Total Costs

Cost Estimate
Bull Run Watershed Study
Potential Stream Channel and Buffer Restoration and Enhancements

Watershed	Site ID	Study Ranking	Length (ft)	Area (sf)	
Linden (166)	L4	7	400	20,000	
	L7	5	550	27,500	
	L8	4	1,137	56,850	
Yorkshire (184 & 100)	Y3	10	161	8,050	
	Y7	6	200	10,000	
			2,448	**2.8**	**Acre**

COSTS BASED ON UNIT COSTS FOR EACH FACILITY
(includes site specific costs)

Watershed	Site ID	Costs Const.	Design 30%	Contingency 20%	Total	Cost Per Linear Foot
Linden (166)	L4	$83,738	$25,121	$21,772	$130,631	$327
	L7	$26,840	$8,052	$6,978	$41,870	$76
	L8	$54,104	$16,231	$14,067	$84,401	$74
Yorkshire (184 & 100)	Y3	$13,563	$4,069	$3,526	$21,158	$131
	Y7	$13,090	$3,927	$3,403	$20,420	$102
	Total	**$191,334**	**$57,400**	**$49,747**	**$298,481**	**$122**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **194-1**

Site Name **Buckhall 194-1 Retrofit and B6 Stream Stabilization**

ITEM	**AMOUNT**	
FOOT PRINT sf	56000	sf
DEPTH OF EX. FT	1	ft
Volume	56000	cf
10% Pool	5600	sf
40% Low Marsh	22400	sf
50% high Marsh	28000	sf

			Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY		$35.00	2074	$72,592.59
Excavate Wet Sediment	CY		$100.00	0	$0.00
Top Soil 4 inchs, SY	SY		$5.00	0	$0.00
Tree/shrubs	EA		$35.00	280	$9,800.00
Emergent Plants	EA		$8.00	2489	$19,912.00
Minor Outlet Modification	EA		$1,000.00	0	$0.00
Major Outlet Mod, ea	EA		$5,000.00	0	$0.00
Replace Riser	LS		$25,000.00	0	$0.00
Stabilize Inlet	EA		$500.00	0	$0.00
Tree/Shrub Removal	LS		$500.00	0	$0.00
Stabilize Slope with Matting	SY		$4.00	0	$0.00
Repair Fencing	LF		$25.00	0	$0.00
Repair Spillway	LS		$500.00	0	$0.00
Stabilize Headcuts	EA		$2,000.00	2	$4,000.00
Mowing	LS		$500.00	0	$0.00
Minor LF Orific Clean Out	LS		$200.00	0	$0.00
Litter/ Debris Removal	LS		$300.00	1	$300.00
TOTAL:					**$106,604.59**
Mobilization					**$10,660.46**
Total Construction Costs					$117,265.05
Engineering and Survey		30%			$35,180
Contingency		20%			$30,489
TOTAL COSTS					**$182,933.48**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **194-2**

Site Name **Buckhall 194-2 BMP Improvements and Stream Stabilization**

ITEM	**AMOUNT**	
FOOT PRINT sf	0	sf
DEPTH OF EX. FT	1	ft
Volume	0	cf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	0	$0.00
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	0	$0.00
Emergent Plants	EA	$8.00	0	$0.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	1	$5,000.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	0	$0.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	1	$500.00
Stabilize Headcuts	EA	$2,000.00	2	$4,000.00
Stabilize Outfall Channel	LF	$100.00	100	$10,000.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$19,500.00**
Mobilization				**$1,950.00**

Total Construction Costs		$21,450.00
Engineering and Survey	30%	$6,435
Contingency	20%	$5,577
TOTAL COSTS		**$33,462.00**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **194-3**

