County-wide Stream Inventory Data Analysis

Executive Summary August 2011

Introduction

Arlington County completed a County-wide assessment of streams to determine condition and restoration potential for the purpose of developing a prioritized list of stream restoration projects as part of the County's Stormwater Master Plan update.

In addition to reducing streambank erosion and downstream sedimentation and improving habitat, stream restoration can also incorporate protection of storm and sanitary sewer infrastructure in a more sustainable way than localized hardening/protection methods. Therefore, the County-wide stream inventory looked closely at both physical stream conditions and infrastructure conditions with the goal of developing restoration priorities for specific stream systems and surrounding infrastructure.

Secondary objectives of the study included characterization of in-stream habitat and riparian buffer condition for purposes of further prioritizing stream and buffer restoration need/potential.

The stream inventory is also a complementary element to the County's Natural Resources Management Plan, which includes several recommendations for the protection and management of stream corridors.

Key elements of the inventory included:

- 124,256 LF (23.5 miles) assessed by County consultant, Vanasse, Hangen, Brustlin (VHB) Inc.
- Individual stream reaches established using U.S. Army Corps of Engineers Unified Stream Methodology Stream Assessment Reach (SAR) approach. A SAR represents a stream segment that exhibits consistent physical characteristics throughout its length. When physical characteristics, such as entrenchment, width/depth ratio, and/or slope are observed to change significantly along the steam corridor, a new SAR is established for analysis and evaluation.
- Channel Evolution Model (CEM) applied to determine evolutionary state of physical stream conditions, accounting for partial and full stabilization with concrete, rip-rap, etc. (see CEM description below)
- Stormwater outfall and sanitary sewer/water infrastructure conditions evaluated using the Center for Watershed Protection's Unified Stream Assessment methodology
- Other data collected include Rosgen stream classification, flow regime (e.g., perennial, ephemeral, etc.), riparian buffer and in-stream habitat, and Cowardin wetland classification.
- Prior assessment: Donaldson Run Tributary B watershed; Little Pimmit Run watershed; but need to incorporate infrastructure conditions

- Streams not assessed:
  - Washington Golf and Country Club (private property with no current relationship with property owner, unlike ANCC)
  - Arlington Cemetery and Fort Myer (federal property with no County responsibility/control)
  - Donaldson Run Tributary A (previously restored)
  - Four Mile Run below Shirlington Road (Flood control project under study/restoration design by US Army Corps of Engineers as well as City/County consultant)

Methods

General data collection

VHB determined the start and end points of each SAR by the application of the CEM and USM methods. VHB field surveyed these locations using an Xplore iX104C3PLUS Series tablet computer coupled to a Trimble Pathfinder® ProXT™ receiver and Hurricane Antenna. Expected accuracy is 1.0 ± 0.3 meter when satellite signal strength is suitable.

VHB also assessed and documented (e.g., photos, measurements of pipe exposure, etc.) the condition of storm and sewer/water infrastructure and stream blockages in stream valleys. Storm sewer outfalls and exposed sanitary sewer lines and related infrastructure were also field-located with the GPS-enabled tablet computer when significant deviations from the GIS basemap were observed and the satellite signal strength was suitable. VHB also field located stream blockages.

When GPS data collection was not possible due to a lack of satellite coverage or dense canopy cover / artificial overhang, VHB digitized the locations of features of interest by hand directly into the GIS database. VHB also used a tape measure instead of GPS and/or direct digitizing when it was determined to provide the best balance of efficiency and accuracy. Major deviations from the GIS stream centerline were noted in the field and hand digitized as appropriate.

Within each SAR, VHB selected one (1) representative cross-section for analysis (where bankfull indicators were present and discernable). Using a hand level, pocket rod, surveyor's tape, and chaining pins, VHB measured the maximum bankfull depth and relative height of the top of the lowest bank, and calculated bank-height ratio to determine the degree of channel incision. A preliminary Rosgen classification for the SAR was also determined using best professional judgment and field observations. VHB then determined the stage of the Channel Evolution Model for each SAR. In addition, VHB: entered the data within the electronic field forms identified above using the GPS-enabled tablet computer; recorded the location of the cross section using GPS/direct digitizing/tape measure, as appropriate; and photographed the location of the representative cross section with the tape stretched from bankfull stage left to bankfull stage right looking downstream from above the cross section location and from the floodplain on river left across the tape.

