

Road Segment Risk Assessment: Harford County, Maryland

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Executive Summary

The Department of Public Works in Harford County has requested road segments at risk of erosion be identified for preventive maintenance application. The final deliverable for this project will be a map, data, and report categorizing the risk levels along with a list of the most at-risk road segments. A Hot Spot Analysis identifying areas with the greatest concentration of at-risk road segments will also be included.

The project had several phases. First, county road sections that were not bridges and that were close to streams (<25 feet) were selected and isolated. Second, the team calculated and characterized the soil type, drainage area, and distance from the stream as erosion risk indicators. Third, the team created an index that weights soil type, drainage area, and distance to identify the highest risk road segments. The team then separated the identified road segments into high, medium, and low risk categories and produced a list of the 347 road segments most at-risk. After a hot-spot analysis to find areas of the county that contain clusters of high-risk road segments, the team finished by reporting to the county the roads in need of checks or repair.

Project Background and Purpose

With the increases in storm frequency and intensity there is a need to take preventive measures against road embankment failures and erosion. As scientists predict even more extreme storm events in the near future due to climate change, this project is relevant to taking

proactive actions against problems. Early action should save the county money as preventive measures are usually cheaper than those taken to repair after the fact. Further development of previously low-density areas creates demands for roads as well as increases resource and amenities access and creates more runoff from these impervious surfaces. The quantity and force of the stormwater in contact with these surfaces and entering the stream systems increases detrimental embankment erosion effects. The development also increases population, so these road failures would affect more people living in or visiting Harford County. More runoff is also a consequence of these eroded road embankments as streams cut into the soil and carry it downstream. This causes water pollution issues as sediment and other debris enters major water systems possibly disrupting natural processes.



Figure 1. Eroded road embankment (Jeff Stratmeyer, Harford County Department of Public Works)



Figure 2. Repaired road embankment (Jeff Stratmeyer, Harford County Department of Public Works)

Jeff Stratmeyer of the Division of Highways within the Harford County Department of Public Works asked us to identify road segments that are at risk of embankment erosion based on three characteristics: soil type, drainage area, and distance from a stream. The county will use this information to proactively repair and strengthen road embankments. We hope to provide the county with information that will help them prioritize resources to maintain roadway infrastructure in the most cost-effective way.

Background Research

The project began with research on road segments near streams that are at risk of embankment erosion to identify similar experiences and to familiarize the team with the variables used in this project. For example, the definition of a drainage system or the measurements usually taken to identify and maintain roads at risk. The team also noted that

roads and streams cross each other in different ways and specific interventions are recommended for each.

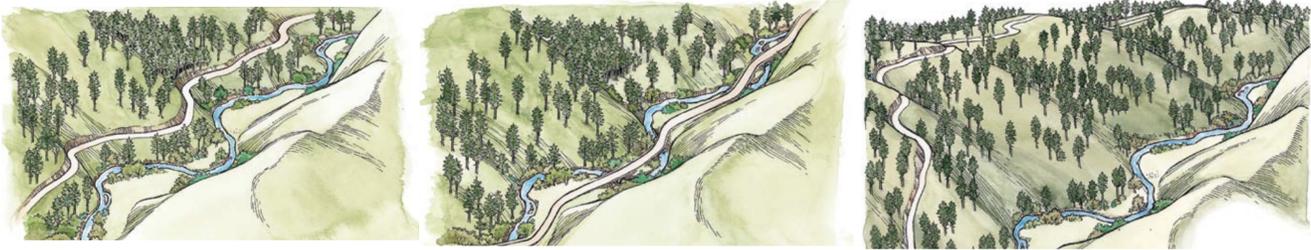


Figure 3: Roads and streams crossings (A Guide for Forest Access Road Construction and Maintenance in the Southern Appalachian Mountains)

Roads are an essential part of forest management and if they not well planned, constructed, and maintained, roads located next to streams, on steep slopes or on unstable topography can erode with sediment loss or destruction over time.

A drainage system, also known as river systems, are the patterns formed by the streams, rivers, and lakes in a particular drainage basin. Some studies recommend installing a culvert or ditch drainage system to reduce the amount of water flowing onto the road and to direct water away from the road.

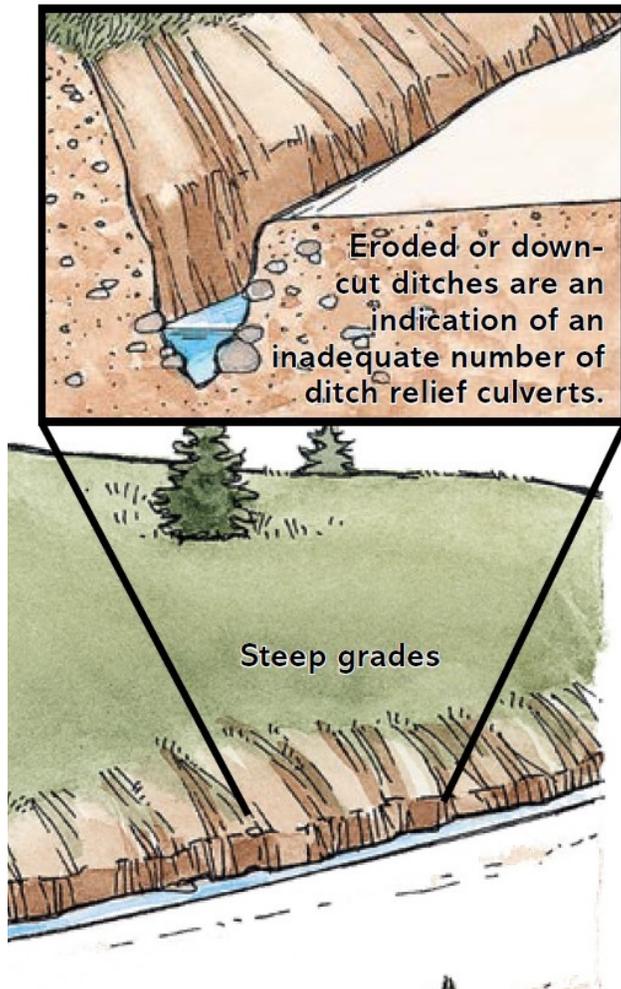


Figure 4. Erosion indication (A Guide for Forest Access Road Construction and Maintenance in the Southern Appalachian Mountains)

These studies led the team to better understand this project, how to address the issue, and how to inform the county about problem areas needing immediate maintenance attention.