Site Name **Buckhall 194-3 BMP Improvements**

ITEM	**AMOUNT**	
FOOT PRINT sf	10000	sf
DEPTH OF EX. FT	1	ft
Volume	10000	cf
10% Pool	1000	sf
40% Low Marsh	4000	sf
50% high Marsh	5000	sf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	370	$12,962.96
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	0	$0.00
Emergent Plants	EA	$8.00	0	$0.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	0	$0.00
Replace Riser	LS	$25,000.00	1	$25,000.00
Stabilize Inlet	EA	$500.00	1	$500.00
Tree/Shrub Removal	LS	$500.00	2	$1,000.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	1	$500.00
Mowing	LS	$500.00	1	$500.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	1	$300.00
TOTAL:				**$40,762.96**
Mobilization				**$4,076.30**

Total Construction Costs		$44,839.26
Engineering and Survey	30%	$13,452
Contingency	20%	$11,658
TOTAL COSTS		**$69,949.24**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **186-1**

Site Name **Yorkshire 186-1 BMP Water Quality Retrofit**

ITEM	**AMOUNT**	
FOOT PRINT sf	5400	sf
DEPTH OF EX. FT	1	ft
Volume	5400	cf
10% Pool	540	sf
40% Low Marsh	2160	sf
50% high Marsh	2700	sf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	200	$7,000.00
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	27	$945.00
Emergent Plants	EA	$8.00	0	$0.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	1	$5,000.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	2	$1,000.00
Tree/Shrub Removal	LS	$500.00	2	$1,000.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	400	$10,000.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
			0	$0.00
		$0.00	0	$0.00
		$0.00	0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	1	$300.00
TOTAL:				**$25,245.00**
Mobilization				**$2,524.50**

Total Construction Costs		$27,769.50
Engineering and Survey	30%	$8,331
Contingency	20%	$7,220
TOTAL COSTS		**$43,320.42**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-1**

Site Name **Linden 166-1 BMP Safety Improvements**

ITEM	**AMOUNT**	
FOOT PRINT sf	4352	sf
DEPTH OF EX. FT	1	ft
Volume	4352	cf
10% Pool	435	sf
40% Low Marsh	1741	sf
50% high Marsh	2176	sf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	161	$5,641.48
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	22	$762.00
Emergent Plants	EA	$8.00	0	$0.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	0	$0.00
Replace Riser	LS	$25,000.00	1	$25,000.00
Stabilize Inlet	EA	$500.00	2	$1,000.00
Tree/Shrub Removal	LS	$500.00	1	$500.00
Stabilize Slope with Matting	SY	$4.00	1800	$7,200.00
Repair Fencing	LF	$25.00	50	$1,250.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
Grade Stable Access	LS	$10,000.00	1	$10,000.00
		$0.00	0	$0.00
		$0.00	0	$0.00
Mowing	LS	$500.00	1	$500.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	1	$300.00
TOTAL:				**$52,153.48**
Mobilization				**$5,215.35**

Total Construction Costs		$57,368.83
Engineering and Survey	30%	$17,211
Contingency	20%	$14,916
TOTAL COSTS		**$89,495.37**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-7**

Site Name **Linden 166-7 BMP Water Quality Retrofit**

ITEM	**AMOUNT**	
FOOT PRINT sf	19000	sf
DEPTH OF EX. FT	1	ft
Volume	19000	cf
10% Pool	1900	sf
40% Low Marsh	7600	sf
50% high Marsh	9500	sf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	704	$24,629.63
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	95	$3,325.00
Emergent Plants	EA	$8.00	844	$6,756.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	1	$5,000.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	1	$500.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
			0	$0.00
		$0.00	0	$0.00
		$0.00	0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$40,210.63**
Mobilization				**$4,021.06**

Total Construction Costs		$44,231.69
Engineering and Survey	30%	$13,270
Contingency	20%	$11,500
TOTAL COSTS		**$69,001.44**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-8**