VHB also applied Form 1 of the USM to assess channel condition, riparian buffer, in-stream habitat, and degree of channel alteration. Scoring for riparian buffer was simplified to obtain a single score for each side of the stream channel by averaging riparian conditions within 100 feet of the stream over the entire length of the SAR.

VHB evaluated the physical condition of stormwater outfalls, exposed utilities, and stream blockages, collecting data using forms OT, UT, and SC of the Center for Watershed Protection's (CWP) Unified Stream Assessment (USA) methodology (Version 2.0, February 2005). Data collected included the structure GIS identification number, the major attributes of damaged/vulnerable storm and sanitary sewer and related infrastructure including pipe/culvert dimensions and material, type and degree of damage sustained (e.g., undercut/scour hole, undermined apron, failing embankment, collapsed pipe segment, exposed sanitary line encased/unencased, exposed sanitary manholes, etc.), and photo numbers. Condition scores range from 1 (best) to 5 (worst).

VHB also evaluated physical restoration access, based on the categories and scoring explained in the USA user's manual: good / fair / difficult.

All CWP USA data were collected using the tablet computer.

Little Pimmit Run

VHB collected similar data for Little Pimmit Run during a comprehensive study of this watershed in 2008/2009, including both CEM and USM data. OT, UT, and SC data were not collected directly but severe conditions were noted and are generally reflected in the 'Results' section. See also the comprehensive information on the County website at
http://www.arlingtonva.us/departments/EnvironmentalServices/cpe/page60407.aspx

And, specifically, the Little Pimmit Run Watershed and Stream Corridor Report at:
http://www.arlingtonva.us/departments/EnvironmentalServices/cpe/page60407.aspx

Donaldson Run Tributary B

For the Donaldson Run Tributary B stream restoration project, VHB collected data for this tributary in 2009, with a focus on CEM and overall geomorphology data. OT, UT, and SC data were not collected directly but severe conditions were noted, especially within the project reach from North Upton Street to the confluence with Tributary A, and are generally reflected in the 'Results' section.
For more information, please see:
http://www.arlingtonva.us/departments/EnvironmentalServices/epo/page75482.aspx

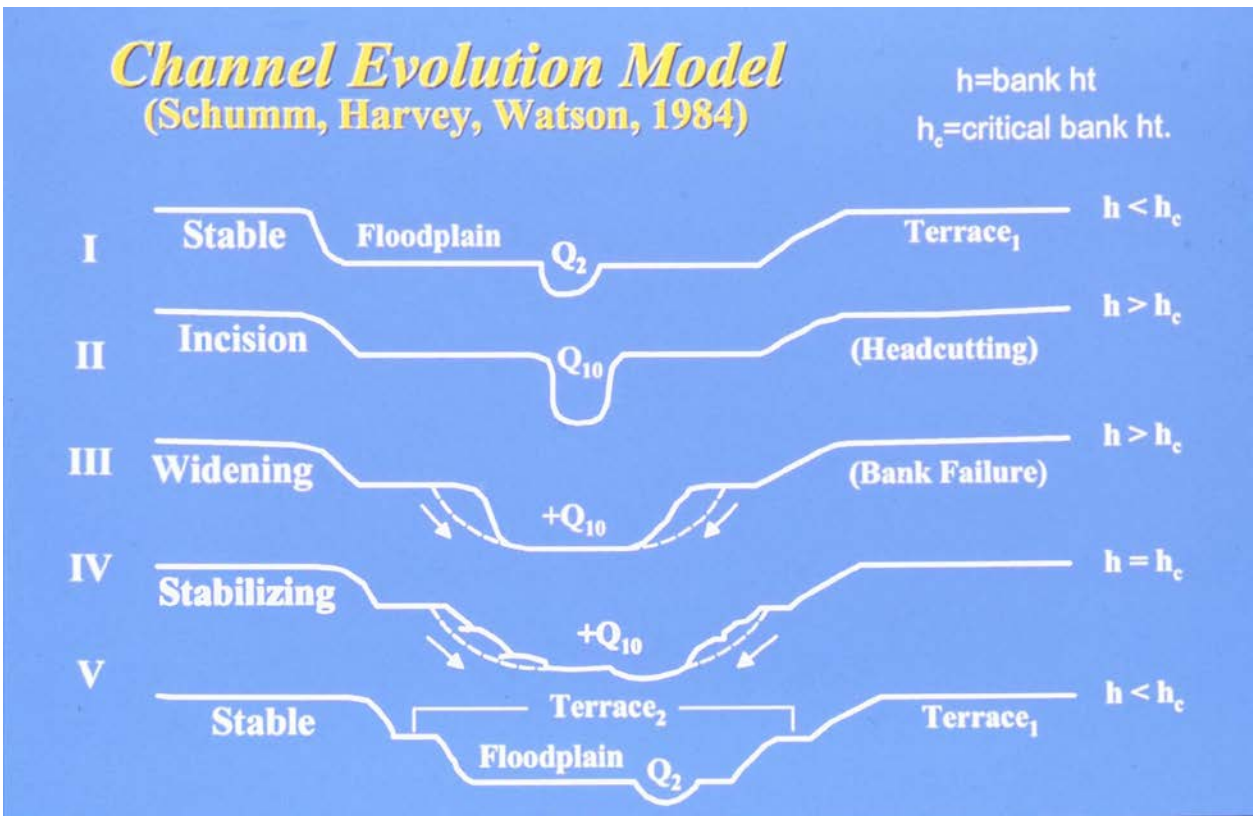
VHB did not collect USM data for the 4,143 linear feet of channel assessed.

