Benthic TMDL Study on Deep Run, Dover Creek, and Upham Brook Watersheds in Henrico and Goochland Counties and the City of Richmond

First Community Engagement Meeting Handout
7/10/2023, 2:00 pm, Virginia DEQ Piedmont Regional Office

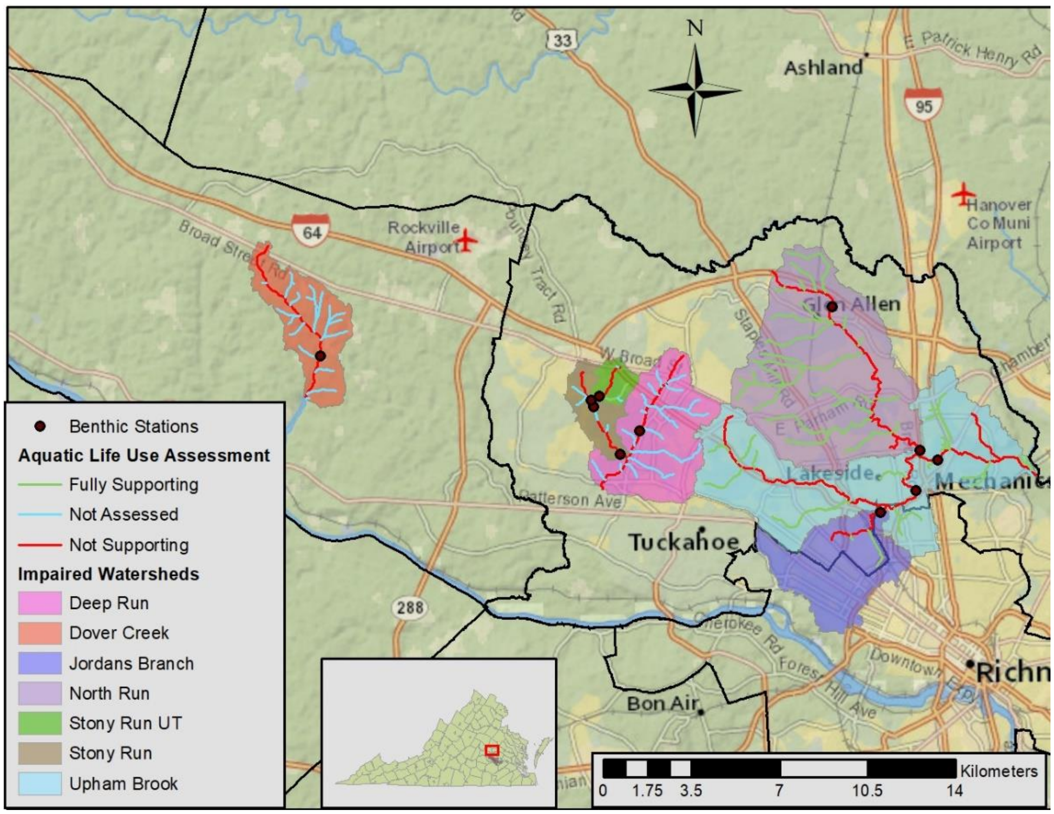

Figure 1. Streams included in the Benthic TMDL Project.

1. TMDL Development Process Introduction

The VA Department of Environmental Quality (DEQ) and its contractors, Wetland Studies and Solutions Inc. (WSSI) and James Madison University (JMU), are working to complete a Total Maximum Daily Load (TMDL) study for the streams shown in Figure 1 and listed in Table 1.

A TMDL is the total amount of a pollutant a water body can contain and still meet water quality standards. The study will identify the target pollutant causing the poor water quality, sources of the pollutant in the watersheds, the current magnitude of the pollutant contributions from each source, and the pollutant reductions needed from those sources to restore the benthic macroinvertebrate community in each stream.

Table 1. Impaired streams included in the Benthic TMDL Project.

Stream Name	NWBD	Impaired Assessment Units	Cause Group Code	First listed	Length (miles)	Impairment Description
Deep Run	JM84	VAP-H39R_DPR01A00	H39R-27-BEN	2016	4.16	Headwaters to the pond at river mile 1.47
Dover Creek	JM82	VAP-H39R_DOV01A00	H39R-26-BEN	2020	4.76	Headwaters to the upstream limit of Dover Lake
Jordans Branch	JL18	VAP-G05R_JOP01A14	G05R-14-BEN	2016	2.19	Headwaters to the mouth at Upham Brook
North Run	JL18	VAP-G05R_NTR01A00	G05R-09-BEN	2014	4.24	Hungary Creek to the mouth at Upham Brook
	JL18	VAP-G05R_NTR02A06	G05R-09-BEN	2008	3.66	Headwaters to Hungary Creek
Stony Run	JM84	VAP-H39R_SNJ01A04	H39R-13-BEN	2008	1.01	Headwaters to the extent of backwater at the pond
	JM84	VAP-H39R_SNJ02A04	H39R-28-BEN	2016	1.35	From the dam of the pond downstream to the mouth at Deep Run
Stony Run UT	JM84	VAP-H39R_XYT01A08	H39R-15-BEN	2008	1.27	Headwaters to the mouth at Stony Run
Upham Brook	JL18	VAP-G05R_UPM01A02	G05R-16-BEN	2016	10.99	Headwaters to the mouth at the Chickahominy River, excluding Upham Brook from Flippen Creek to the UT above Wilkinson Rd.
	JL18	VAP-G05R_UPM01B08	G05R-16-BEN	2016	1.16	Flippen Creek downstream to UT above Wilkinson Road

Throughout the TMDL process, we will hold a series of Community Engagement Meetings to share information about the project with the community and ask for feedback and input. The purpose of Community Engagement Meetings is to merge outside expertise with local knowledge, so that together, we can produce a stream cleanup plan that is accurate, achievable, and acceptable to all parties. Areas where we will specifically ask for input from the community include:

- Historic and current land use
- Future development
- Previous and planned restoration projects
- Local monitoring efforts
- Key stakeholder groups and contacts
- Additional sources of data
- Ground truthing of stressors analysis findings
- Selection of pollutant reduction scenarios

Questions:
Any questions about the impairments included in this project?
Any questions about the TMDL process in general or the role of the community?