Site Name **Linden 166-8 BMP Water Quality Investigation and Retrofit**

ITEM	**AMOUNT**	
FOOT PRINT sf	0	sf
DEPTH OF EX. FT	0	ft
Volume	0	cf

		Quantity	**Unit Cost**	**Cost**
Excavation Dry Sediment	CY	$35.00	0	$0.00
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Tree/shrubs	EA	$35.00	0	$0.00
Emergent Plants	EA	$8.00	0	$0.00
Minor Outlet Modification	EA	$1,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	1	$5,000.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	0	$0.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
			0	$0.00
Aerator	EA	$5,000.00	2	$10,000.00
			0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	1	$300.00
TOTAL:				**$15,300.00**
Mobilization				**$1,530.00**

Total Construction Costs		$16,830.00
Engineering and Survey	30%	$5,049
Contingency	20%	$4,376
TOTAL COSTS		**$26,254.80**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **194-5**

Site Name **Buckhall 194-5 Outfall Retrofit**

ITEM	**UNIT**	
LENGTH, ft	60	
WIDTH, ft	30	1800 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	
	4.25	
Excavation, cf	7650	
Soil, cf	4500	
Mulch, cf	450	
Pea Gravel, cf	600	
#57 Stone, cf	1200	

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	283	$35.00	$9,917.00
Soil	CY	167	$60.00	$10,000.00
Mulch	CY	17	$35.00	$584.00
Pea Gravel	CY	22	$100.00	$2,223.00
#57 Stone	CY	44	$40.00	$1,778.00
Tree/shrubs		18	$35.00	$630.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	1	$2,000.00	$2,000.00
Outlet Channel	LF	150	$25.00	$3,750.00
Flow Splitter	EA	1	$1,000.00	$1,000.00
Under Drain	LF	300	$1.00	$300.00
TOTAL:				$32,182.00
Mobilization				$3,218.20
Total Construction Costs				$35,400.20
Engineering and Survey		30%		$10,620
Contingency		20%		$9,204
TOTAL COSTS				**$55,224.31**
Drainage Area		8 Ac		
Impervious Surface		2 Ac		
Cost per Acre/Imp Surface				**$27,612.16**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **186-5**

Site Name **Yorkshire 186-5 Outfall Retrofit**

Bioretention Area Assumptions

ITEM	**UNIT**	
LENGTH, ft	50	
WIDTH, ft	42	2100 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	331	$35.00	$11,570.00
Soil	CY	194	$60.00	$11,667.00
Mulch	CY	19	$35.00	$681.00
Pea Gravel	CY	26	$100.00	$2,593.00
#57 Stone	CY	52	$40.00	$2,075.00
Tree/shrubs		21	$35.00	$735.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	1	$2,000.00	$2,000.00
Outlet Channel	LF	50	$25.00	$1,250.00
Under Drain	FT	370	$1.00	$370.00
Buffer Plantings	1000SF	5	$600.00	$3,000.00
Conc. Removal	SY	0	$10.00	$0.00
Head Cut Stabilization	EA	0	$2,000.00	$0.00
Clearing	AC	0.1	$7,500.00	$750.00
Outlet Stabiilzation	EA	1	$500.00	$500.00
TOTAL:				$37,191.00
Mobilization				$3,719.10

Total Construction Costs		$40,910.10
Engineering and Survey	30%	$12,273
Contingency	20%	$10,637
TOTAL COSTS		**$63,819.76**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **186-5**

Site Name **Yorkshire 186-5 Outfall Retrofit**

ITEM	**AMOUNT**	
FOOT PRINT sf	3180	sf
DEPTH OF EX. FT	3	ft
Volume	9540	cf
10% Pool	318	sf
40% Low Marsh	1272	sf
50% high Marsh	1590	sf

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	353	$35.00	$12,367.00
Top Soil 4 inchs	SY	353	$5.00	$1,767.00
Tree/shrubs		15.9	$35.00	$557.00
Emergent Plants		141	$8.00	$1,128.00
Outlet	EA	1	$5,000.00	$5,000.00
Outlet Channel	LF	25	$25.00	$625.00
TOTAL:				$21,444.00
Mobilization				$2,144.40
Total Construction Costs				$23,588.40
Engineering and Survey		30%		$7,077
Contingency		20%		$6,133
TOTAL COSTS				**$36,797.90**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-13**