Donaldson Run Tributary A

VHB did not assess the approximately 3,000 linear feet of stream channel along this tributary – where comprehensive stream restoration work occurred from 2005 to 2007. The CEM conditions along this reach are in the Stage I/V category (see next section), reflecting the floodplain reconnection and overall channel stability associated with the natural channel design-based restoration work.

Channel Evolution Model

For the County-wide stream inventory, the Channel Evolution Model (CEM) is the primary tool used to assess the physical condition of streams and prioritize restoration need. The CEM uses several field indicators to describe morphological conditions and the degree of departure from equilibrium. Such indicators include active and abandoned floodplain features, headcutting/downcutting, vertical and concave streambanks, bank slumping, meander-bend migration, and streambed aggradation. Each of these indicators helps to define existing conditions and predict future morphological adjustments. The general CEM model diagram is shown in Figure and the complete field worksheet is included in Appendix A.



The CEM is comprised of five geomorphic stages that can be identified through application of the field indicators described above. Stage I represents the stable/equilibrium condition where energy contained in stream flow is balanced by resistance of sediment flow and other channel features. This balance in energy distribution is achieved through appropriate integration of the physical characteristics associated with channel plan-form, cross-sectional shape, and streambed profile. Stage I systems typically possess a relatively small main channel capable of handling the full range of flows up to and including channel forming and maintaining (bankfull) discharge. This channel is well connected to an active floodplain that serves to spread and dissipate energy in flows exceeding bankfull. Stage I systems are usually relatively easy to identify because they demonstrate consistency and predictability in channel form while exhibiting minimal signs of erosion and sedimentation.

A disruption in the balance between stream flow and sediment flow typically initiates Stage II, or Incision. Excess energy contained in more frequent high velocity flows is transferred to the streambed resulting in headcutting and/or downcutting. As the stream cuts a course deeper in the valley floor, streambanks become higher and steeper ultimately reaching a critical bank height or threshold of stability. When the critical bank height is exceeded streambanks begin to fail through slumping and mass wasting processes. Slumped material is washed away during significant discharge events as the system transitions from Stage II to Stage III, Widening.

Streambank slumping and channel widening continue until the stream achieves a cross-sectional area large enough to distribute energy more uniformly and allow for colonization of vegetation on slumped and depositional materials. During the late phases of Stage III, channel cross-sectional area begins to stabilize as the stream migrates laterally to adjust plan form and slope. Lateral migration and the development of floodplain features within the incised channel marks the beginning of Stage IV, Stabilizing.