Objectives

1. Identify at-risk county road segments that are prime spots for Harford County to implement preventive maintenance and proactive repair.

2. Identify locations with a high concentration of at-risk road segments and deliver a list of most at-risk road segments with accompanying data and maps.

Data Collection and Preparation

All layers and metadata descriptions were provided by the Harford County Department of Public Works. This included four county stream layers, a road centerline layer, a planimetric layer showing the horizontal position of bridge features on the Earth's surface and a soil type layer. The original centerline attribute dataset included road names, which were used to label the segments for the final report. Research determined the erodibility of the soil types and used the built-in digital elevation model (DEM) layer in ArcGIS online to calculate the drainage areas. Data was cleaned using Microsoft Excel and then put into ArcMap for analysis and visualization.

Methods

Identifying At-Risk Road Segments

In the four layers of streams data, the fourth layer contained ditches and small streams so this layer was excluded from the calculations. The merge tool was used to combine stream layers 1, 2, and 3 into one layer. The county-provided centerline layer depicted roads besides county roads so the team first identified just county roads using the variable "SHIELD." Selected roads were labeled "C" and exported out into a separate layer. Based on conversations with the county, they believed the most at-risk streams are located within 25 feet of streams. The team

used the buffer tool to create a 25-foot buffer along all of the streams and filtered out segments within the buffer using the clip tool. These road segments were selected and exported into a separate layer.

The county also provided the planimetric shapefile that lists bridges as attributes. “Select by attributes” was used to identify bridges and remove them from the layers. “Select by location” for those bridges that fall within or cross the road segments was performed and all segments that didn’t meet these conditions were exported into a separate layer. The team found 347 road segments of interest for this project (Figure 5).

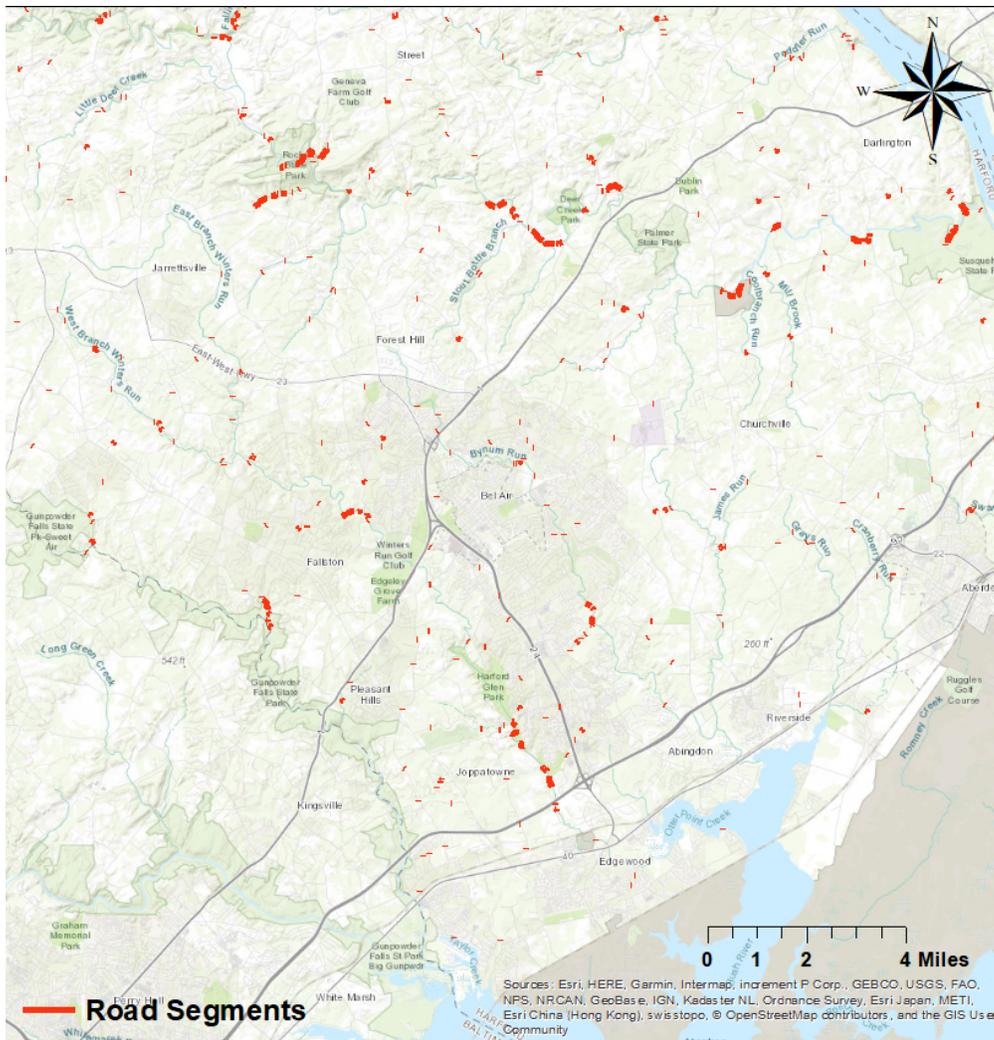


Figure 5. Identified road segments

Identifying Soil Characteristics

The team researched and used soil classification data document from the Harford County Health Department (source: U.S. Geological Survey). The document includes all the soil types within the county and also other information including period to test, drainage class,

flooding, depth to bedrock and stoniness, slope, and overall soil rating.