2. Benthic Stressor Analysis Approach

The goal of the Stressor Analysis is to identify the pollutant(s) responsible for the benthic impairment. This is accomplished by a weight of evidence approach that evaluates all available information on potential candidate stressors (Figure 2). These candidate stressors are separated into the following groupings: non-stressors, possible stressors, or probable stressors. The TMDL is then developed to target pollutants that are identified as probable stressors.

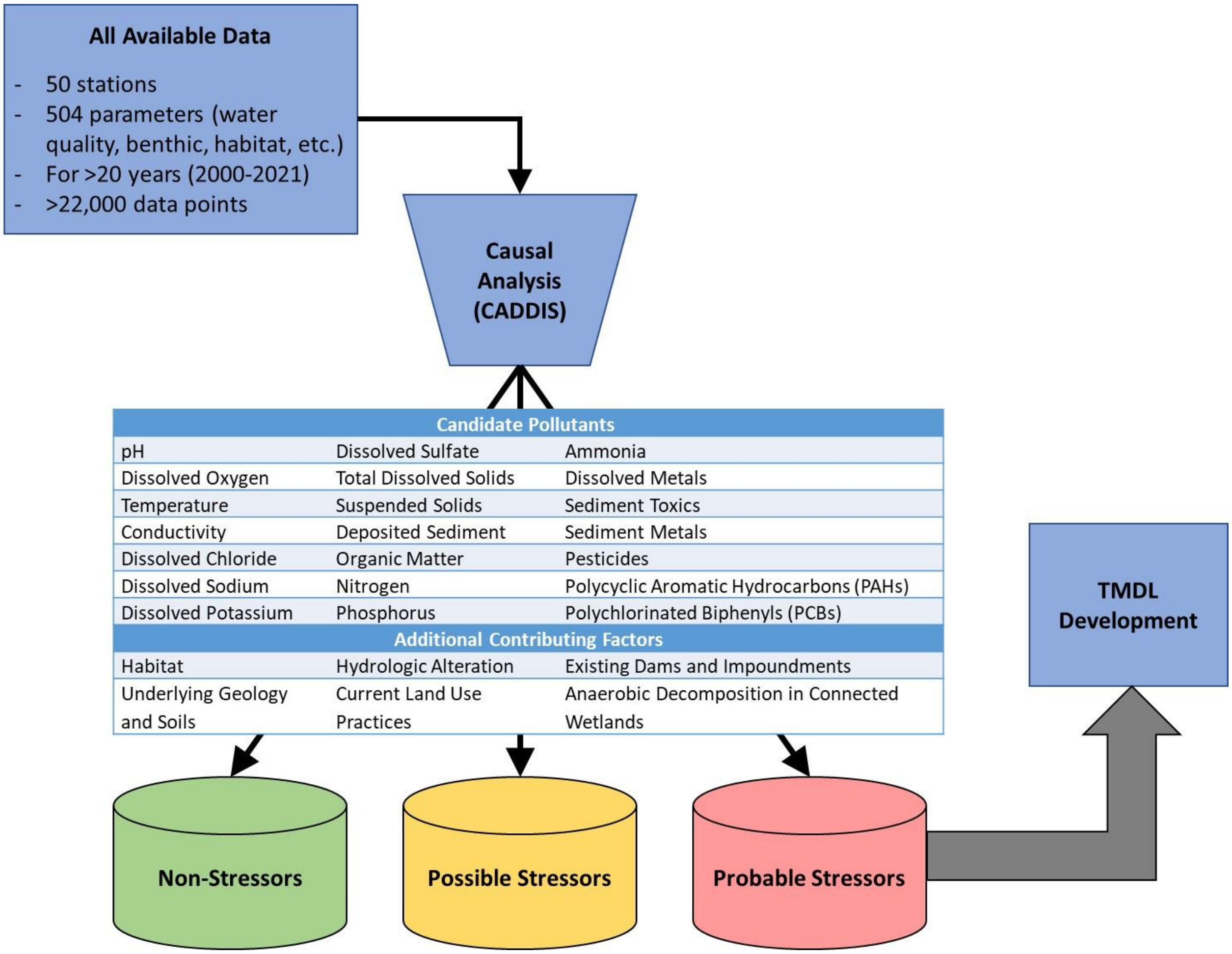

Figure 2. Stressor analysis approach.

In order to classify candidate stressors into the appropriate bins (non-stressor, possible stressor, probable stressor), JMU used a formal causal analysis approach developed by EPA, known as CADDIS (Causal Analysis Diagnosis Decision Information System). The CADDIS approach evaluates 18 lines of evidence that support or refute each candidate stressor as the cause of impairment (Table 2). In each stream, each candidate stressor is scored from -3 to +3 based on each line of evidence. Total scores across all lines of evidence are then summed to produce a stressor score that reflects the likelihood of that stressor being responsible for the impairment. Candidate stressors that have large negative scores are classified as non-stressors, those with low

(< 3) positive scores are classified as possible stressors, and those with high positive scores are classified as probable stressors.

Table 2. Example of CADDIS approach for a given stressor (does not reflect actual data).