During Stage IV, the base flow, bankfull and floodplain channels develop as the stream begins carving a predictable pattern and streambed morphology. Streambank slumping and erosional processes are minimal in Stage IV except along the outside of meander bends. As accelerated meander bend migration subsides and floodplain features become fully developed, the stream achieves a new state of equilibrium recognized as Stage V in the CEM.

The Stage V stream has developed a predictable and self-maintaining pattern, dimension and profile capable of handling the full range of flows produced by its watershed. It is typically a reflection of Stage I but on a larger scale and at a lower elevation in the valley.

Degraded stream systems typically exhibit an overlap of the evolutionary stages of adjustment, and, at times several stages may occur concurrently in the system. For example, it is not unusual for Stage II (Downcutting) and Stage III (Widening) to occur at the same time in a given stream reach, especially in an urbanizing watershed experiencing radical changes in hydrologic and sediment regimes.   Stages II and III are of most concern because both represent active stages of erosion, with downstream sedimentation, habitat degradation, and infrastructure damage of significant concern.

Infrastructure assessment

The second key set of tools used in the inventory applied the Center for Watershed Protection's Unified Stream Assessment (USA) methodology (Version 2.0, February 2005) to evaluate the condition of stormwater outfalls and sanitary sewer infrastructure (and, where applicable, water infrastructure).

The two forms below present the data collected for these two main infrastructure types. For stormwater outfalls (OT), the field evaluation focused primarily on the physical condition of the outfall, with an emphasis on erosion and pipe conditions. Illicit discharge conditions were rare, but where identified, corrected.

Storm Water Outfalls **OT**

WATERSHED/SUBSHED:		**DATE:** ___/_____/___	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:**____:____AM/PM	**PHOTO ID:** (*Camera-Pic #*) /#	
SITE ID (*Condition-#*): **OT-**_____	**LAT** ___° _____' _____" **LONG** ___° _____' _____" **LMK**_____		**GPS:** (*Unit ID*)

BANK: ☐ LT ☐ RT ☐ Head **FLOW:** ☐ None ☐ Trickle ☐ Moderate ☐ Substantial ☐ Other:	**TYPE:** ☐ Closed pipe	**MATERIAL:** ☐ Concrete ☐ Metal ☐ PVC/Plastic ☐ Brick ☐ Other:	**SHAPE:** ☐ Single ☐ Circular ☐ Double ☐ Elliptical ☐ Triple ☐ Other:	**DIMENSIONS:** Diameter:_____(in)	**SUBMERGED:** ☐ No ☐ Partially ☐ Fully
	☐ Open channel	☐ Concrete ☐ Earthen ☐ Other:	☐ Trapezoid ☐ Parabolic ☐ Other:	Depth: _____(in) Width (Top):_____(in) " (Bottom):_____(in)	*NOT APPLICABLE*

CONDITION: ☐ None ☐ Chip/Cracked ☐ Peeling Paint ☐ Corrosion ☐ Other:	**ODOR:** ☐ No ☐ Gas ☐ Sewage ☐ Rancid/Sour ☐ Sulfide ☐ Other:	**DEPOSITS/STAINS:** ☐ None ☐ Oily ☐ Flow Line ☐ Paint ☐ Other:	**VEGGIE DENSITY:** ☐ None ☐ Normal ☐ Inhibited ☐ Excessive ☐ Other:	**PIPE BENTHIC GROWTH:** ☐ None ☐ Brown ☐ Orange ☐ Green ☐ Other: **POOL QUALITY:** ☐ No pool ☐ Good ☐ Odors ☐ Colors ☐ Oils ☐ Suds ☐ Algae ☐ Floatables ☐ Other:

FOR FLOWING ONLY	**COLOR:**	☐ Clear ☐ Brown ☐ Grey ☐ Yellow ☐ Green ☐ Orange ☐ Red ☐ Other:
	TURBIDITY:	☐ None ☐ Slight Cloudiness ☐ Cloudy ☐ Opaque
	FLOATABLES:	☐ None ☐ Sewage (toilet paper, etc.) ☐ Petroleum (oil sheen) ☐ Other:
OTHER CONCERNS:		☐ Excess Trash (paper/plastic bags) ☐ Dumping (bulk) ☐ Excessive Sedimentation ☐ Needs Regular Maintenance ☐ Bank Erosion ☐ Other:

POTENTIAL RESTORATION CANDIDATE ☐ Discharge investigation ☐ Stream daylighting ☐ Local stream repair/outfall stabilization
☐ no ☐ Storm water retrofit ☐ Other:

If yes for daylighting:
Length of vegetative cover from outfall: ___________ft Type of existing vegetation:______________________ Slope: ___________°

If yes for stormwater:
Is stormwater currently controlled? Land Use description:_________________________________
☐ Yes ☐ No ☐ Not investigated Area available:

OUTFALL SEVERITY: (*circle #*)	Heavy discharge with a distinct color and/or a strong smell. The amount of discharge is significant compared to the amount of normal flow in receiving stream; discharge appears to be having a significant impact downstream.		Small discharge; flow mostly clear and odorless. If the discharge has a color and/or odor, the amount of discharge is very small compared to the stream's base flow and any impact appears to be minor / localized.		Outfall does not have dry weather discharge; staining; or appearance of causing any erosion problems.
	5	4	3	2	1

SKETCH/NOTES:

REPORTED TO AUTHORITIES: ☐ YES ☐ NO

Utility Impacts **UT**

WATERSHED/SUBSHED:	**DATE:** ___/_____/___	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:**___:____AM/PM	**PHOTO ID:** (*Camera-Pic #*) /#
SITE ID: (*Condition-#*) **UT-**_____	**LAT**___°_____'_____" **LONG** ___°_____'_____" **LMK:** _____	**GPS:** (*Unit ID*)

TYPE:	**MATERIAL:**	**LOCATION:**	**POTENTIAL FISH BARRIER:**	**PIPE DIMENSIONS:**
☐ Leaking sewer ☐ Exposed pipe ☐ Exposed manhole ☐ Other:	☐ Concrete ☐ Corrugated metal ☐ Smooth metal ☐ PVC ☐ Other:	☐ Floodplain ☐ Stream bank ☐ Above stream ☐ Stream bottom ☐ Other:	☐ Yes ☐ No	Diameter: _____in Length exposed: _____ft
			CONDITION: ☐ Joint failure ☐ Protective covering broken ☐ Other:	☐ Pipe corrosion/cracking ☐ Manhole cover absent

EVIDENCE OF DISCHARGE:		
	COLOR	☐ None ☐ Clear ☐ Dark Brown ☐ Lt Brown ☐ Yellowish ☐ Greenish ☐ Other:
	ODOR	☐ None ☐ Sewage ☐ Oily ☐ Sulfide ☐ Chlorine ☐ Other:
	DEPOSITS	☐ None ☐ Tampons/Toilet Paper ☐ Lime ☐ Surface oils ☐ Stains ☐ Other:

POTENTIAL RESTORATION CANDIDATE ☐ Structural repairs ☐ Pipe testing ☐ Citizen hotlines ☐ Dry weather sampling
☐ no ☐ Fish barrier removal ☐ Other:

If yes to fish barrier, Water Drop: ________ (in)

UTILITY IMPACT SEVERITY: (*Circle #*)			
Leaking= ☐ 5	Section of pipe undermined by erosion and could collapse in the near future; a pipe running across the bed or suspended above the stream; a long section along the edge of the stream where nearly the entire side of the pipe is exposed; or a manhole stack that is located in the center of the stream channel and there is evidence of stack failure.	A moderately long section of pipe is partially exposed but there is no immediate threat that the pipe will be undermined and break in the immediate future. The primary concern is that the pipe may be punctured by large debris during a large storm event.	Small section of exposed pipe, stream bank near the pipe is stable; the pipe is across the bottom of the stream but only a small portion of the top of the pipe exposed; the pipe is exposed but is reinforced with concrete and it is not causing a blockage to upstream fish movement; a manhole stack that is at the edge of the stream and does not extend very far out into the active stream channel.
	5	4 3	2 1

NOTES:

REPORTED TO LOCAL AUTHORITIES ☐ Yes ☐ No

Results

Staff evaluated SARs by watershed, with a focus on the following data and analyses:

- CEM: Total channel length in most actively degrading CEM categories (II, II/III, and III) without stabilization; percent channel length in these categories
- Outfalls: Total number of outfalls in worst condition (4 and 5); percent of outfalls in these categories
- Utilities: Total number of utility elements in worst condition (4 and 5); percent of utility elements in these categories

CEM

The summary table below and the pie charts attached show the linear feet of stream (and percentage) in each of the main CEM categories for each watershed. Stages II, II/III, and III are the most actively degrading evolutionary states and are displayed in orange and red. Stages III/IV and IV are shown in yellow as these stages represent the early stages of stability. Stages I/V and IV/V are shown in green.