SOIL SERIES	MAP SYMBOL	PERIOD TO TEST	SOIL DRAINAGE CLASS	FLOODING	DEPTH TO BEDROCK AND STONINESS	PERM. FIRST 4FT	SLOPE	OVERALL SOIL RATING
Anytime - Soils to be tested at anytime of the year		Restricted Test -Soils must be tested typically between Feb. 1 - April 30th but actual dates subject to precipitation and monitoring well info.			Do Not Test - Soils cannot be tested at anytime due to flooding			
Aldino	Ada,AdB,AsB AdC	Feb. 1- April 30th	Moderate Moderate	Slight Slight	Slight Slight	Severe Severe	Slight Moderate	Severe Severe
Aluvial Land	Av	Do Not Test	Severe	Severe	Slight	Variable	Slight	Severe
Baile	BaA,BaB	Feb. 1- April 30th	Severe	Slight	Slight	Severe	Slight	Severe
Beltsville	BeA,BeB,BeC	Feb. 1- April 30th	Moderate	Slight	Slight	Severe	Slight	Severe
Brandywine	BrC2 BrD3,BrE3	Anytime Anytime	Slight	Slight	Slight	Slight(2)	Moderate Severe	Moderate Severe
Chester	CcA,CcB2,CgB2 CcC2,CgC2 CgD2	Anytime Anytime Anytime	Slight Slight Slight	Slight Slight Slight	Slight Slight Slight	Slight Slight Slight	Slight Moderate Severe	Slight Moderate Severe
Chillium*	ChB2	Feb. 1- April 30th	Slight	Slight	Slight	Moderate	Slight	Moderate
Chillium-Nesh.*	CkC2	Feb. 1- April 30th	Slight	Slight	Slight	Moderate	Slight	Moderate
Chrome*	CrE	Feb. 1- April 30th	Slight	Slight	Severe	Moderate	Severe	Severe
Dodorus	Du	Do Not Test	Mod to Severe	Severe	Slight	Slight	Slight	Severe
Comus	Cv	Do Not Test	Slight	Severe	Slight	Slight	Slight	Severe
Cut and fill Land	Cx	Not Rated To Variable						
Delanco	Dca,DcB	Feb. 1- April 30th	Moderate	Slight	Slight	Severe	Slight	Severe
Elioak	EhB2 EhC2	Anytime Anytime	Slight Slight	Slight Slight	Slight Slight	Slight Slight	Slight Moderate	Slight Moderate
Elkton	En	Feb. 1- April 30th	Severe	Slight	Slight	Severe	Slight	Severe
Elsinboro	EsA,EsB2,EsC2	Anytime	Slight	Slight	Slight	Slight	Slight	Slight
Evesboro	EvC	Anytime	Slight	Slight	Slight	Slight(2)	Slight to Mod.	Slight to Mod.

(1) These soils have a seasonally perched zone of saturation above a firm, dense subsoil or fragipan.

Figure 6. Soil classification table (U.S. Geological Survey)

According to *A Guide for Forest Access Road Construction and Maintenance in the Southern Appalachian Mountains* (2014), erosion control and stability of fill slopes and cut banks are impossible to maintain on poorly drained soils, which makes this data crucial in creating a risk index. Based on that information, the team picked overall soil rating as the reference for classifying road segment soil types. In this rating, soil types are classified in four categories: slight, slight to moderate, moderate, and severe with severe indicating the highest

risk of erosion. The team assigned values from 1 to 4 based on the overall soil rating, with 1 representing slight risk and 4 representing severe risk. This was difficult to perform in ArcMap so Microsoft Excel was used instead.

Soil Rating System	
Soil Description	Rating
Severe	4
Moderate	3
Slight to Moderate	2
Slight	1

Figure 7. Soil rating system

This data was converted into a Microsoft Excel workbook and joined the map's table. The team used the resulting data to classify road segment soil types and removed the seven segments that didn't have soil data reported, resulting in a final 347 road segments. The next task was to turn the description of the soil erosion risk into a quantifiable number for the index.

Calculating Distance Between Stream and Road

ArcMap's "near (analysis)" tool was used to calculate the distance in feet between stream and road. This tool identifies the shortest distance between the nearest polylines between two layers. Many segments were identified with a distance of zero feet as they run directly parallel to the stream.

Calculating the Watershed Area

The “feature to point” tool was used to find the midpoint of the lines (road segments). This data was uploaded to ArcGIS online for the “create watersheds” tool under the analysis toolbox. This tool calculates where water entering the stream system at the center of the road segment comes from and the square mile area of this coverage. This tool snaps to the closest drainage line of the center of the road segments and adjusts those points as needed. The attribute table for ArcGIS online was exported as a .csv file and the “join” tool was used to combine this information with the existing road segments attributes.