Lines of Evidence	**Deep Run**	**Dover Creek**	**Jordans Branch**	**North Run**	**Stony Run**	**Stony Run UT**	**Upham Brook**
Spatial Co-occurrence	-3	-1	-1	-1	+2	+3	+3
Temporal Co-occurrence	-2	-1	0	0	+2	+2	+2
Causal Pathway	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Stressor-Response Relationships from the Field	-2	-1	+2	+2	+1	0	0
Temporal Sequence	-3	-1	0	0	+1	+1	+1
Symptoms	-2	-1	+1	+1	+2	+2	0
Stressor-Response Relationships from Other Field Studies	-2	-2	-2	-2	[illegible]	0	0
Stressor-Response Relationships from Laboratory Studies	-2	-1	+1	+1	+1	+1	+1
Stressor-Response Relationships from Simulation Models	-3	-1	+2	+2	+2	[illegible]	-3
Mechanistically Plausible Cause	-2	-1	0	0	-1	+2	+2
Manipulation of Exposure at Other Sites	-2	-2	-1	0	+2	+2	+2
Analogous Stressors	-2	-1	0	0	+1	+1	+1
Consistency of Evidence	-3	-1	0	0	+1	0	0
Explanation of the Evidence	-2	-1	0	0	+1	0	0
SUM	**-32**	**-17**	**+3**	**+2**	**+12**	**+10**	**+7**
	Non-Stressor		**Possible Stressor**		**Probable Stressor**		

Do this for each candidate cause

Scoring

Score	Explanation
+3	The line of evidence **strongly supports** the candidate stressor as the cause of the impairment
+2	The line of evidence **moderately supports** the candidate stressor as the cause of the impairment
+1	The line of evidence **weakly supports** the candidate stressor as the cause of the impairment
0	The line of evidence **does not support or refute** the candidate stressor as the cause of the impairment
-1	The line of evidence **weakly refutes** the candidate stressor as the cause of the impairment
-2	The line of evidence **moderately refutes** the candidate stressor as the cause of the impairment
-3	The line of evidence **strongly refutes** the candidate stressor as the cause of the impairment

Questions:
Is this approach clear?
Do you have any concerns regarding this approach?

3. Stressor Analysis Findings

The stressor analysis determined that sediment was a probable stressor in each of the impaired streams. Phosphorus was a probable stressor in Dover Creek, Stony Run, and Upham Brook. Dissolved oxygen (DO), pH, and organic matter were additional probable stressors in North Run due to natural wetland conditions (Table 3 and Table 4).

Table 3. Stressor analysis results.

Candidate Stressor	Deep Run	Dover Creek	Jordans Branch	North Run	Stony Run	Stony Run UT	Upham Brook
Temperature	-8	-10	-5	-6	-5	-8	-6
pH	-24	-23	-23	6	-24	-24	-9
Dissolved Oxygen	-5	-14	-2	13	1	-9	3
Conductivity/Total Dissolved Solids	3	-11	1	-1	2	3	3
Dissolved Sodium	3	-13	3	0	1	2	1
Dissolved Potassium	-3	-1	-1	-1	-3	-4	-2
Dissolved Chloride	-1	-13	-3	-10	-10	-3	-4
Dissolved Sulfate	-9	-11	-10	-12	-10	-12	-9
Sediment	10	5	9	12	12	12	12
Organic Matter	-1	0	-2	12	-1	-1	0
Phosphorus	-2	11	2	3	5	-2	9
Nitrogen	-11	2	1	-9	-9	-8	3
Ammonia	-15	-12	-13	-13	-15	-14	-12
Dissolved Metals	-13	-13	-13	-13	-13	-12	-13
Sediment Toxics	-2	-2	-5	-8	-6	-5	-2

Table 4. Stressor analysis results summarized.

Stream	Probable Stressors	TMDL Target
Deep Run	-Sediment	-Sediment
Dover Creek	-Sediment -Phosphorus	-Sediment -Phosphorus
Jordans Branch	-Sediment	-Sediment
North Run	-Sediment (-pH, Dissolved Oxygen, Organic Matter)	-Sediment (-natural conditions)
Stony Run	-Sediment -Phosphorus	-Sediment -Phosphorus
Stony Run UT	-Sediment	-Sediment
Upham Brook	-Sediment -Phosphorus	-Sediment -Phosphorus

3.1 Sediment

Some of the lines of evidence supporting sediment as a probable stressor in these streams included:

- Total habitat scores and instream habitat metrics were significantly lower in most streams than in the reference, indicating sediment as a stressor (Figure 3).
- Total habitat scores were significantly correlated with benthic health across sites.

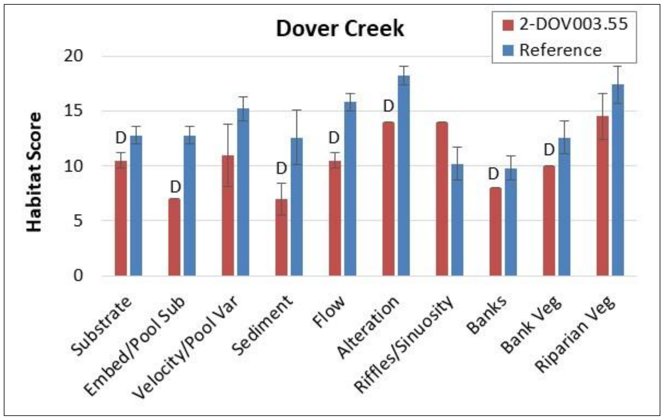

Figure 3. Bar chart of total habitat scores and instream habitat metrics.

- Total suspended solids and turbidity were significantly higher in some impaired streams than in the unimpaired reference (Figure 4).

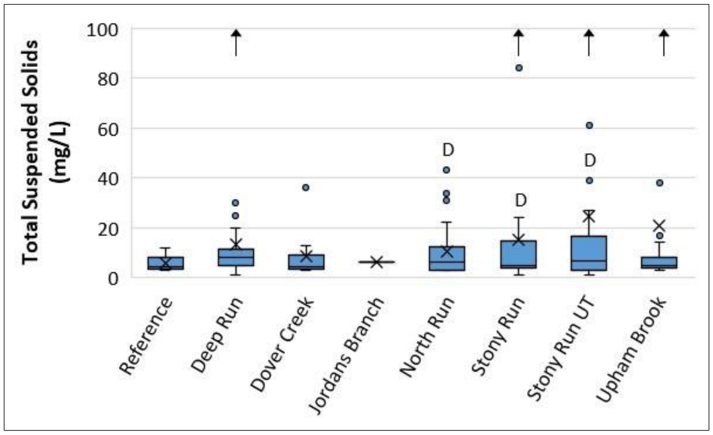

Figure 4. Box and whisker chart of total suspended solids for each watershed.