The yellow highlighted cells in the summary table indicate the top six subwatersheds in two categories:

- Total length of channel in CEM stages II, II/III, and III (without stabilization)
- Percent of total watershed channel length in CEM stages II, II/III, and III (without stabilization)

The top six subwatersheds were chosen as a starting point in the prioritization process.

Together, these two sets of data indicate those subwatersheds with the most overall and relative amount of channel in the most actively degrading CEM stages. It should be noted that stream reaches with partial or full stabilization often still have localized stability problems as well as degraded habitat. But, the prioritization exercise in this study emphasized those stream reaches with the most actively degrading CEM conditions without significant stabilization measures in place.

Within each pie chart is a smaller grayscale pie chart that indicates the percentage of Stage II, II/III, and III stream segments that have been 'arrested' or stabilized partially or fully with rip-rap or concrete. Some watersheds, like Lower Long Branch and Little Pimmit Run, show a significant length of stream channel in Stages II, II/III, and III (50% and 77%, respectively, of total channel length), but most (81% and 88%) of these segments have been artificially hardened and stabilized. In contrast, 74% of the stream segments in the Windy Run watershed are in Stages II, II/III, and III, with only 6% partially or fully stabilized.

Subwatershed	Length of Assessed Channel (ft)	Length of Channel Arrested in CEM Stages II, II/III, or III (ft)	Length of Channel in CEM Stages II, II/III, or III (not arrested) (ft)	Percent of CEM Stages II, II/III, or III channel length not arrested	Percent of Total Watershed Channel Length in CEM Stages II, II/III, or III (not arrested)
Arlington Branch	5,701	251	575	70%	10%
Arlington Forest Branch	2,073	58	0	0%	0%
Bailey's Branch	1,263	938	0	0%	0%
Colonial Village Branch	2,198	0	106	100%	5%
Doctor's Branch	4,075	1,170	418	26%	10%
Donaldson Run	13,161	671	5,773	90%	44%
Four Mile Run, Upper Mainstem 1	8,097	0	902	100%	11%
Four Mile Run, Upper Mainstem 2	20,804	3,593	3,485	49%	17%
Four Mile Run, Middle Mainstem	17,518	0	799	100%	5%
Gulf Branch	7,794	996	2,409	71%	31%
Lower Long Branch	6,848	2,777	657	19%	10%
Upper Long Branch	5,051	1,239	460	27%	9%
Little Pimmit Run	5,282	3,569	492	12%	9%
Lubber Run	6,411	3,314	1,029	24%	16%
Palisades	2,902	0	2,605	100%	94%
Pimmit Run	6,673	70	2,129	97%	32%
Rixey Branch	1,774	0	1,344	100%	76%
Spout Run	5,997	270	1,579	85%	26%
Westover Branch	214	0	0	0%	0%
Windy Run	5,704	274	3,959	94%	69%

The top six watersheds with the most length of channel in CEM stages II, II/III, and III (without stabilization) include:

- Donaldson Run
- Windy Run
- Four Mile Run Upper Mainstem 2
- Palisades
- Gulf Branch
- Pimmit Run

The top six watersheds with the highest percentage of channel in CEM stages II, II/III, and III (without stabilization) include:

- Palisades
- Rixey Branch
- Windy Run
- Donaldson Run
- Pimmit Run
- Gulf Branch

