The Potomac River with Virginia (right), Maryland (the river and far left), and the District of Columbia (far background). Sept. 18, 2014
Photo by Jim Cummins

Biological Surveys of Three Potomac River Mainstem Reaches
2013 Summary Report ICPRB # ICP14-4
EPA Section 106 Monitoring Initiative, Grant # I-98339411.
By Jim Cummins

Objectives

The ecological conditions and status of large rivers such as the Potomac River's mainstem are not as well documented as those of wadeable streams. This project is designed to enhance the basin jurisdictions collective understanding and documentation of the mainstem's ecological condition. It will help determine if the mainstem is meeting water quality goals and Clean Water Act objectives. The project also improves our ability to assess potential impacts such as flow modifications in the Great Falls and Little Falls sections. The project augments the statewide monitoring programs of Maryland, Virginia, West Virginia and the District of Columbia as well as MD Core (mainstem) stations and EPA's Large River Assessment sites.

Tasks Performed

Biological evaluations were conducted at three Potomac River mainstem reaches (See Appendix Figure A-1 for a map of river reach locations):

1) Knoxville, approximately 2 miles (3.2 km) downstream of the Potomac-Shenandoah confluence, near Knoxville MD.
2) Carderock, near Scotts Run and approximately 1 mile (1.6 km) upstream from the American Legion Memorial Bridge on the I-495 Washington beltway.
3) Little Falls, immediately downstream of the rubble remains of the C&O Canal's Dam #1 (near the Brookmont Dam), and approximately 1 mile (1.6 km) upstream from Chain Bridge.

These reaches were selected to help fill small but critical gaps in coverage under Maryland's Core Trend Stations for the Potomac River's mainstem. Data from the Knoxville reach will improve our understanding of the mixing zones below the confluence of the Shenandoah and Potomac Rivers. The Carderock and Little Falls reaches are important for evaluation of potential compounding effects of water withdrawal during drought periods due to large Washington Metropolitan area water supply withdrawals and a hydroelectric facility which has consumptive water use due to evaporative cooling. This report summarizes activities in 2013. Analysis of the information is ongoing but not yet complete, in large part because this is only the second year of a multi-year project.

Three biological indicator groups are assessed at each reach; 1) benthic macroinvertebrates, 2) submerged aquatic vegetation (SAV), including an attached filamentous green algae (FGA) component, and 3) freshwater mussels.

Each reach has an annual target of 4 benthic macroinvertebrate sites and a biannual target of 10 SAV/algae transects and 36 freshwater mussel sites. Habitat was characterized at each site regarding substrate characteristics, depth, flow, degree of filamentous algae, and percentage of SAV. Reach locations are considered fixed, are sampled over a three year period to help cover inter-year flow variability, and are planned for re-sampling at ten-year intervals in order to help evaluate trends.

Site selections within each reach were performed through random selection of computer generated and numbered 25m² grids imposed over digital maps of each reach (see Appendix Figure A-2 showing an example of the grid overlay for the Carderock Reach and Appendix Figures A-3 through A-5 for the randomly selected sample sites at each reach). Final site locations were determined through field audits over the first two years of the survey (2012 and 2013). General and an Endangered Species scientific collecting permit are obtained from the Maryland Department of Natural Resources to cover our field research activities. In addition, the Chesapeake and Ohio National Historic Park is notified about this project and the dates of our field work.

Field work was conducted between August 6th and September 18th, 2013, during late summer and early fall, when the Potomac River is typically near its lowest flow levels. 2013 was a wet year and storms and high flows did occur during this period, as can be seen in Figure 1 below. The study protocols for appropriate flow levels during field work are that flows should be less than 1.2 x median flow (less than 3300 cfs). These levels of flows typically provide for excellent water clarity, shallow exposure of mussel beds, ease of prosecution, and safety.