- Seasonal trends in benthic health in most streams indicated poor health in the spring following high spring flows that typically bring higher sediment loads.
- Taxonomic community structure indicated shifts to sediment-tolerant Dipteran dominated communities and away from Ephemeroptera, Plecoptera, and Trichoptera, which generally prefer clean substrate (Figure 5).

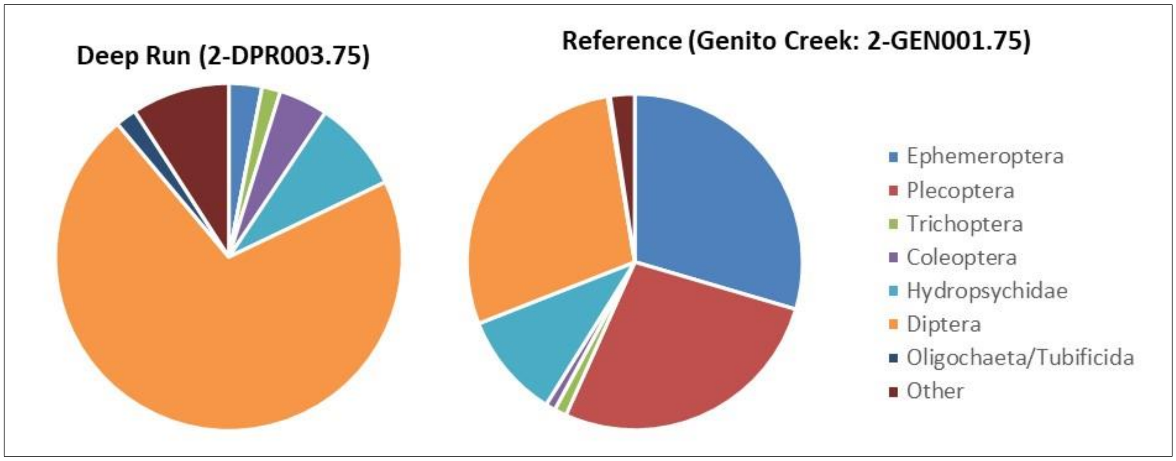

Figure 5. Pie chart showing shifts in taxonomic community structure.

- Average Biological Condition Gradient scores ranked sediment-associated stressors as the top stressor in most streams.
- Functional feeding group analysis in most streams indicated shifts to filterers and collectors that prefer sediment conditions and away from shredders and scrapers that prefer clean substrate (Figure 6).

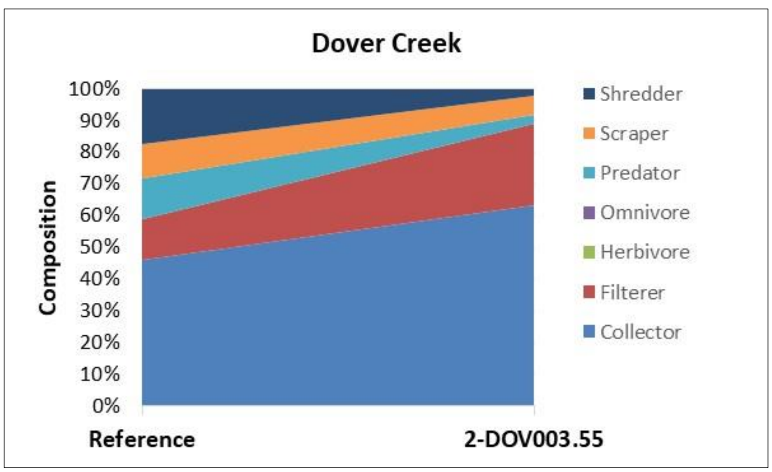

Figure 6. Stacked bar chart showing shifts in functional feeding groups.

- Relative bed stability analysis showed that the bed substrate in some streams (Deep Run, North Run, and Upham Brook) was unstable, and all streams exhibited significant embeddedness (43-96%).

Questions:
Do these findings seem reasonable based on your knowledge and experience in the watershed?

3.2 Phosphorus

Some of the lines of evidence supporting phosphorus as a probable stressor in Dover Creek, Stony Run, and Upham Brook included:

- Median phosphorus levels in Stony Run and Upham Brook were in the medium probability range for stressor effects, and phosphorus levels in Dover Creek were in the high probability range (Figure 7).
- On or around the time of benthic sampling, phosphorus levels in Dover Creek and Stony Run were in the high probability range for stressor effects.
- Streams exceeded EPA-recommended phosphorus criterion for the ecoregion.

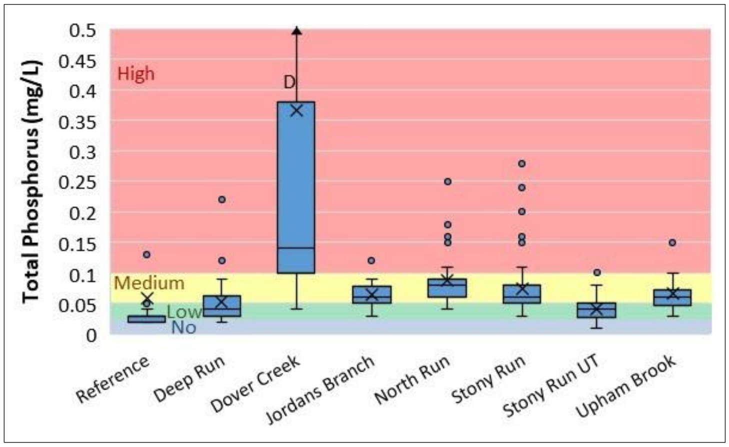

Figure 7. Box and whisker chart of total phosphorus for each watershed.

- Low DO (below 5 mg/L), indicating potential nutrient enrichment, was observed in each of these streams (Figure 8).