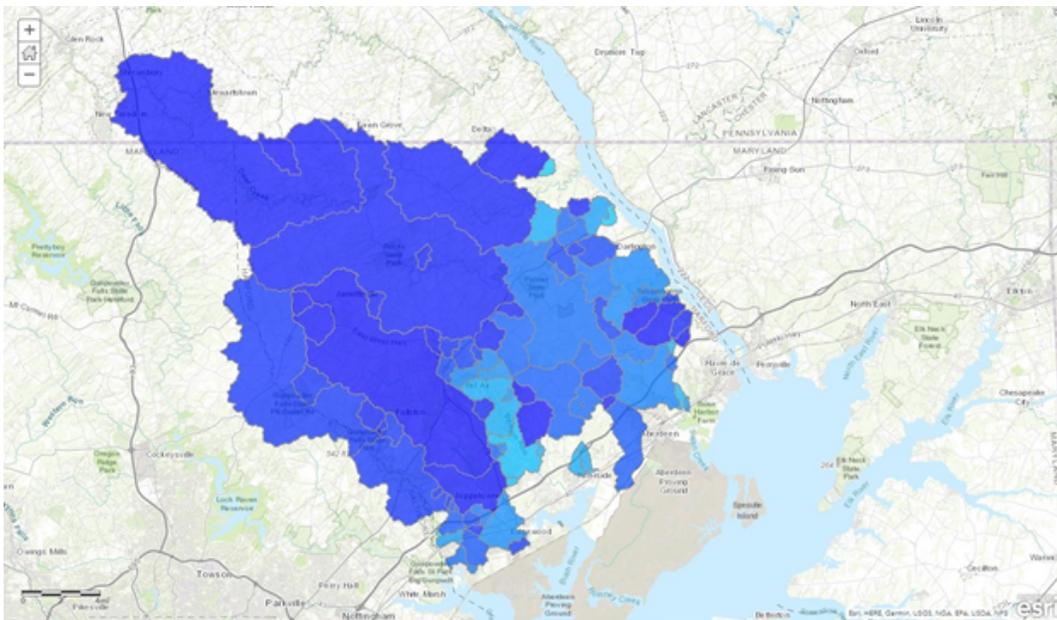


Figure 8. Watershed areas identified in ArcOnline

Risk Index Creation

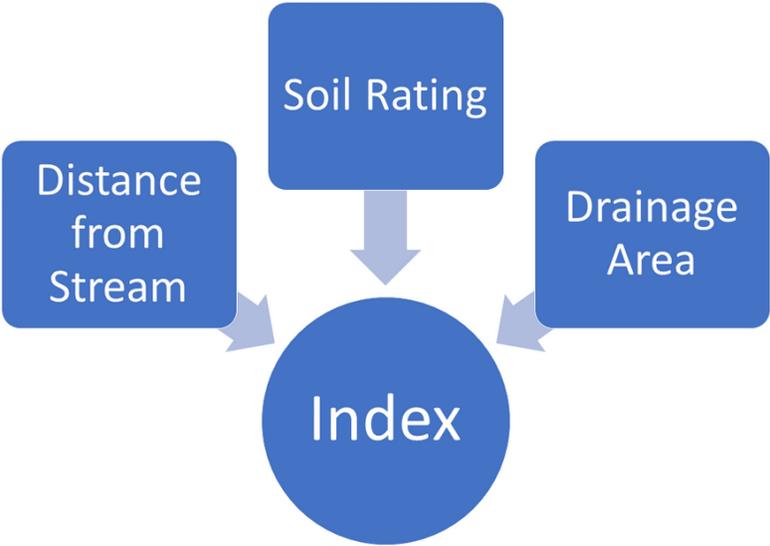


Figure 9. Risk index

Standardizing Variables – Z-Scores

After calculating all three variables the team then compiled the index. The “table to Excel” tool was used to export the road segment attribute table into Excel. This table was used to calculate the means and standard deviations for all three variables to prepare for calculating the z-scores. This function standardizes the variables to easily create the index using variables that were initially measured in different units. The following equation was used to calculate the z-score (Taylor, 2014):

$$z = \frac{x - \mu}{\sigma}$$

μ = Mean
 σ = Standard Deviation

Adding Weight Factors

Based on conversations with the client, weights were assigned to each variable's z-score. Distance to the road was identified as the most critical variable. It was given a weight of 50 percent and subtracted from the other variables because the closer a stream is to a road, the more vulnerable the road segment is to bank erosion. Drainage area and soil rating were considered to be of equal value and were given weights of 25 percent. The result was the following equation:

$$\text{Segment Equation: Risk Index} = (0.25 * \text{Drainage Area}) + (0.25 * \text{Soil Type}) - (0.5 * \text{Distance between road and stream})$$

Results

Higher index scores represent a greater risk that the road will face severe embankment erosion that requires maintenance or major repairs. These index values for the identified 347 at-risk road segments were broken into three categories and mapped in red for high risk, orange for moderate risk, and yellow for low risk (Figure 10). A road's risk category was determined based on where in the distribution of index scores the segment fell. So, a low-risk segment is in the bottom third of index scores, a moderate in the middle third, and a high-risk segment is in the top third of the index scores.



Figure 10. Symbolized road segments

Analysis

While most segments are short one-off stretches of road, there are some areas that seem to have a concentration of high-risk segments. For example, Walters Mill Road, off of Route 1 parallels Deer Creek, has significant flows that are the likely reason for multiple high-risk segments. Harmony Church Road by the Churchville Test Area is another road with long stretches of high-risk segments. Deer Creek parallels this road as well. Other significant

stretches of risk include Knopp Road by Rocks State Park and Craigs Corner Road in Susquehanna State Park.

Highest Risk Road Segments

The table below shows a subset of the ten most at-risk segments taken from the full list of 347 road segments at very high risk (attached in the appendix). Since most of the at-risk segments are parallel or very close to streams, the watershed area and soil rating are instrumental in ranking the roads. The watershed area, being a continuous variable, is a very consequential variable.

Rank	Street	Length (ft)	Soil Rating	Distance to Stream (ft)	Watershed Area (sq mi)	Index Score
1	Stafford Rd	544.66	4	0	170.81	2.02
2	Glenville Rd	336.13	4	0	161.22	1.91
3	Stokes Rd	36.41	4	0	161.20	1.91
4	Harmony Church Rd	3,246.37	4	0	143.74	1.73
5	Sandy Hook Rd	2,155.20	4	0	124.80	1.53
6	Sandy Hook Rd	1,705.82	4	0	123.52	1.52

7	Walters Mill Rd	3,771.92	4	0	119.16	1.47
8	Walters Mill Rd	2,699.64	4	0	110.72	1.38
9	Holy Cross Rd	564.02	4	0	87.01	1.13
10	Grier Nursery Rd	3,099.07	3	0	104.27	1.10