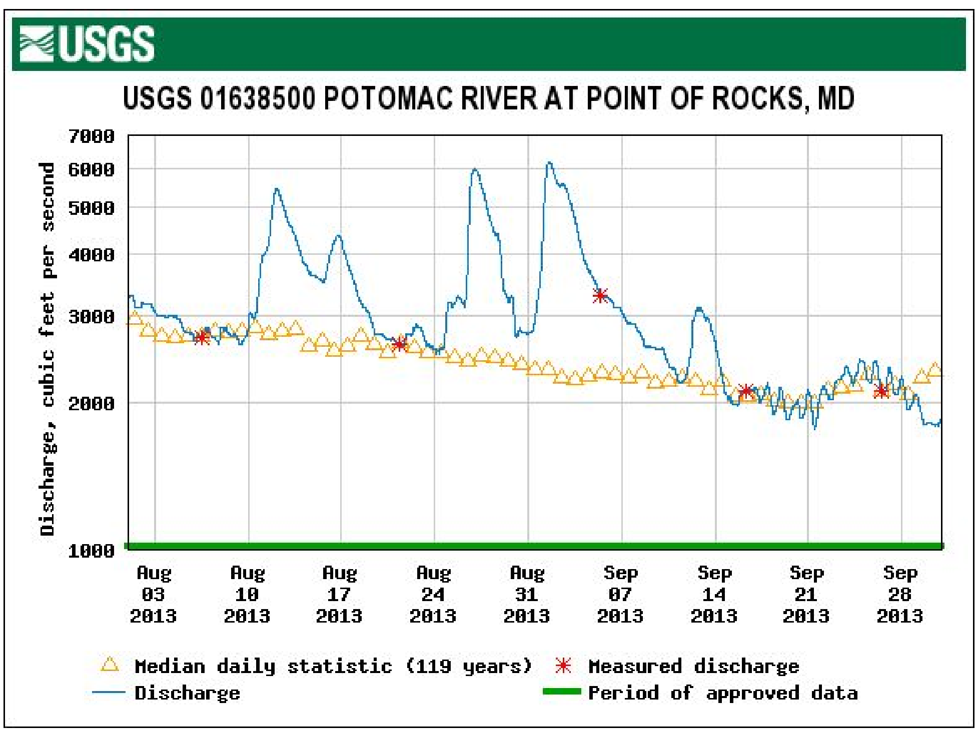

Figure 1: Flows recorded at USGS's Point of Rocks Gage, 8/1/13 – 9/30/13.
This gage is located approximately midway between the three river reaches in the study

All three reaches are shallow, rock-dominated fall areas. They are in sections of the river which are difficult to access and evaluate with conventional boats, the two reaches located in the Potomac Gorge have no associated boat ramps, which has been a major obstacle to their ecological evaluations.   Therefore canoes were used because they could be portaged and they facilitated access to individual sites within each reach.   A handheld global positioning system (Garmin model Etrex 20) was used to locate the centerpoint of each site.

The methods used to sample the three biological indicator groups were as follows:

1) Benthic Macro-invertebrates: A 500 micron mesh kick net was used to collect invertebrates from four riffle/run habitat sites within each river reach, each consisting of a six-kick composite of ¼ meter^2 kicks (for a total surface collection area of 1½ meter^2 at each site). Samples were preserved in the field in 70%+ alcohol, with labels both in and on the container. Samples were transferred to storage and laboratory facilities for subsequent sorting and laboratory identification, enumeration and data entry.   Each sample is subsampled by random selection of 28 grids in order to extract two - 100 organism counts (+/- 20%) and one 200 organism count (+/- 20%), making the total target count of 400 individuals/sample (+/- 20%).   Laboratory identifications are performed to genus/species level of taxonomy. This sample size follows recent monitoring recommendations (Mandel et al., 2011) (C. Buchanan, 2010).

2) Freshwater Mussels: At the centerpoint of each selected 25m^2 site, located by hand-held gps, timed quantitative visual and excavation searches for mussels were conducted within a ¼ m^2 quadrat frame (see Figure 2), which were then followed by a timed qualitative visual search performed within a 2m radius circle (12½ m^2 area) centered on that quadrat.   The quadrat area was first visually examined for mussels and then excavated to a depth of approximately 15 cm.   Sand, gravel, gobble and any mussels from the excavations were placed into a ¼ m^2 box (with a 1 cm^2 (.375 in^2) wire-mesh bottom), then removed from the water for examination in the canoes. Mussels encountered during the subsequent circle search were kept separately.   All mussels were kept in shaded containers with fresh river water until the mussels were identified, measured (length, width and height), recorded (see Appendix B: 2013 Field Form for Mainstem Freshwater Mussel), and then placed back into the river in their approximate original location and orientation.   Digital images were made of some mussels for the purpose of vouchers or to document any questions or anomalies.   Results of the timed visual and excavation searches are used to develop taxa richness and abundance. Habitat parameters taken at each quadrat included depth, flow characterizations, estimates of substrate composition, stream morphology, embeddedness, and percent coverage of SAV. Timed qualitative visual searches are also used to assess species richness, relative abundance and to aid in detecting rare species. Timed excavation searches are quantitative measures for estimating the relative occurrence of buried species or individuals that would otherwise be overlooked with solely visual searches. (Strayer et al. 1997, Obermeyer 1998, Strayer and Smith 2003).

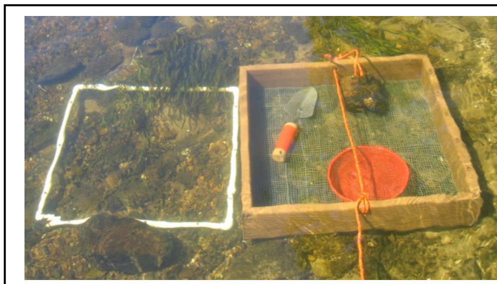

Figure 2:   ¼ m^2 Quadrat (white) and Collection Box (brown) used in mussel surveys.