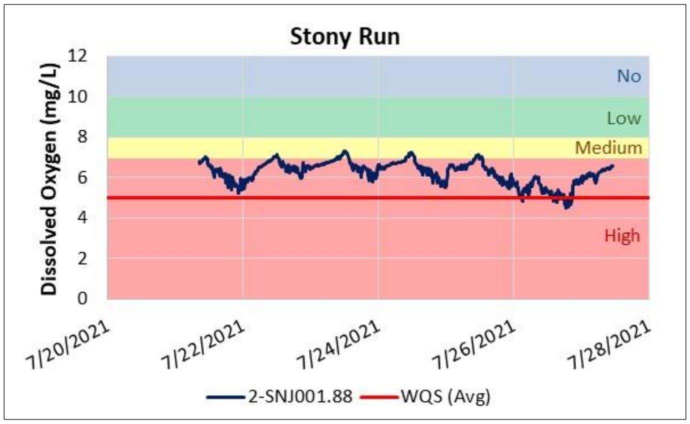

Figure 8. Line chart showing dissolved oxygen information over time.

- Large diurnal swings in DO in Upham Brook may indicate nutrient enrichment (Figure 9).

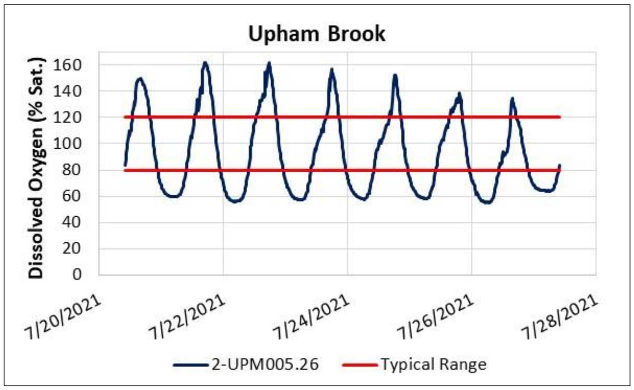

Figure 9. Line chart showing diurnal swings in dissolved oxygen over time.

- Biological condition gradient scores ranked nutrients as the top stressor in Dover Creek and second stressor in Stony Run and Upham Brook.

Questions:
Do these findings seem reasonable based on your knowledge and experience in the watershed?

3.3 pH, Dissolved Oxygen, and Organic Matter

Some of the lines of evidence supporting pH, DO, and organic matter as probable stressors under natural conditions in North Run included:

- Four samples in North Run were below the pH water quality standard of 6.0 (Figure 10).

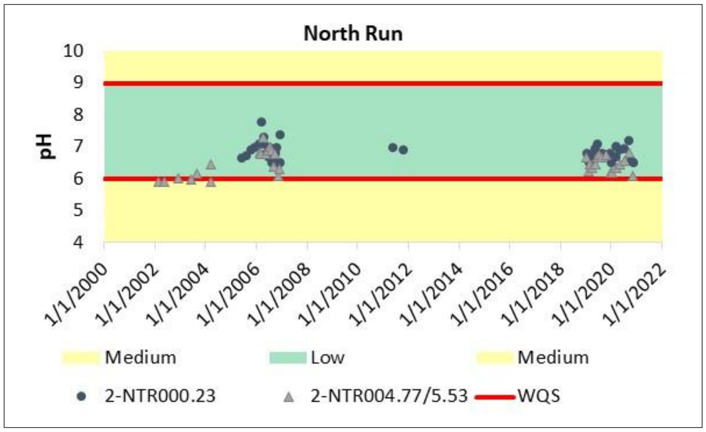

Figure 10. Scatterplot chart of pH for North Run.

- DO in North Run was consistently below the water quality standard of 5 mg/L (Figure 11).

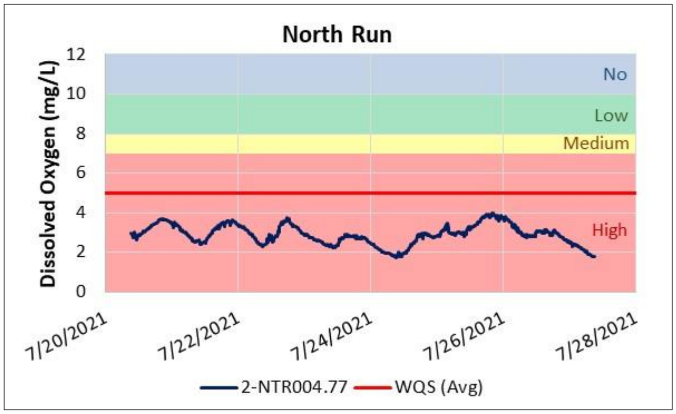

Figure 11. Line chart of dissolved oxygen for North Run.

- Total organic carbon was much higher than in the reference, and dissolved organic carbon was above the 80th percentile of Mid-Atlantic coastal plain streams (Figure 12).

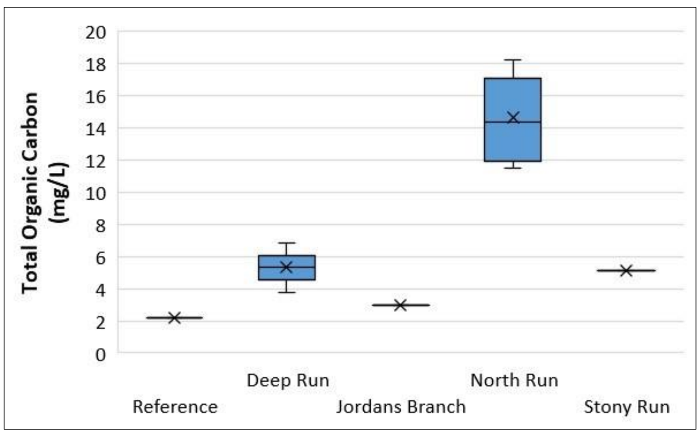

Figure 12. Box and whisker chart for total organic carbon.

- The low pH, low DO, and high organic matter conditions in North Run were determined to be a natural condition resulting from the prevalence of connected wetlands (14% of upper North Run watershed). In these permanently or periodically flooded wetlands, oxygen is quickly depleted and decomposition of dense organic matter proceeds through anaerobic pathways that can lead to the production of organic acids.