Site Name **Linden 166-13 Outfall Retrofit**

ITEM	**UNIT**	
LENGTH, ft	65	
WIDTH, ft	50	3250 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	512	$35.00	$17,906.00
Soil	CY	301	$60.00	$18,056.00
Mulch	CY	30	$35.00	$1,054.00
Pea Gravel	CY	40	$100.00	$4,013.00
#57 Stone	CY	80	$40.00	$3,210.00
Tree/shrubs		32.5	$35.00	$1,138.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	1	$2,000.00	$2,000.00
Outlet Channel	LF	100	$25.00	$2,500.00
Flow Splitter	EA	1	$1,000.00	$1,000.00
Under Drain	FT	585	$1.00	$585.00
TOTAL:				$51,462.00
Mobilization				$5,146.20

Total Construction Costs		$56,608.20
Engineering and Survey	30%	$16,982
Contingency	20%	$14,718
TOTAL COSTS		**$88,308.79**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-14**

Site Name **Linden 166-14 Outfall Retrofit**

Bioretention Area Assumptions

ITEM	**UNIT**	
LENGTH, ft	125	
WIDTH, ft	40	5000 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	787	$35.00	$27,547.00
Soil	CY	463	$60.00	$27,778.00
Mulch	CY	46	$35.00	$1,621.00
Pea Gravel	CY	62	$100.00	$6,173.00
#57 Stone	CY	123	$40.00	$4,939.00
Tree/shrubs		50	$35.00	$1,750.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	1	$2,000.00	$2,000.00
Outlet Channel	LF	40	$25.00	$1,000.00
Under Drain	FT	875	$1.00	$875.00
Flow Splitter	EA	0	$1,000.00	$0.00
Buffer Plantings	1000SF	10	$600.00	$6,000.00
Conc. Removal	SY	144	$10.00	$1,440.00
Restore Channel		350	$50.00	$17,500.00
Head Cut Stabilization	EA	2	$2,000.00	$4,000.00
Clearing	AC	0.1	$7,500.00	$750.00
Outlet Stabiilzation	EA	1	$500.00	$500.00
TOTAL:				$103,873.00
Mobilization				$10,387.30

Total Construction Costs		$114,260.30
Engineering and Survey	30%	$34,278
Contingency	20%	$29,708
TOTAL COSTS		**$178,246.07**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **166-15**

Site Name **Linden 166-15 Outfall Retrofit**

ITEM	**UNIT**	
LENGTH, ft	80	
WIDTH, ft	25	2000 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	

		Quantity	**Unit Cost**	**Cost**
Excavation	CY	315	$35.00	$11,019.00
Soil	CY	185	$60.00	$11,112.00
Mulch	CY	19	$35.00	$649.00
Pea Gravel	CY	25	$100.00	$2,470.00
#57 Stone	CY	49	$40.00	$1,976.00
Tree/shrubs		20	$35.00	$700.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	1	$2,000.00	$2,000.00
Outlet Channel	LF	81	$25.00	$2,025.00
Flow Splitter	EA	1	$1,000.00	$1,000.00
Under Drain	FT	320	$1.00	$320.00
Fencing		100	$25.00	$2,500.00
TOTAL:				$35,771.00
Mobilization				$3,577.10
Total Construction Costs				$39,348.10
Engineering and Survey		30%		$11,804
Contingency		20%		$10,231
TOTAL COSTS				**$61,383.04**
Drainage Area		6 Ac		
Impervious Surface		1.82 Ac		
Cost per Acre/Imp Surface				**$33,726.94**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **Y3**