Figure 11. Most at-risk road segments

Risk Hot Spot Analysis

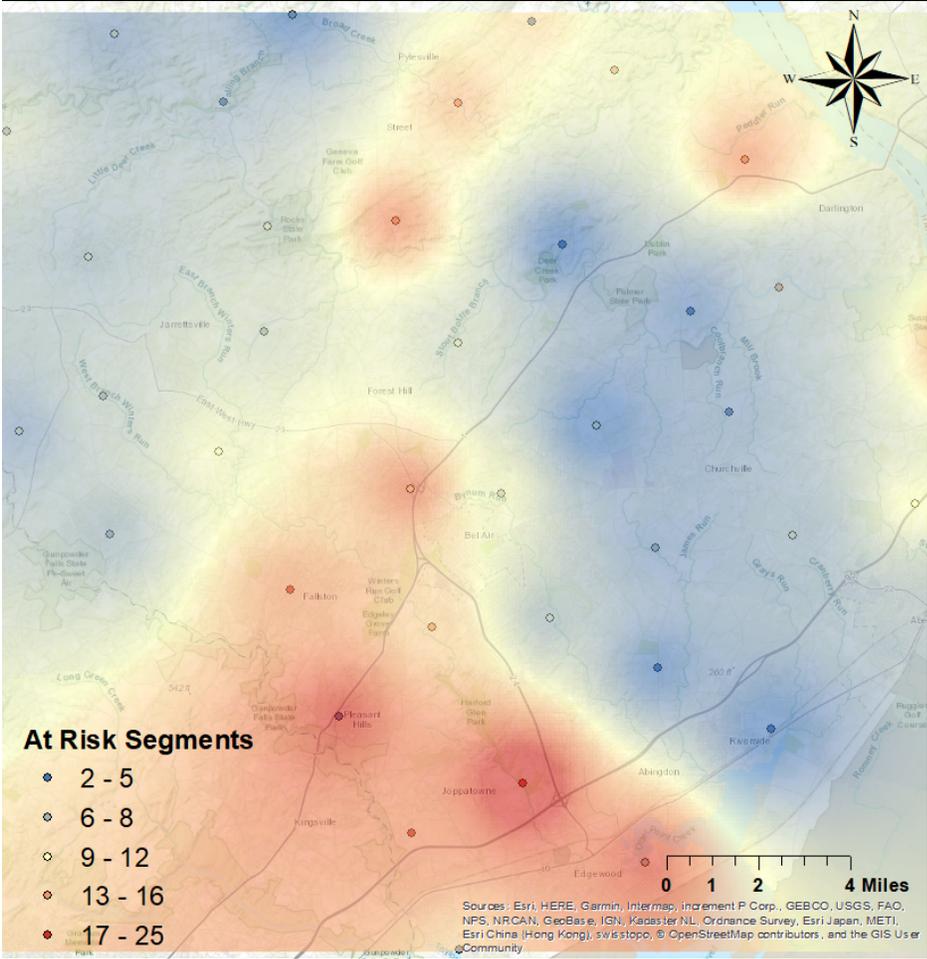


Figure 12. Hot spot analysis

The “hot spot analysis” tool was used to identify clusters of at-risk road segments so the county can decide where to prioritize resources. Figure 12 is a supplementary map that identifies areas with severe embankment erosion risk road segments, which should help the Department of Public Work optimize investigation of the status of these road segments. The team aggregated the number of at-risk road segments within a one-mile radius. Based on the result shown in Figure 12, the highest concentration of road segments are located in the southern portion of the county by Harford Glen Park. By contrast, the area around Bel Air is not as concentrated with at-risk segments. Areas with between 17 and 25 high-risk road segments are identified in darker red. There are a few hotspots in the northern part of the county as well, around the state parks (Rocks State Park and near the Susquehanna River). This is likely due to the steep topography and rivers that run through the parks.

While it’s useful to know where the concentrations of segments are, it is important to note that the segments are spread fairly evenly throughout the county. The clusters concentrated in the southern part of the county follow the County’s major roads including Route 1, Veterans Memorial Highway, and I-95 near more highly developed areas.

Further Research and Recommendations

On this project, the team noted that the slope of an area around a road segment is also a major factor in possible embankment erosion. Road segments located at the lowest points receive the greatest amount of water flow no matter where the segment is within the watershed. The county didn’t request this factor and so the team didn’t calculate or include this

factor in the deliverables. However, further analysis of the segments with embankment erosion potential should include corresponding elevation in the calculations.

The Harford County Department of Public Works should consider starting preventive maintenance and proactive repair within the identified hot spot clusters. Roads and paths along Deer Creek should also be prioritized based on its high flow and the large number of roads it intersects and parallels.

References

A Guide for Forest Access Road Construction and Maintenance in the Southern Appalachian Mountains, the N.C. Forest Service, N.C. Wildlife Resources Commissions, 2014 United States Department of Agriculture, <https://www.ncforestservice.gov/publications/WQ0214.pdf>

U.S. Geological Survey. *Harford County Soil Chart*. Harford County Health Department.

Retrieved from:

<http://harfordcountyhealth.com/wp-content/uploads/2011/02/Harford-County-Soils-Chart.pdf>

Taylor, Courtney. (2014, May 21). Z-Score Formula. Retrieved from:

<https://www.thoughtco.com/z-score-formula-3126281>

Appendix

OBJECTID in ArcGIS	Street	Zip Code	Municipality	Length (ft)	Index Score
11611	STAFFORD RD	21078	HAVRE DE GRACE	544.663	2.01546
340	GLENVILLE RD	21034	DARLINGTON	336.135	1.91403
7476	STOKES RD	21034	DARLINGTON	36.4074	1.91385
7106	HARMONY CHURCH RD	21034	DARLINGTON	3246.37	1.72922
685	SANDY HOOK RD	21154	STREET	2155.2	1.52883
593	SANDY HOOK RD	21015	BEL AIR	1705.82	1.5153
3156	WALTERS MILL RD	21050	FOREST HILL	3771.92	1.46923
3780	WALTERS MILL RD	21050	FOREST HILL	2699.64	1.37989

9624	HOLY CROSS RD	21154	STREET	564.02	1.12919
23656	GRIER NURSERY RD	21154	STREET	3099.08	1.10427
22832	RED BRIDGE RD	21132	PYLESVILLE	765.419	0.86
3356	PERRY AVE	21040	EDGEWOOD	21.098	0.81602
13813	FASHION WAY	21085	JOPPA	911.145	0.77313
2871	FRANKLINVILLE RD	21085	JOPPA	756.866	0.75749
7853	JERUSALEM RD	21087	KINGSVILLE	84.8499	0.70277
6862	SINGER RD	21085	JOPPA	5.04728	0.69368
1175	HARFORD CREAMERY RD	21161	WHITE HALL	533.223	0.62982
20804	JOLLY ACRES RD	21161	WHITE HALL	208.173	0.60016
20800	GREEN RD	21161	WHITE HALL	360.965	0.5412
20802	GREEN RD	21161	WHITE HALL	6.97104	0.54061
13755	VALE RD	21014	BEL AIR	462.51	0.53179
543	GREENE RD	21013	BALDWIN	253.514	0.46494
12634	PLEASANTVILLE RD	21050	FOREST HILL	573.417	0.41848
5598	MILL GREEN RD	21154	STREET	443.73	0.38305
8238	TAYLOR RD	21154	STREET	431.512	0.36762
10783	WHEEL RD	21015	BEL AIR	129.771	0.35145