Questions:
Do these findings seem reasonable based on your knowledge and experience in the watershed?

4. Watershed Land Cover

Land cover data from the Virginia Geographic Information Network's (VGIN) 2016 Virginia Land Cover Database (VLCD) was used to estimate acres of the various land cover categories in each TMDL watershed (Table 5 and Table 6). Land cover maps of the TMDL watersheds are provided in Figure 13, Figure 14, and Figure 15. Estimated sediment and phosphorus loading rates could then be applied to each land cover category to estimate the amount of the pollutants originating from that land cover category in each watershed.

Questions:
Do you know of any recent or planned land cover changes that we should be reflecting?

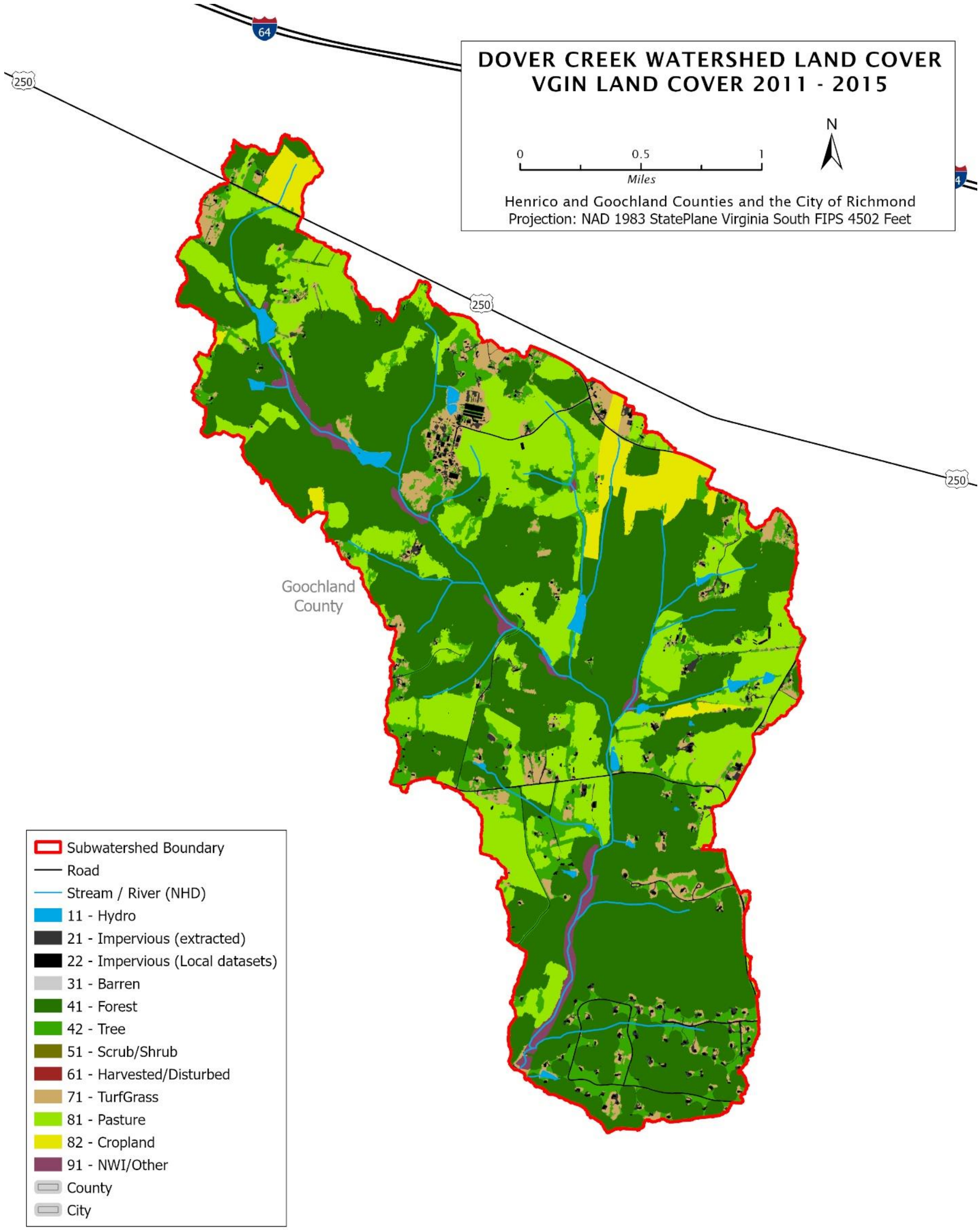

Figure 13. VGIN VLCD distribution for Dover Creek.