Site Name **Utility Stabilization and Buffer Enhancement**

	AMOUNT	
Length	161	
Width	50	
FOOT PRINT sf	8050	sf

		Quantity	Unit Cost	Cost
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Minor Outlet Modification	EA	$5,000.00	0	$0.00
Replace Riser	EA	$1,000.00	0	$0.00
Replace Riser	LS	$25,000.00	0	$0.00
Riparian Buffer	1000sf	$600.00	8	$4,830.00
Emergent Plants	EA	$8.00	0	$0.00
Stabilize Inlet	EA	$500.00	1	$500.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	1	$2,000.00
Stabilize Outfall Channel	LF	$100.00	50	$5,000.00
			0	$0.00
			0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$12,330.00**
Mobilization				**$1,233.00**

Total Construction Costs		$13,563.00
Engineering and Survey	30%	$4,069
Contingency	20%	$3,526
TOTAL COSTS		**$21,158.28**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **Y7**

Site Name **Stream Stabilization and Buffer Enhancement**

	AMOUNT	
Length	200	
Width	50	
FOOT PRINT sf	10000	sf

		Quantity	**Unit Cost**	**Cost**
Excavate Wet Sediment	CY	$100.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Riparian Buffer	1000sf	$600.00	10	$6,000.00
Stabilize Inlet	EA	$500.00	2	$1,000.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	2	$4,000.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
			0	$0.00
			0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	3	$900.00
TOTAL:				**$11,900.00**
Mobilization				**$1,190.00**

Total Construction Costs		$13,090.00
Engineering and Survey	30%	$3,927
Contingency	20%	$3,403
TOTAL COSTS		**$20,420.40**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **L4**

Site Name **Channel and Buffer Restoration**

	AMOUNT	
Length	400	
Width	50	
FOOT PRINT sf	20000	sf

		Quantity	**Unit Cost**	**Cost**
Excavate Wet Sediment	CY	$100.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Replace Riser	LS	$25,000.00	0	$0.00
Riparian Buffer	1000sf	$600.00	20	$12,000.00
Emergent Plants	EA	$8.00	0	$0.00
Stabilize Inlet	EA	$500.00	0	$0.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
Remove Concrete	LF	$25.00	285	$7,125.00
Restore Channel	LF	$200.00	285	$57,000.00
			0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$76,125.00**
Mobilization				**$7,612.50**

Total Construction Costs		$83,737.50
Engineering and Survey	30%	$25,121
Contingency	20%	$21,772
TOTAL COSTS		**$130,630.50**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **L7**

Site Name **Stream Buffer and Wetland Enhancement**

	AMOUNT	
Length	550	
Width	50	
FOOT PRINT sf	27500	sf

		Quantity	**Unit Cost**	**Cost**
Excavate Wet Sediment	CY	$100.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	0	$0.00
Top Soil 4 inchs, SY	SY	$5.00	0	$0.00
Riparian Buffer	1000sf	$600.00	28	$16,500.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	0	$0.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
Replace Pipe	LF	$20.00	20	$400.00
Wetland Enhancement	AC	$5,000.00	1.5	$7,500.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$24,400.00**
Mobilization				**$2,440.00**

Total Construction Costs		$26,840.00
Engineering and Survey	30%	$8,052
Contingency	20%	$6,978
TOTAL COSTS		**$41,870.40**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

Site Number **L8**

Site Name **Stream Buffer and Water Quality Swales**

	AMOUNT	
Length	1137	lf
Width	50	lf
FOOT PRINT sf	56850	sf

		Quantity	Unit Cost	Cost
Riparian Buffer	1000sf	$100.00	57	$5,685.00
Emergent Plants	EA	$8.00	0	$0.00
Excavation Dry Sediment	CY	$35.00	0	$0.00
Excavate Wet Sediment	CY	$100.00	0	$0.00
Minor Outlet Modification	EA	$5,000.00	0	$0.00
Major Outlet Mod, ea	EA	$5,000.00	0	$0.00
Replace Riser	LS	$25,000.00	0	$0.00
Stabilize Inlet	EA	$500.00	0	$0.00
Tree/Shrub Removal	LS	$500.00	0	$0.00
Stabilize Slope with Matting	SY	$4.00	0	$0.00
Repair Fencing	LF	$25.00	0	$0.00
Repair Spillway	LS	$500.00	0	$0.00
Stabilize Headcuts	EA	$2,000.00	0	$0.00
Stabilize Outfall Channel	LF	$100.00	0	$0.00
Water Quality Swale	Lf	$100.00	435	$43,500.00
		$0.00	0	$0.00
Mowing	LS	$500.00	0	$0.00
Minor LF Orific Clean Out	LS	$200.00	0	$0.00
Litter/ Debris Removal	LS	$300.00	0	$0.00
TOTAL:				**$49,185.00**
Mobilization				**$4,918.50**