3) Submerged Aquatic Vegetation (SAV) and Attached Filamentous Algae (AFA): Evaluations of SAV and AFA were conducted at two scales; 1) at 10 randomly selected 25 meter linear transects

within each river reach, and 2) at each of the ¼ meter² mussel quadrats. The linear transects were used to record species and measurements of the length of line covering individual species clusters (in .1 m increments) to derive diversity and percent coverage (see Appendix C: 2013 Field Form for Submerged Aquatic Vegetation)

After field work was completed, field data sheet information was transferred to Excel® electronic spreadsheets. These spreadsheets are available upon request.

Results:

1. Benthic Macroinvertebrates: Each of the twelve collections were sorted and picked into 400 organism subsamples composed of one 200 organism subsample and two 100 organism subsamples. Thereby, in total, there were thirty-six subsamples consisting of twenty-four – 100 count samples and twelve – 200 count samples. Laboratory identifications and tabulations of the 2013 subsamples are still in process. Upon completion, e macro-invertebrate results from 2012 and 2013 will be run through the Cheseapeake Bay Biotic Index of Biologic Integrity (BIBI) (Buchanan et al., 2011) which was designed for non-tidal wadeable streams. This will be a first cut to help evaluate and develop a similar benthic IBI for large river environments.

2. Freshwater Mussels: Seventy-two sites were surveyed, thirty-six in the Knoxville reach and thirty-six at Carderock. We were unable to conduct mussel or SAV/Algae surveys of the Little Falls reach due to persistent high river levels which not only reduced water clarity but elevated safety concerns and contributed to seasonal break-up of SAV.

A total of 247 living mussels comprised of three species were found in 2013 (Table 1). The Eastern Elliptio (*Elliptio complanata*) were the most abundant. Eastern Elliptio were especially abundant in the Carderock Reach, as was the case with the Little Falls reach in 2012. A few Lampmussels (*Lampsilis sp.**) were found at each reach, being slightly more abundant at the Knoxville reach. While uncommon, the presence of the Brook Floater (*Alasmidonta varicosa*), a Maryland endangered species, at two of the reaches is notable. A sole living Creeper (*Strophitus undulates*) was collected at the Knoxville site in 2012 and a fresh dead shell was found in the Knoxville study area in 2013.

Table 1: Freshwater Mussel Species and Counts from Potomac River Mainstem Reaches surveyed in 2012 and 2013.

Species	Common Name	Site: Knoxville, Near confluence of Shenandoah (2012 - 2013)	Site: Carderock Upstream of Stubblefield falls. (2012[1] - 2013)	Site: Little Falls Downstream of Brookmont Dam (2012 only)
Alasmidonta varicosa	Brook Floater	2 – 5		1(FD)
Elliptio complanata	Eastern Elliptio	9 – 9	48 - 226	192
Strophitus undulates	Creeper	1 – 1(FD)		
Lampsilis sp.[2]	Lampmussel	13 – 5	2 - 2	4
Detection by time● (# mussels/person-hour)		3.06 - 5.12	44.71	19.4
Density[1] (# mussels/m²)		0.06 - 0.05	0.49	0.44

● Combining visual and excavation searches.

[1] Carderock counts are only partial for 2012 due to high flows interrupting survey.
[2] There are outstanding taxonomic issues with Lampsilis species, these may be *L. cariosa, L. cardium*, hybrids between the two, or a native subspecies *L. cardium cohongoroton*.

All three sites have relatively low mussel diversity, four species or less. The Knoxville reach had the greatest mussel diversity but the lowest mussel density. The predominance of the Eastern Elliptio at both the Carderock and Little Falls reaches is evidence of their ability to better colonize small rock crevices than the other mussel species. These reaches experience a lot of scouring flows because they are areas where the river's width is constrained and reduced into a narrow gorge. The river bottoms in the Carderock and Little Falls reaches had averages of 45% and 31%, respectively, for bedrock or boulder substrate.

Figure 3: Assemblage of mussels collected at Site #51 at Little Falls, Potomac River. All are various age Eastern elliptios, except for one Lampmussel (Lampsilis sp. complex) at bottom right.

3. Submerged Aquatic Vegetation (SAV) and Filamentous Green Algae (FGA): SAV species documented in the survey were water stargrass (*Heteranthra dubia*), water celery (*Vallisneria americana*), and a very minor amount (0.08%) of the algae muskgrass (*Chara spp*.) (See Table 2). The Knoxville reach was the only one of the three studied reaches which had any degree of SAV, at 34.9% coverage in 2012 and 19% coverage in 2013. The Carderock reach had no SAV in the measured transects and the Little Falls reach only 3.6%, most of which was submerged American water willow (*Justicia americana*), technically not an SAV species. The average periphyton coverage was less than 1, or low, which is good, as excessive amounts of periphyton can impede SAV growth by reducing light to the leaves. Periphyton can become heavy if there are excessive nutrients but neither appeared to be limiting factors. All three reaches are fall areas and scour is a factor that is suppressing SAV due to removal and/or periodic re-suspension of suitable substrate.