13921	ROBIN HOOD RD	21078	HAVRE DE GRACE	191.37	0.34502
13923	ROBIN HOOD RD	21078	HAVRE DE GRACE	143.552	0.3411
13922	ROBIN HOOD RD	21078	HAVRE DE GRACE	40.1468	0.3411
24086	RIDGE RD	21132	PYLESVILLE	1012.93	0.32995
2341	OLD ROBIN HOOD RD	21001	ABERDEEN	514.679	0.32069
12763	MACPHAIL RD	21015	BEL AIR	138.125	0.31383
21639	MADONNA RD	21154	STREET	357.173	0.31016
1428	PUTNAM RD	21050	FOREST HILL	147.872	0.30234
13295	BRIERHILL DR	21015	BEL AIR	122.84	0.3006
11531	NOVA SCOTIA RD	21015	BEL AIR	824.63	0.29574
24465	ST MARYS RD	21132	PYLESVILLE	32.5243	0.28482
24063	OLD PYLESVILLE RD	21132	PYLESVILLE	168.768	0.28481
24062	OLD PYLESVILLE RD	21132	PYLESVILLE	31.4862	0.28481
5062	MOORES MILL RD	21014	BEL AIR	692.514	0.28472
3941	POTEET RD	21050	FOREST HILL	124.198	0.28445
2060	PHILLIPS MILL RD	21050	FOREST HILL	443.789	0.28414
13889	THOMAS RUN RD	21015	BEL AIR	280.931	0.28301

8285	CHARLES ST	21047	FALLSTON	3752.97	0.27121
1506	MORSE RD	21050	FOREST HILL	125.827	0.27044
881	SPESUTIA RD	21001	ABERDEEN	133.963	0.26941
19596	DEEP RUN RD	21160	WHITEFORD	958.725	0.26832
26076	DEEP RUN RD	21160	WHITEFORD	97.3827	0.26601
562	GLEN COVE RD	21034	DARLINGTON	286.342	0.26431
22809	FALLING BRANCH RD	21132	PYLESVILLE	2588.15	0.26385
12468	SOUTHAMPTON RD	21014	BEL AIR	356.663	0.26258
11970	OLD SOUTHAMPTON RD	21014	BEL AIR	217.417	0.26219
9961	DEER CREEK CHURCH RD	21050	FOREST HILL	128.022	0.26061
7517	GLEN COVE RD	21034	DARLINGTON	85.0806	0.25967
8299	RIVER RD	21034	DARLINGTON	123.686	0.2594
22830	NEAL RD	21132	PYLESVILLE	766.885	0.25411
22827	MCFADDEN RD	21132	PYLESVILLE	350.037	0.25345
10005	PENNINGTON RD	21015	BEL AIR	1622.55	0.25314
6620	GLEN COVE RD	21034	DARLINGTON	301.415	0.24972
9344	THOMAS BRIDGE RD	21154	STREET	481.337	0.24972
10294	HOUCKS MILL RD	21111	MONKTON	53.561	0.24927

8103	DURHAM RD	21047	FALLSTON	712.702	0.24829
1957	OLD ROBIN HOOD RD	21001	ABERDEEN	230.199	0.24785
2385	JARRETTSVILLE RD	21084	JARRETTSVILL E	250.321	0.24585
12735	CARRS MILL RD	21047	FALLSTON	114.076	0.24577
1727	DETHS FORD RD	21034	DARLINGTON	83.9095	0.24477
8288	ROCK RUN RD	21078	HAVRE DE GRACE	464.753	0.24421
289	GLENVILLE RD	21028	CHURCHVILLE	122.599	0.24317
13074	CEDARDAY DR	21015	BEL AIR	113.996	0.24159
637	ROCK RUN RD	21078	HAVRE DE GRACE	406.717	0.24061
12358	ALDINO STEPNEY RD	21001	ABERDEEN	258.575	0.24005
13982	CEDAR LN	21015	BEL AIR	431.66	0.23836
11568	BOTTOM RD	21047	FALLSTON	61.6634	0.23822
5638	QUAKER BOTTOM RD	21078	HAVRE DE GRACE	109.084	0.23812
4281	TRAPPE CHURCH RD	21034	DARLINGTON	368.223	0.23802
12228	NORTH AVE	21014	BEL AIR	192.221	0.23564
2705	PLUMTREE RD	21015	BEL AIR	323.172	0.23516
12608	SHARON RD	21084	JARRETTSVILL E	225.389	0.23487

16769	MC DERMOTT RD	21132	PYLESVILLE	106.946	0.23446
21608	AMOSS MILL RD	21161	WHITE HALL	129.079	0.23369
7914	GREENE RD	21013	BALDWIN	410.913	0.23335
18394	DELP RD	21160	WHITEFORD	103.051	0.2333
7938	SINGER RD	21085	JOPPA	306.146	0.23304
969	OLD YORK RD	21111	MONKTON	730.363	0.23267
3436	CHAPEL RD	21001	ABERDEEN	145.88	0.23233
10472	TROYER RD	21161	WHITE HALL	724.773	0.23226
8369	BERNADETTE DR	21050	FOREST HILL	152.042	0.23187
10032	NELSON MILL RD	21084	JARRETTSVILLE	100.017	0.23157
4466	CHESTNUT HILL RD	21050	FOREST HILL	673.5	0.23143
6944	CHESTNUT HILL RD	21050	FOREST HILL	11.5871	0.23143
12756	TOLLGATE RD	21015	BEL AIR	110.374	0.2314
6518	SAINT CLAIR BRIDGE RD	21154	STREET	342.724	0.23091
2071	MOORES RD	21013	BALDWIN	725.059	0.23072
10444	BOGGS RD	21050	FOREST HILL	1383.01	0.23008
581	BEAR CREEK DR	21050	FOREST HILL	121.206	0.23003
3897	JOPPA FARM RD	21085	JOPPA	40.3097	0.22948

7965	ROCKS CHROME HILL RD	21084	JARRETTSVILL E	175.378	0.22916
8512	WILKINSON RD	21078	HAVRE DE GRACE	248.669	0.22914
3158	RECKORD RD	21087	KINGSVILLE	192.35	0.22909
24471	WHEELER SCHOOL RD	21132	PYLESVILLE	1096.13	0.22856
5133	FURNACE RD	21047	FALLSTON	849.756	0.22852
6412	CARSINS RUN RD	21001	ABERDEEN	2317.52	0.22826
11172	MONTREAL DR	21001	ABERDEEN	111.621	0.22793
20799	GREEN RD	21161	WHITE HALL	854.183	0.22736
11904	BYNUM RIDGE RD	21050	FOREST HILL	140.421	0.22735
13892	THOMAS RUN RD	21015	BEL AIR	121.17	0.22731
13978	BOTTOM RD	21047	FALLSTON	494.349	0.22615
7297	KNOPP RD	21084	JARRETTSVILL E	2367.46	0.22576
9407	BYNUM RD	21050	FOREST HILL	111.929	0.22573
1640	OAK FARM RD	21028	CHURCHVILLE	281.907	0.22556
1776	RUFFS MILL RD	21015	BEL AIR	1600.56	0.22522
2005	HARMONY CHURCH RD	21034	DARLINGTON	129.469	0.2251
18398	KERR RD	21160	WHITEFORD	343.118	0.2249