Total Construction Costs		$54,103.50
Engineering and Survey	30%	$16,231
Contingency	20%	$14,067
TOTAL COSTS		**$84,401.46**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

STANDARD COSTS
For Riparian Buffer

ITEM	AMOUNT	
FOOT PRINT sf	43560	sf
DEPTH OF EX. FT	3	ft
Volume	130680	cf
10% Pool	4356	sf
40% Low Marsh	17424	sf
50% high Marsh	21780	sf

		Quantity	Unit Cost	Cost
B&B trees	20FT OC	54.45	$150.00	$8,168.00
Shrubs	10FT OC	302.5	$35.00	$10,588.00
Signage		LS	$100.00	$100.00
Mulch	CY	39.66111	$35.00	$1,388.14
TOTAL:				$20,244.14
Mobilization				$2,024.41

Total Construction Costs $22,268.55 PER ACRE

$517.87 **PER 1000 SF**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

STANDARD COSTS
For Bioretention

ITEM	UNIT	
LENGTH, ft	435	
WIDTH, ft	100	43500 sf
DEPTH PONDING, in	6	
DEPTH MULCH, in	3	
DEPTH SOIL, in	30	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	8	

		Quantity	Unit Cost	Cost	
Excavation	CY	6847	$35.00	$239,653.00	
Soil	CY	4028	$60.00	$241,667.00	
Mulch	CY	403	$35.00	$14,098.00	
Pea Gravel	CY	537	$35.00	$18,797.00	
#57 Stone	CY	1074	$20.00	$21,482.00	
Tree/shrubs		435	$35.00	$15,225.00	
Curb cut	LS	0	$300.00	$0.00	
Outlet	EA	1	$2,000.00	$2,000.00	
Outlet Channel	LF	0	$25.00	$0.00	
Under Drain	FT	8265	$1.00	$8,265.00	
TOTAL:				$561,187.00	PER ACRE
Mobilization				$56,118.70	

Total Construction Costs		$617,305.70	PER ACRE
Engineering and Survey	30%	$185,192	
Contingency	20%	$160,499	
TOTAL COSTS		**$962,996.89**	

$14,355.95 PER 1000 SF

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

STANDARD COSTS
For Constructed Wetland

ITEM	AMOUNT	
FOOT PRINT sf	43560	sf
DEPTH OF EX. FT	3	ft
Volume	130680	cf
10% Pool	4356	sf
40% Low Marsh	17424	sf
50% high Marsh	21780	sf

		Quantity	Unit Cost	Cost
Excavation	CY	4840	$35.00	$169,400.00
Top Soil 4 inchs	SY	4840	$5.00	$24,200.00
Tree/shrubs		217.8	$35.00	$7,623.00
Emergent Plants		1936	$8.00	$15,488.00
Outlet	EA	1	$5,000.00	$5,000.00
Outlet Channel	LF	25	$25.00	$625.00
TOTAL:				$222,336.00
Mobilization				$22,233.60

Total Construction Costs		$244,569.60	PER ACRE
Engineering and Survey	30%	$73,371	
Contingency	20%	$63,588	
TOTAL COSTS		**$381,528.58**	PER ACRE