Table 2 Coverage of Submerged Aquatic Vegetation (SAV)
from Potomac River Mainstem Reaches surveyed in 2012 and 2013.

Reach	Year	% Star Grass	% Water Celery	% Muskgrass	% Submerged Water Willow	% Sites with No SAV	Average Periphyton Scale 0-3, (absent-high)
Knoxville	2012	31.2	3.5	0.08	0.02	65.1	0.7
Knoxville	2013	11	8	0	0	81	.5
Carderock	2013	0	0	0	0	100	0
Little Falls	2012	0.9	0	0	2.7	96.4	0

Filamentous green algae was not routinely encountered. However, it was found at levels sufficient to limit habitat quality at two sites in the Knoxville reach. In addition, the Knoxville reach contained several areas outside of selected sites which were heavily impacted by blue-green algae (Figure 4). While FGA manifestation was most prevalent in the south-eastern side of the reach, the most influenced by Shenandoah River inputs, it was patchy within that area. The patchy nature was confounding as water quality was similar at that side and there were no obvious differences in habitat types that would help explain how FGA would manifest in one area and not another.

Figure 4: Blue-green algae encountered at several locations in the Knoxville reach.

4. Habitat: The depth of all 108 sites ranged from 1.9 m (6.2 ft) to 0.1 m (0.33 ft., or 4”) with an averaged 0.7 m (2.2 ft). Knoxville and Little Falls had nearly identical average depths (0.64 m and 0.65 m, respectively) while Carderock was a little deeper at 0.82 m. The typical substrate composition of all sites was dominated by cobble (27.7%) and gravel (20.6%). There was substantial bedrock (19.4%) and boulders (14.2%), with less finer materials like sand (13.5%) and silt (3.5%). Other materials, like detritus and shells of bivalves, primarily Corbicula shells, made up the remaining 1.2 % of the substrate.

Table 3: Habitat Parameters

Reach	Average Depth	% Bedrock	% Boulders	% Cobble	% Gravel	% Sand	% Silt	% Other	Estimate of Habitat Availability
Knoxville	0.64	15.1	9.9	30.4	22.2	13.4	6.5	3.5	65.9
Little Falls	0.65	16.0	14.6	31.0	21.7	14.0	2.0	0.1	66.5
Carderock	0.82	27.0	18.2	21.6	17.9	13.1	2.1	0.0	57.2
All Reaches	0.70	19.4	14.2	27.7	20.6	13.5	3.5	1.2	63.2

5) Water Quality: Table 4 below provides field water quality results. Water quality will be evaluated through a combination of field measurements and the results of the Maryland Department of Natural Resources Core Trend Stations on the mainstem Potomac River; (POT1830) near Shepherdstown, WV, (POT1595), at Point of Rocks, and (POT1184) at Little Falls.

Table 4: Water Quality Measurements

Site	Date	Flow (CFS)	USGS Gage*	Gage Median	Clarity Meters	Water Temp	DO	Cond	pH	TDS
CarRck42	8/23/2013	3000	POR	2500	1.25	27.4	7.12	332	8.71	216
CarRck286	8/23/2013	3000	POR	2500	1.25	27.46	8.15	332	8.73	216
Kxvll2156	8/7/2013	2800	POR	2780	1.5	24.13	8.17	387	8.19	252
Kxvll1036	8/7/2013	2800	POR	2780	1.5	24.39	9.28	323	8.4	210
Kxvll1841	8/7/2013	2800	POR	2780	1.5	24.38	8.77	388	8.31	252

*POR = Point of Rocks, USGS flow data is provisional.

In 2011 the Maryland Department of the Environment concluded that nutrients in general and phosphorus in particular are not impairing designated uses in the Potomac River mainstem in Frederick or Montgomery Counties (MDE, 2011). In 2009 the Maryland Department of Natural Resources reported that the biotic index values measured at their mainstem station near Shepherdstown (POT1830) were in the good range. While this study is still preliminary, so far the findings support this conclusion.

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Appendix A, Figures A1-A5

Figure A-1 Map of the locations of the Potomac River mainstem reaches studied in this project.