7322	LAPIDUM RD	21078	HAVRE DE GRACE	1046.97	0.22462
24067	OLD PYLESVILLE RD	21132	PYLESVILLE	915.109	0.22442
5037	COOL BRANCH RD	21028	CHURCHVILLE	294.007	0.22433
13804	RING FACTORY RD	21015	BEL AIR	424.421	0.22415
2363	RING FACTORY RD	21014	BEL AIR	25.0726	0.22415
11206	OSBORNE PKY	21050	FOREST HILL	109.866	0.2241
8350	HENDERSON RD	21014	BEL AIR	116.807	0.22386
7974	LAUREL BROOK RD	21047	FALLSTON	34.6485	0.2238
16766	FAWN GROVE RD	21132	PYLESVILLE	112.681	0.22373
12731	ANGLESIDE RD	21047	FALLSTON	153.76	0.22356
4657	RUSH RD	21084	JARRETTSVILL E	580.857	0.22353
1875	RUSH RD	21084	JARRETTSVILL E	365.846	0.22353
11488	KNOPP RD	21084	JARRETTSVILL E	638.662	0.22341
12595	GLENVILLE RD	21078	HAVRE DE GRACE	166.774	0.22338
6048	GLENVILLE RD	21078	HAVRE DE GRACE	25.0529	0.22329
5269	HILLENDALE RD	21014	BEL AIR	20.4118	0.22326
1080	FURNACE RD	21047	FALLSTON	345.076	0.22291

4009	SNAKE LN	21028	CHURCHVILLE	103.559	0.22284
26463	HEAPS RD	21160	WHITEFORD	103.192	0.22268
7611	HOOPES RD	21050	FOREST HILL	119.51	0.22245
3489	WARD RD	21050	FOREST HILL	201.688	0.22243
3603	HOUCKS MILL RD	21111	MONKTON	109.58	0.22242
4921	MANDEVILLE RD	21085	JOPPA	111.12	0.22241
9671	RING FACTORY RD	21085	JOPPA	944.477	0.22239
10240	DRY BRANCH RD	21161	WHITE HALL	434.321	0.22197
9816	TOLLGATE RD	21014	BEL AIR	155.25	0.22197
9063	GUNPOWDER RIDGE RD	21085	JOPPA	160.196	0.22193
2267	SOUTHAMPTON RD	21014	BEL AIR	131.797	0.22182
20794	CHURCH LN	21161	WHITE HALL	1140.43	0.22165
21196	AMOSS RD	21161	WHITE HALL	108.034	0.22154
6317	FRONTAGE RD	21001	ABERDEEN	107.998	0.2212
7735	ROCKS STATION RD	21154	STREET	2239.51	0.22106
9363	OLD JOPPA RD	21085	JOPPA	119.913	0.22039
12597	BEATTY RD	21111	MONKTON	118.976	0.22032
1737	RYAN RD	21047	FALLSTON	663.534	0.22027

4113	LAUREL BROOK RD	21047	FALLSTON	200.577	0.22007
9906	BUSH CHAPEL RD	21001	ABERDEEN	226.554	0.21989
12614	GIBSON RD	21050	FOREST HILL	104.531	0.21979
9981	LAUREL BROOK RD	21047	FALLSTON	120.653	0.21954
26877	MACTON RD	21154	STREET	303.602	0.21924
26878	MACTON RD	21154	STREET	114.331	0.21923
23648	GRIER NURSERY RD	21132	PYLESVILLE	683.753	0.21915
5186	JOHNSON MILL RD	21050	FOREST HILL	833.407	0.21904
7016	BROOKHAVEN CT	21047	FALLSTON	101.879	0.21901
4562	PYLE RD	21050	FOREST HILL	205.588	0.2185
1880	ASBURY RD	21028	CHURCHVILLE	1042.35	0.21848
8783	SCARBORO RD	21154	STREET	519.734	0.21846
13891	THOMAS RUN RD	21015	BEL AIR	279.739	0.21825
5176	RING FACTORY RD	21014	BEL AIR	101.031	0.21801
8988	WEBSTER-LAPIDUM RD	21078	HAVRE DE GRACE	90.6911	0.218
11087	RIGDON RD	21084	JARRETTSVILLE	411.274	0.21787
3720	MARDIC DR	21050	FOREST HILL	104.708	0.21778
9482	MARDIC DR	21050	FOREST HILL	101.32	0.21774

9449	KALMIA RD	21015	BEL AIR	549.941	0.21751
12606	BAILEY RD	21050	FOREST HILL	549.006	0.21747
5862	GRAFTON LN	21028	CHURCHVILLE	198.138	0.21732
4148	LEMON RD	21084	JARRETTSVILL E	303.781	0.2168
6163	WILGIS RD	21047	FALLSTON	382.684	0.2167
13397	JOPPA FARM RD	21085	JOPPA	349.131	0.21642
14739	CHAPEL RD	21078	HAVRE DE GRACE	265.133	0.21633
3407	ARENA RD	21154	STREET	151.454	0.21621
13557	BRASS MILL RD	21017	BELCAMP	100.011	0.2162
4862	MORSE RD	21050	FOREST HILL	532.058	0.21609
6721	COX RD	21084	JARRETTSVILL E	383.88	0.21609
3220	OLD LEVEL RD	21078	HAVRE DE GRACE	127.755	0.21609
5472	APPLIANCE DR	21017	BELCAMP	101.128	0.21543
3384	DEER HILL RD	21154	STREET	100.335	0.21534
3302	OLD JOPPA RD	21085	JOPPA	102.531	0.21527
11398	MAHAN RD	21001	ABERDEEN	240.241	0.21514
4522	CLAYTON RD	21085	JOPPA	116.598	0.21501
13243	TOLLGATE RD	21009	ABINGDON	80.2642	0.21466