$5,687.67 **PER 1000 SF**

Bull Run Watershed Study

Prince William County, Virginia

CONCEPTUAL NARRATIVE COST ESTIMATE

STANDARD COSTS
For Water Quality Swale

	UNIT	
LENGTH, ft	435	
WIDTH, ft	10	4350
DEPTH PONDING, in	6	
DEPTH MULCH, in	0	
DEPTH SOIL, in	24	
DEPTH PEA GRAVEL, in	4	
DEPTH #57 STONE, in	6	

		Quantity	Unit Cost	Cost
Excavation	CY	537	$35.00	$18,797.00
Soil	CY	322	$60.00	$19,334.00
Mulch	CY	0	$35.00	$0.00
Pea Gravel	CY	54	$35.00	$1,880.00
#57 Stone	CY	81	$20.00	$1,612.00
Tree/shrubs		0	$35.00	$0.00
Curb cut	LS	0	$300.00	$0.00
Outlet	EA	0	$2,000.00	$0.00
Outlet Channel	LF	0	$25.00	$0.00
Under Drain	FT	435	$1.00	$435.00
TOTAL:				$42,058.00
Mobilization				$4,205.80

Total Construction Costs		$46,263.80	
Engineering and Survey	30%	$13,879	
Contingency	20%	$12,029	
TOTAL COSTS		**$72,171.53**	
		$106.35	**per LF**

WHITMAN, REQUARDT & ASSOCIATES, LLP

Engineers • Architects • Planners

Baltimore Office
801 South Caroline Street
Baltimore, Maryland 21231
Office: (410) 235-3450

Richmond Office
9030 Stony Point Parkway, Suite 220
Richmond, Virginia 23235
Office: (804) 272-8700
Fax: (804) 272-8897

Blacksburg Office
1700 Kraft Drive, Suite 1200
Blacksburg, Virginia 24060
Office: (540) 951-3727
Fax: (540) 951-3741

Fairfax Office
3701 Pender Drive, Suite 210
Fairfax, Virginia 22030
Office: (703) 293-9717
Fax: (703) 273-6773

Newport News Office
11870 Merchants Walk, Suite 100
Newport News, Virginia 23606
Office: (757) 599-5101
Fax: (757) 599-5320

Pittsburgh Office
300 Seven Fields Boulevard, Suite 130
Seven Fields, Pennsylvania 16046
Office: (724) 779-7940
Fax: (724) 779-7943

York Office
224 St. Charles Way, Suite 140
York, Pennsylvania 17402
Office: (717) 741-5057
Fax: (717) 741-5124

Wilmington Office
Three Mill Road, Suite 309
Wilmington, Delaware 19803
Office: (302) 571-9001
Fax: (302) 571-9011

WHITMAN, REQUARDT & ASSOCIATES, LLP

Engineers • Architects • Planners

Baltimore Office
801 South Caroline Street
Baltimore, Maryland 21231
Office: (410) 235-3450

Richmond Office
9030 Stony Point Parkway, Suite 220
Richmond, Virginia 23235
Office: (804) 272-8700
Fax: (804) 272-8897

Blacksburg Office
1700 Kraft Drive, Suite 1200
Blacksburg, Virginia 24060
Office: (540) 951-3727
Fax: (540) 951-3741

Fairfax Office
3701 Pender Drive, Suite 210
Fairfax, Virginia 22030
Office: (703) 293-9717
Fax: (703) 273-6773

Newport News Office
11870 Merchants Walk, Suite 100
Newport News, Virginia 23606
Office: (757) 599-5101
Fax: (757) 599-5320

Pittsburgh Office
300 Seven Fields Boulevard, Suite 130
Seven Fields, Pennsylvania 16046
Office: (724) 779-7940
Fax: (724) 779-7943

York Office
224 St. Charles Way, Suite 140
York, Pennsylvania 17402
Office: (717) 741-5057
Fax: (717) 741-5124

Wilmington Office
Three Mill Road, Suite 309
Wilmington, Delaware 19803
Office: (302) 571-9001
Fax: (302) 571-9011