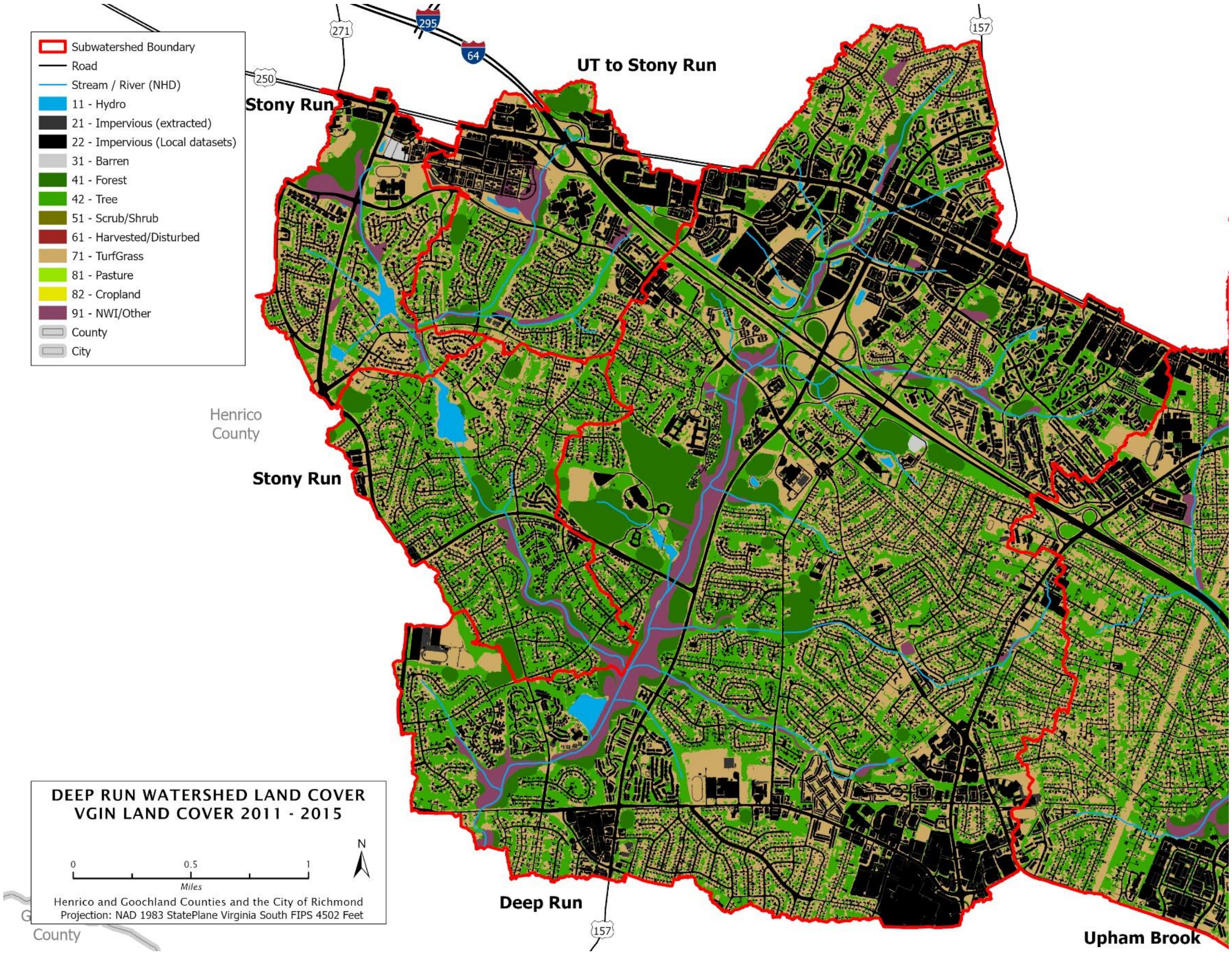

Figure 14. VGIN VLCD distribution for Deep Run and tributaries Stony Run and UT to Stony Run.

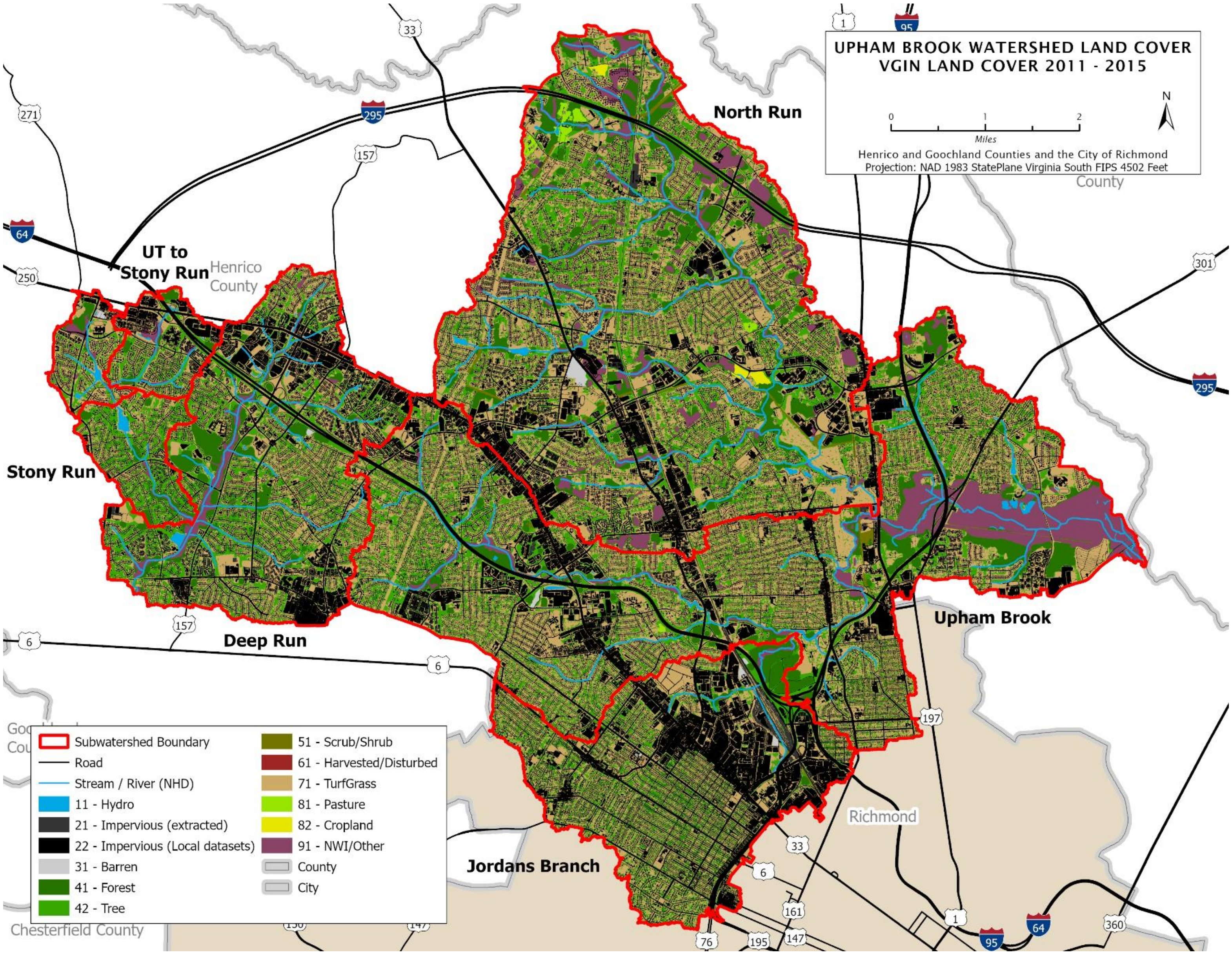

Figure 15. VGIN VLCD distribution for Upham Brook and tributaries North Run and Jordans Branch.