Infrastructure

Subwatershed	Stormwater Outfalls (OT)							% 4 OR 5
	Severity						Total	
	1	2	3	4	5	4 or 5		
Arlington Branch	34	1	0	1	0	1	36	2.8%
Arlington Forest Branch	7	0	0	1	0	1	8	12.5%
Bailey's Branch	4	0	0	0	0	0	4	0.0%
Colonial Village Branch	9	4	2	0	0	0	15	0.0%
Doctor's Branch	20	3	0	0	0	0	23	0.0%
Donaldson Run	8	4	2	1	4	5	19	26.3%
Four Mile Run, Upper Mainstem 1	24	11	2	0	0	0	37	0.0%
Four Mile Run, Upper Mainstem 2	33	7	5	0	1	1	46	2.2%
Four Mile Run, Middle Mainstem	40	10	1	0	2	2	53	3.8%
Gulf Branch	10	3	3	3	5	8	24	33.3%
Lower Long Branch	15	3	1	0	0	0	19	0.0%
Upper Long Branch	7	3	1	1	1	2	13	15.4%
Lubber Run	23	2	2	0	0	0	27	0.0%
Palisades	0	3	1	0	3	3	7	42.9%
Pimmit Run	4	1	2	1	2	3	10	30.0%
Rixey Branch	0	3	1	1	1	2	6	33.3%
Spout Run	36	3	2	0	0	0	41	0.0%
Westover Branch	0	0	0	0	0	0	0	
Windy Run	13	2	2	6	1	7	24	29.2%

The top six watersheds with the most number (and as a percentage of total outfalls) of stormwater outfalls in the worst condition (4 and 5):

- Gulf Branch
- Windy Run
- Donaldson Run
- Palisades
- Pimmit Run
- Rixey Branch

Subwatershed	Utility Impacts (UT)							% 4 OR 5
	Severity						Total	
	1	2	3	4	5	4 or 5		
Arlington Branch	0	1	1	0	0	0	2	0.0%
Arlington Forest Branch	0	0	0	0	0	0	0	
Bailey's Branch	4	0	0	0	0	0	4	0.0%
Colonial Village Branch	2	0	0	0	0	0	2	0.0%
Doctor's Branch	7	1	0	2	0	2	10	20.0%
Donaldson Run	0	1	0	0	0	0	1	0.0%
Four Mile Run, Upper Mainstem 1	2	1	1	2	0	2	6	33.3%
Four Mile Run, Upper Mainstem 2	21	1	2	0	0	0	24	0.0%
Four Mile Run, Middle Mainstem	7	1	1	0	0	0	9	0.0%
Gulf Branch	4	0	2	2	2	4	10	40.0%
Lower Long Branch	2	3	0	0	0	0	5	0.0%
Upper Long Branch	0	0	0	0	0	0	0	
Lubber Run	6	1	0	1	0	1	8	12.5%
Palisades	0	0	0	0	1	1	1	100.0%
Pimmit Run	1	0	1	0	0	0	2	0.0%
Rixey Branch	0	0	0	0	0	0	0	
Spout Run	14	2	0	1	1	2	18	11.1%
Westover Branch	0	0	0	0	0	0	0	
Windy Run	1	1	2	0	1	1	5	20.0%

The top watersheds with the most number (and as a percentage of total elements) of utility elements in the worst condition (4 and 5):

- Gulf Branch
- Four Mile Run Upper Mainstem 1
- Doctor’s Branch
- Spout Run
- Palisades, Lubber Run and Windy Run (1 element each, various percentages)

CEM + Infrastructure

The top watersheds with the worst CEM conditions (both absolute length and by percent of subwatershed stream network) and the worst conditions in at least one of the two infrastructure categories (both by absolute number of infrastructure elements and as a percent of total infrastructure elements):

- Gulf Branch (both infrastructure categories)
- Windy Run (both infrastructure categories)
- Donaldson Run (stormwater outfalls)
- Pimmit Run (stormwater outfalls)
- Palisades (stormwater outfalls)

These watersheds represent the highest priorities for future stream restoration and infrastructure protection work.

In-stream Habitat and Riparian Buffer Condition

The USM assessment included an evaluation of both in-stream habitat and riparian buffer condition. These data were not used for the overall prioritization effort as described in the previous section, but are an important overlay to understand the current ecological condition of Arlington's streams.

The in-stream habitat score is based upon a qualitative evaluation of physical habitat elements to support aquatic organisms. Similarly, the riparian buffer condition score is based upon a qualitative evaluation of buffer composition (with an emphasis on canopy trees) and width. Native vs. invasive species assessment was limited for this evaluation.