A = Knoxville Reach, B = Carderock Reach, C = Little Falls Reach

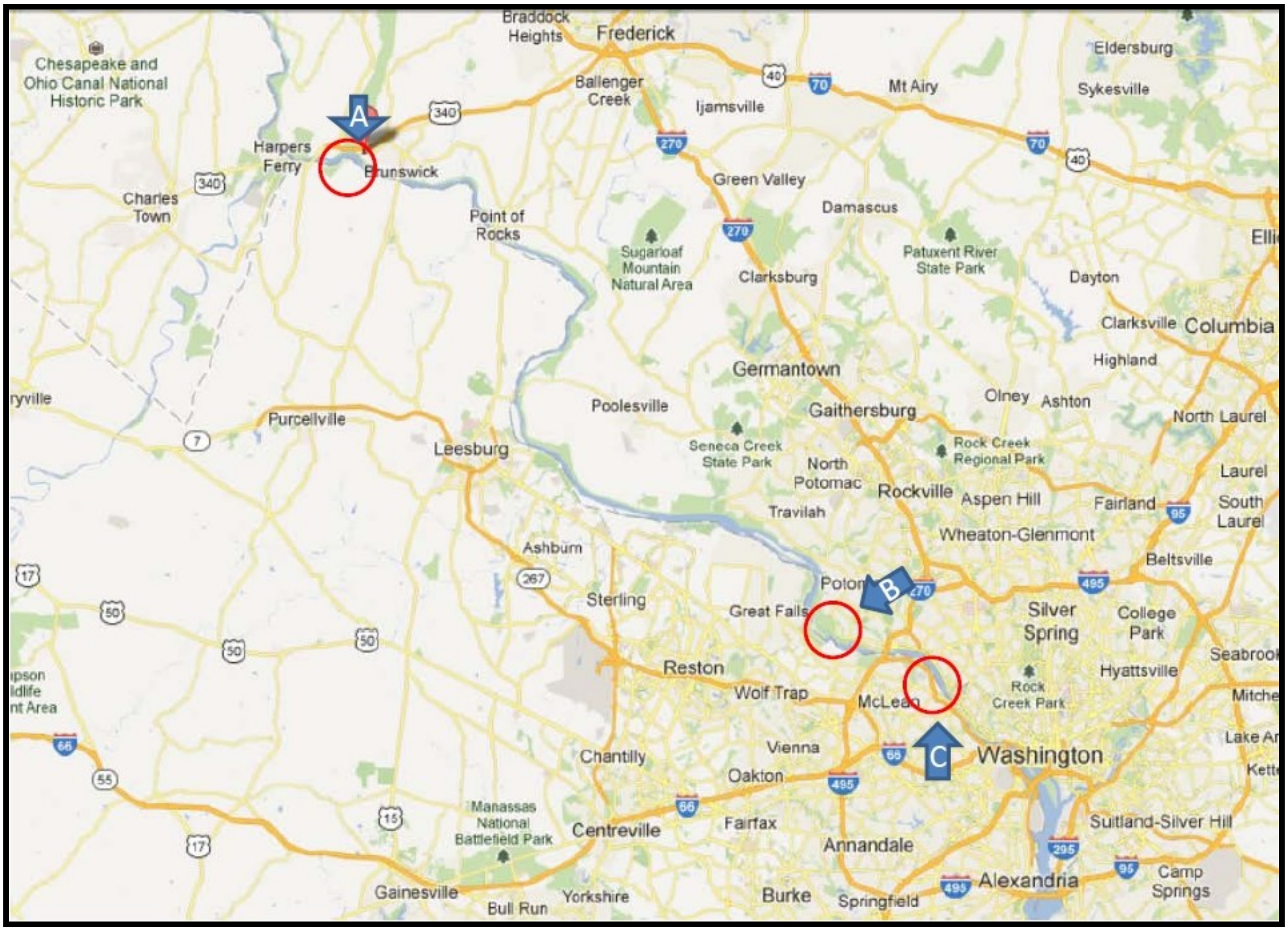


Figure A-2: Potomac River Little Falls Reach with computer grid and randomly selected sampling sites. Yellow boxes are primary sites, red boxes are primary sites where submerged aquatic vegetation transects were conducted, orange and blue sites are alternate sites.