Table 5. VGIN VLCD in the study watershed. Acreages are inclusive of upstream impaired watersheds (e.g. Stony Run acreages include acreages of UT to Stony Run).

Land Use	**Dover Creek**		**UT to Stony Run**		**Stony Run**		**Deep Run**	
	Acres	Percentage (%)	Acres	Percentage (%)	Acres	Percentage (%)	Acres	Percentage (%)
Cropland	111.4	3.5%	-	-	-	-	-	-
Hay/Pasture	695.7	21.9%	-	-	-	-	-	-
Forest	1759.1	55.4%	25.3	4.1%	97.5	5.5%	366.6	5.8%
Trees	277.0	8.7%	125.1	20.4%	476.4	26.6%	1540.1	24.4%
Shrub	-	-	-	-	-	-	0.2	0.0%
Water	30.9	1.0%	1.7	0.3%	24.2	1.4%	43.3	0.7%
Wetland	49.6	1.6%	25.1	4.1%	65.4	3.7%	234.0	3.7%
Barren	-	-	-	-	3.7	0.2%	6.1	0.1%
Turfgrass	149.7	4.7%	163.7	26.7%	489.4	27.4%	1745.5	27.6%
Impervious (extracted)	51.2	1.6%	25.2	4.1%	60.6	3.4%	251.6	4.0%
Impervious (local datasets)	50.0	1.6%	246.0	40.2%	571.6	32.0%	2136.7	33.8%
Total	*3,175*	*100%*	*612*	*100%*	*1,789*	*100%*	*6,324*	*100%*

Table 6. VGIN VLCD distributions in the study watershed continued. Acreages are inclusive of upstream impaired watersheds (i.e. Upham Brook acreages include acreages of North Run and Jordans Branch).

Land Use	**North Run**		**Jordans Branch**		**Upham Brook**	
	Acres	Percentage (%)	Acres	Percentage (%)	Acres	Percentage (%)
Cropland	31.0	0.3%	-	-	31.0	0.1%
Hay/Pasture	48.8	0.5%	-	-	51.7	0.2%
Forest	782.0	7.2%	113.0	2.8%	1465.3	5.8%
Trees	2140.0	19.7%	677.6	16.7%	4876.5	19.3%
Shrub	70.9	0.7%	3.4	0.1%	109.1	0.4%
Water	51.9	0.5%	0.3	0.0%	107.2	0.4%
Wetland	716.3	6.6%	24.6	0.6%	1676.7	6.6%
Barren	25.7	0.2%	10.6	0.3%	41.9	0.2%
Turfgrass	3600.3	33.2%	1042.2	25.8%	7829.0	30.9%
Impervious (extracted)	505.3	4.7%	207.1	5.1%	1112.7	4.4%
Impervious (local datasets)	2875.3	26.5%	1967.8	48.6%	8008.5	31.6%
Total	*10,848*	*100%*	*4,047*	*100%*	*25,309*	*100%*

5. Next Steps

Once a probable stressor has been determined and land cover has been estimated in the watersheds, the next step in the TMDL process includes pollutant source assessment, model development, and endpoint determination (Figure 6). The pollutant source assessment identifies all of the pollutant sources within the watershed and estimates the loads coming from each source. Model development takes all that we know about the watershed, including watershed characteristics, weather, and pollutant sources, and puts it into a calibrated mathematical model. Endpoint determination identifies how much of the pollutant can be assimilated by the stream without exceeding water quality standards. Community Members are asked to provide input on the pollutant sources, modeling approaches, and endpoints in the second Community Engagement Meeting (CEM).

The third Community Engagement Meeting (CEM) will cover the TMDL allocation scenarios to meet the TMDL endpoint for each pollutant, following development and approval of the calibrated and validated watershed models. The scenarios will include waste load allocations (WLA) for all permitted facilities in the watersheds; calculations are based on guidance from DEQ to ensure the appropriate concentration and/or loading rate targets are employed for each facility. The load allocation (LA) from non-point sources and a margin of safety (MOS) will also be included in the TMDL allocation scenarios. Community Member input will be considered when selecting the final allocation scenario for each watershed. Lastly, a final Public Meeting and public comment period will be held for the TMDL followed by the Implementation Plan (IP).

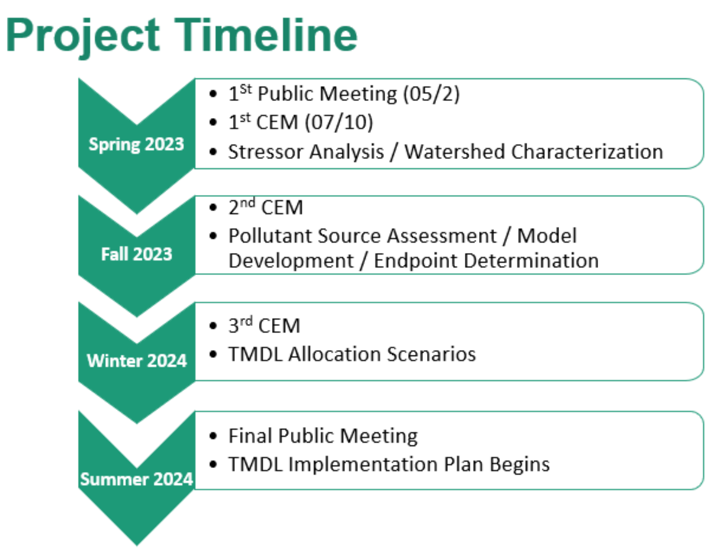

Figure 16. Project timeline.