As expected, given the significant levels of impervious cover in the County as well as physical manipulation of streams, in-stream habitat is marginal to poor for most stream reaches.

Cumulatively, 66 percent of the length of channel assessed had in-stream habitat conditions rated as marginal or poor. Subwatersheds with less than 50 percent of reaches in marginal or poor condition include Four Mile Run Upper Mainstem 1 (25%) and Middle Mainstem(34%) and Upper Long Branch (31%). All other subwatersheds had more than 50 percent of their stream length with in-stream habitat scored as marginal or poor.

Overall, riparian buffer condition scored better – 45 percent of stream reaches had marginal or poor condition scores. These numbers in general reflect the location of many streams in stream valley park systems. There is much more variability in the data relative to in-stream habitat. Some subwatersheds (such as Little Pimmit Run and Doctor's Branch) have very little of their total stream length within parkland. Others, like Donaldson Run and Gulf Branch, have most of their streams located within parks. In contrast, in-stream habitat is more directly associated with primary watershed variables like impervious cover.

Subwatershed	Length of Channel with In-Stream Habitat Marginal or Poor Condition (ft)	Percent of Channel with In-Stream Habitat Marginal or Poor Condition	Length of Channel with Riparian Habitat Marginal or Poor Condition (ft)	Percent of Channel with Riparian Habitat Marginal or Poor Condition
Arlington Branch	5,701	100%	5,379	94%
Arlington Forest Branch	2,073	100%	58	3%
Bailey's Branch	1,263	100%	1,263	100%
Colonial Village Branch	1,511	69%	731	33%
Doctor's Branch	3,354	82%	4,074	100%
Donaldson Run	6,554	73%	505	6%
Four Mile Run, Upper Mainstem 1	1,985	25%	4,254	53%
Four Mile Run, Upper Mainstem 2	11,700	56%	9,671	46%
Four Mile Run, Middle Mainstem	5,967	34%	8,955	51%
Gulf Branch	6,159	79%	778	10%
Lower Long Branch	6,847	100%	6,624	97%
Upper Long Branch	1,589	31%	0	0%
Little Pimmit Run	5,418	97%	4,910	88%
Lubber Run	4,066	63%	2,152	34%
Palisades	2,605	94%	0	0%
Pimmit Run	4,085	61%	662	10%
Rixey Branch	1,344	76%	0	0%
Spout Run	4,611	77%	5,606	93%
Westover Branch	214	100%	0	0%
Windy Run	5,063	89%	845	15%

Discussion and Next Steps

The worst conditions in terms of channel evolution and infrastructure are within the steep palisades portion of the County. In these stream valleys there is significant stream energy and velocities, along with stormwater infrastructure discharging to steep slopes. The one exception is the Upper Four Mile Run watershed ('Upper Mainstem 2') which, with approximately four miles of stream length in this subwatershed, has about half of its stream channel length in CEM stages II, II/III, or III that is not otherwise stabilized. As a percentage of total stream length in the subwatershed, however, these reaches represent less than 20 percent of the system.

Looking at stream and infrastructure conditions together, the highest priority watersheds are:

- Gulf Branch
- Windy Run
- Donaldson Run
- Pimmit Run
- Palisades

The next set of priority watersheds are:

- Four Mile Run Upper Mainstem 2
- Rixey Branch
- Four Mile Run Upper Mainstem 1

The next steps include:

1) A specific evaluation of each priority subwatershed to establish discrete stream restoration projects, based on specific stream reach conditions and proximity to other stream reaches with priority CEM and infrastructure conditions.

   Where there is stormwater or sanitary infrastructure in poor condition but not otherwise co-located with priority stream reaches, these elements are already undergoing evaluation for protection and repair.

2) For priority stream reaches, determination of which reaches are on County-owned land or under County drainage easement.

3) Look at inter-relationships with Natural Resources Management Plan features and recommendations

4) For priority stream reaches, further refinement of the 'physical restoration access' score assigned during the County-wide assessment.

5) More detailed field assessment for up to one mile of discrete projects established under item 1, above.

6) Establishing project budgets and schedules for the priority projects.

7) Update Stream GIS layer