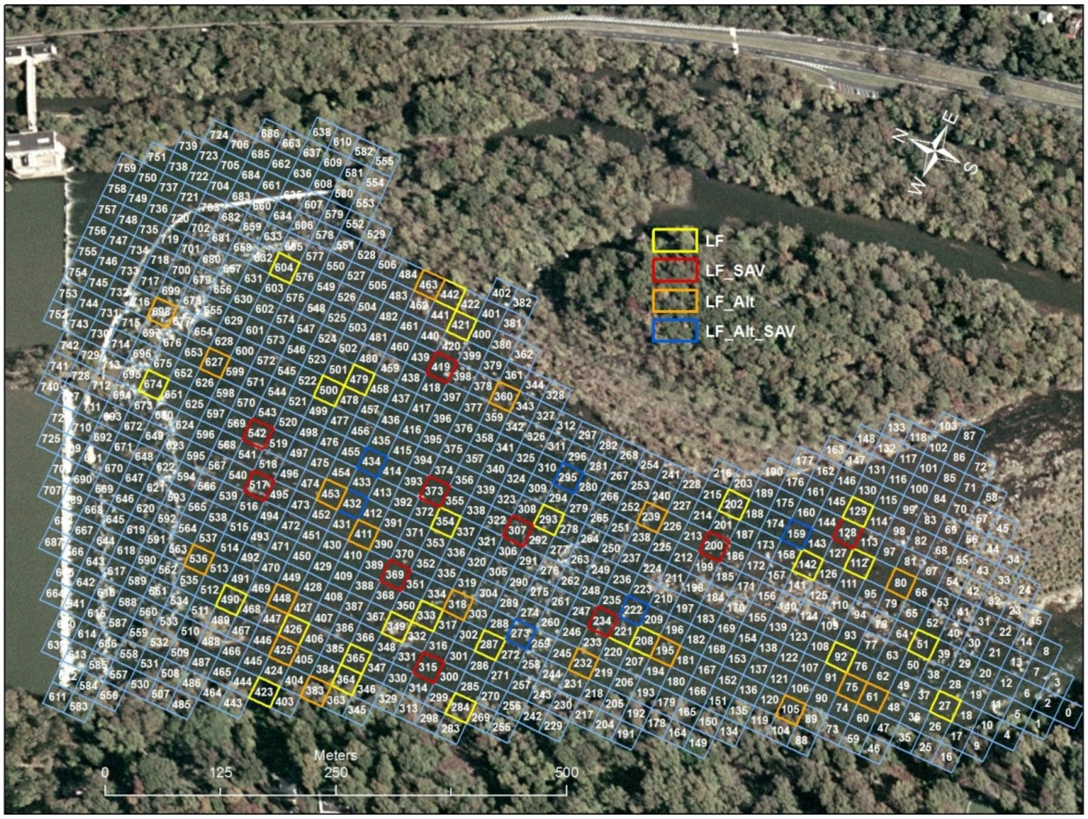


Figure A-3: Potomac River Little Falls Reach with grid removed showing randomly selected field sites.

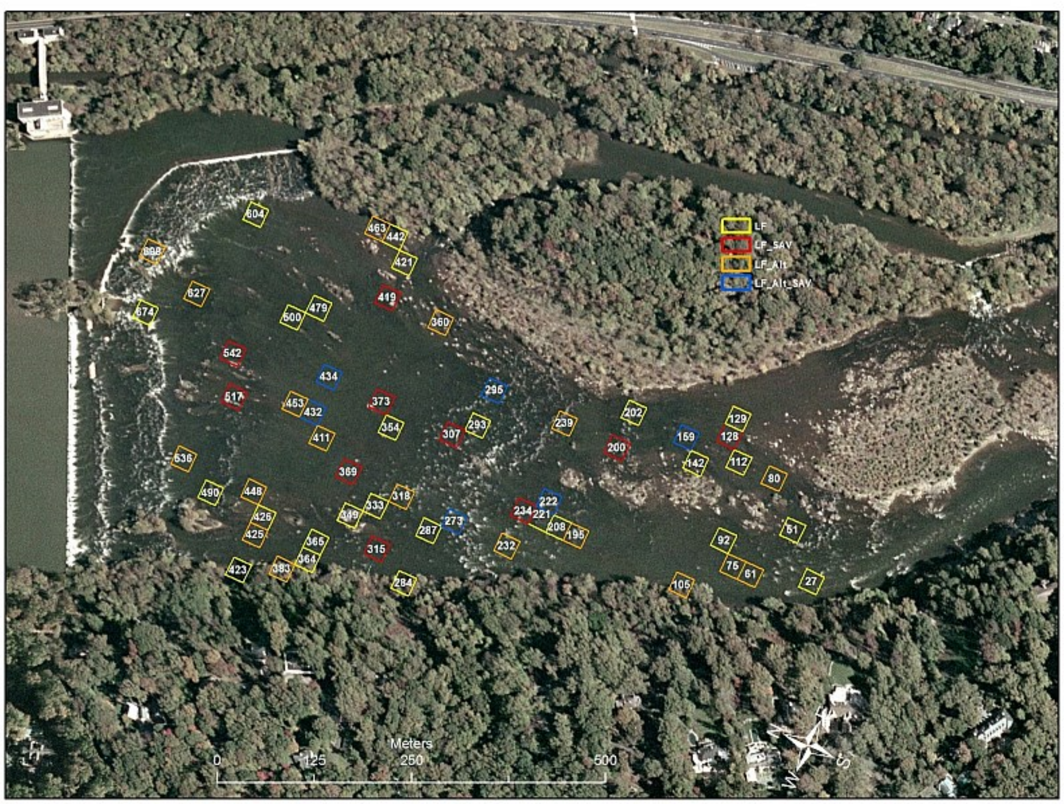


Figure A-4: Carderock Reach, Potomac River, with randomly selected field sites. Yellow boxes are primary sites, red boxes are primary sites where submerged aquatic vegetation transects were conducted, orange and blue sites are alternate sites.

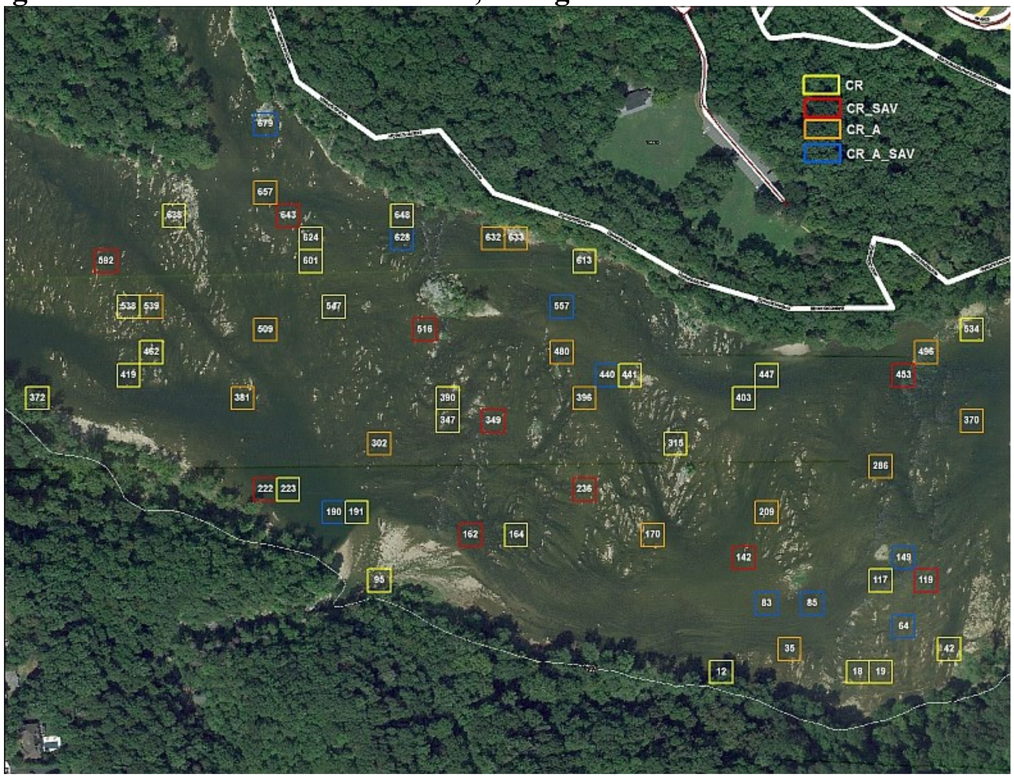
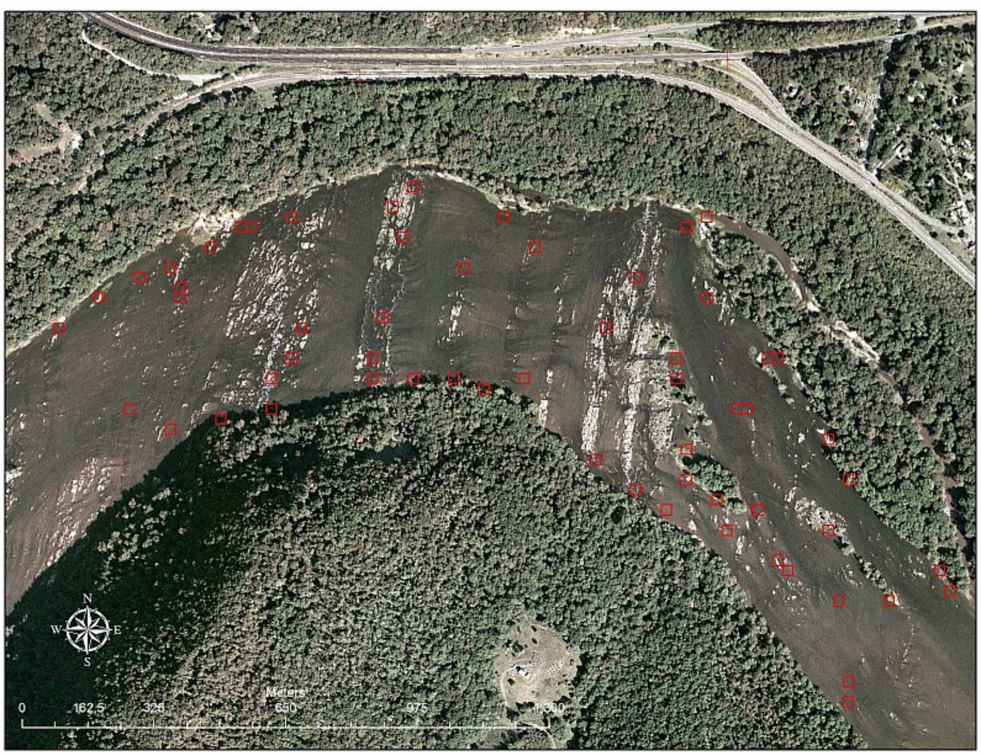


Figure A-5: Knoxville Reach with randomly selected field sites (red boxes).



Mainstem Potomac Evaluation - Freshwater Mussels - Field Form

River Reach ______________________________ Section__________ Date:_____/____/2013
StartTime ____:____ Air Temp _____ Water Temp _____ D.O. ____ Cond. ________ pH _____
Water Clarity (least is .5 m, then in 0.25 meter increments) _________Weather_______________________
Surveyor(s):____Gage Flow/Median______/_______

Site #	**Substrate (Est %)** ---------------------- **Habitat Type (Circle)**	**% Avl Hab**	**Water Depth. In .1 m**	**SAV Type & % Cover**	**Time** quad **V**is + **E**xc	Detects Species, Sizes (in mm) and number detected Label shells as **F**resh, **D**ead, **S**ubfossil	Notes
	Bed= Bol = Cob= Gra = San = Silt = Oth = ---------------------- Po Gl Ri Ra Ca Fa Other:				Vis = ___:___ Exc = ___:___	Vis = Exc = Est. # Corbs = Adjacent = In vicinity =	Current: Still - Lite - Mod - Strong Sunlight: Open or % Overstory
	Bed= Bol = Cob= Gra = San = Silt = Oth = ---------------------- Po Gl Ri Ra Ca Fa Other:				Vis = ___:___ Exc = ___:___	Vis = Exc = Est. # Corbs = Adjacent = In vicinity =	Current: Still - Lite - Mod – Strong Sunlight: Open or % Overstory
	Bed= Bol = Cob= Gra = San = Silt = Oth = --------------------- Po Gl Ri Ra Ca Fa Other:				Vis = ___:___ Exc = ___:___	Vis = Exc = Est. # Corbs = Adjacent = In vicinity =	Current: Still - Lite - Mod – Strong Sunlight: Open or % Overstory
	Bed= Bol = Cob= Gra = San = Silt = Oth = ---------------------- Po Gl Ri Ra Ca Fa Other:				Vis = ___:___ Exc = ___:___	Vis = Exc = Est. # Corbs = Adjacent = In vicinity =	Current: Still - Lite - Mod – Strong Sunlight: Open, Shaded

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Potomac Mainstem - **SAV Field Form**

River Reach _________________________________ Section______ Site #________

Date: ____/____/2013 Surveyor: ____________________ Recorder:____________________

Note: Indicate **RR** for river-right or **RL** for river-left in the left margin at the respective start points.

Length	Depth	Species*	Periphyton/Sediment Cover**	Predominant Substrate
in 0.10 m.	in 0.10m		**H**eavy/**M**ed/**L**ight/**N**one	**Be**d, **Bo**l,**Co**b, **Gr**a, **Sa**n, **Si**l, **Ot**h
0 -				

*See back for ID tips and abbreviations. **Only what is on top of the plants.

Identification Tips*	Scientific Name	Common Name	Abbr.
Submerged Grasses			
Basal Leaves =	Vallisneria Americana	Water Celery	VAL
Whorled Leaves			
Simple leaf			
5-leaved =	Hydrilla verticillata	Hydrilla	HY
3-leaved =	Elodia spp.	Elodea	El
4-8 larger leaves, thick stem	Egeria densa	Brazilian Weed, Anacharis	BW
Compound leaf			
Roughly divided, 9-10 leaves, stiff =	Ceratophyllum demersum	Coontail	CT
Finely divided, loose			
5-leaved whorls =	Myriophyllum brasiliense	Parrot Feather	PF
4-leaved whorls =	Myriophyllum spicatum	Eurasian Milfoil	EM
Opposite Leaves			
Leaf tip angle <90°			
Most leaves > 4 cm long =	Zannichellia palustris	Horned Pondweed	HP
All leaves < 4 cm long =		Naiad spp.	NSpp
Flattened Leaves, no teeth =	Najas quadalupensis	Southern Naiad	SON
Recurved Leaves, strongly toothed =	N. minor	Spiny Naiad	SPN
Fine, "straight" Leaves, weakly toothed			
Very fine wavy leaves =	N. flexilis	Northern Naiad	NON
Very fine straight leaves =	N. gracilliama	Slender Naiad	SLN
Leaf tip angle >90°, floating egg-shaped upper leaves =	Callitriche spp.	Water Starwort	WS
Alternate Leaves			
Leaves < 2 mm wide			
Visible midrib =	Potamogeton pusillus	Slender Pondweed	SLP
No prominent midrib			
All leaves > .5 mm wide =	Stuckenia pectinata	Sago Pondweed	SAP
All leaves < .5 mm wide =	Ruppia maritime	Widgeon grass	WG
Leaves >2mm wide			
Prominent midrib			
Wavy Leaves =	Potamogeton crispus	Curly Pondweed	CUP
Leaves wrap around stem =	Potamogeton perfoliatus	Redhead Grass	RG
No prominent midrib =	Heteranthra dubia	Water Stargrass	SG
Emergent Grass =	Justicia americana	Water Willow	WW
Floating Grass = Triangular or diamond-shaped leaves	Trapa natans	Water Chestnut	ACK
Algae			
Brittle, skunky smelling, whorled-like axis	Chara spp.	Muskgrass	CH

Compiled from: "Underwater Grasses in the Chesapeake Bay & Mid-Atlantic Coastal Waters"