13245	TOLLGATE RD	21009	ABINGDON	69.6146	0.21466
9286	OLD JOPPA RD	21085	JOPPA	924.985	0.21463
5358	YOUNGSTON RD	21084	JARRETTSVILLE	100.03	0.2146
13901	WHEEL RD	21015	BEL AIR	836.683	0.21453
8700	PERRY AVE	21040	EDGEWOOD	94.7671	0.21451
8444	DERBY DR	21047	FALLSTON	100.57	0.21424
696	HUGHES RD	21034	DARLINGTON	104.348	0.21417
13154	INCLINE CT	21154	STREET	103.829	0.21394
1247	QUAKER HILLS CT	21078	HAVRE DE GRACE	86.5262	0.21389
6442	CEDAR CHURCH RD	21034	DARLINGTON	628.147	0.21389
11152	HORNBEAM RD	21040	EDGEWOOD	100.195	0.21343
14740	CHAPEL RD	21078	HAVRE DE GRACE	100.003	0.21328
5980	MONTROSE WAY	21009	ABINGDON	122.729	0.21321
3363	BOYD RD	21154	STREET	900.232	0.21308
12574	CHERRY HILL RD	21154	STREET	658.239	0.21307
13860	LAUREL BUSH RD	21009	ABINGDON	71.0597	0.21299
1560	WESLEYAN DR	21028	CHURCHVILLE	100.911	0.21295
20805	JOLLY ACRES RD	21161	WHITE HALL	196.949	0.21269

13981	CARICO LN	21161	WHITE HALL	524.085	0.21258
8091	HUGHES RD	21034	DARLINGTON	292.574	0.21255
24	LEESWOOD RD	21014	BEL AIR	177.022	0.21252
12705	GRAVEL HILL RD	21078	HAVRE DE GRACE	91.2344	0.21238
625	TRELLIS LN	21009	ABINGDON	102.245	0.21215
12986	CLAYTON RD	21085	JOPPA	111.826	0.21209
1965	SINGER RD	21009	ABINGDON	209.395	0.21194
11388	SINGER RD	21009	ABINGDON	94.9015	0.21194
11337	OAKMONT RD	21047	FALLSTON	140.86	0.21191
4832	BOX HILL SOUTH PKY	21009	ABINGDON	101.554	0.21132
10238	TOLLGATE RD	21009	ABINGDON	110.364	0.21129
9190	BOYD RD	21154	STREET	102.723	0.21124
24081	RIDGE RD	21160	WHITEFORD	128.143	0.21123
5200	WILLIAMS DR	21078	HAVRE DE GRACE	100.413	0.21086
7214	CHILBERRY AVE	21085	JOPPA	5.74965	0.2107
2523	BEVERLY DR	21085	JOPPA	979.626	0.21042
4268	FRANKLINVILLE RD	21085	JOPPA	740.546	0.21042
5240	GREENSPRING CT	21085	JOPPA	451.199	0.21013

3441	PARKWOOD DR	21050	FOREST HILL	96.0269	0.20984
3312	GREENSPRING AVE	21085	JOPPA	637.941	0.20982
2096	KENNARD AVE	21040	EDGEWOOD	16.1624	0.20921
5960	OAKINGTON RD	21078	HAVRE DE GRACE	220.236	0.209
7669	EDWARDS LN	21015	BEL AIR	425.504	0.20892
26462	HEAPS RD	21154	STREET	270.328	0.14568
11167	POCOCK RD	21111	MONKTON	58.0183	0.14232
1593	PHILLIPS MILL RD	21050	FOREST HILL	249.256	0.09822
22808	EDEN MILL RD	21132	PYLESVILLE	202.66	0.08551
22024	TELEGRAPH RD	21132	PYLESVILLE	1622.71	0.08428
20407	TABERNACLE RD	21160	WHITEFORD	142.635	0.06602
7395	SHARON RD	21084	JARRETTSVILLE	33.4764	0.02877
3822	FRIENDSHIP RD	21047	FALLSTON	2074.96	0.0166
3131	HARMONY CHURCH RD	21078	HAVRE DE GRACE	319.268	0.01416
1032	HOUCKS MILL RD	21111	MONKTON	104.171	0.01365
511	GUNPOWDER FARMS RD	21047	FALLSTON	130.054	0.01207
10027	MILL GREEN RD	21154	STREET	733.962	0.01084

23652	GRIER NURSERY RD	21154	STREET	1092.24	0.01026
9882	STOCKTON RD	21085	JOPPA	18.8275	0.00987
4448	STOCKTON RD	21085	JOPPA	102.312	0.00982
3423	JOHNSON MILL RD	21050	FOREST HILL	564.821	0.00947
4810	GLASGOW RD	21154	STREET	190.305	0.00919
10073	LAPIDUM RD	21078	HAVRE DE GRACE	97.8301	0.00642
1103	HENDERSON RD	21014	BEL AIR	106.31	0.00626
9003	ROLLING RD	21014	BEL AIR	103.925	0.00574
9771	GRAVEL HILL RD	21078	HAVRE DE GRACE	120.188	0.00491
12266	MONTROSE WAY	21009	ABINGDON	110.76	0.00459
13868	LAUREL BUSH RD	21009	ABINGDON	111.47	0.0044
12497	12 STONES RD	21015	BEL AIR	403.058	0.0038
7487	PLEASANTVILLE RD	21047	FALLSTON	502.235	-0.0508
24057	HEAPS SCHOOL RD	21132	PYLESVILLE	142.638	-0.0758
7057	HESS RD	21111	MONKTON	163.235	-0.2882
2768	MACPHAIL RD	21015	BEL AIR	366.735	-0.2983
13991	COSNER RD	21050	FOREST HILL	1286.99	-0.3114
847	PUTNAM RD	21050	FOREST HILL	105.043	-0.3198

10582	SUSQUEHANNA HALL RD	21160	WHITEFORD	944.567	-0.3441
8848	GLEN COVE RD	21034	DARLINGTON	226.024	-0.3634
11122	HARFORD CREAMERY RD	21161	WHITE HALL	128.012	-0.3687
16359	WEST HEAPS RD	21132	PYLESVILLE	766.611	-0.3707
3041	COOL SPRING RD	21015	BEL AIR	102.997	-0.3737
22824	LINKOUS RD	21132	PYLESVILLE	612.429	-0.3753
21618	CAREA RD	21161	WHITE HALL	205.016	-0.3861
21194	AMOSS RD	21161	WHITE HALL	160.301	-0.3882
5800	HESS RD	21047	FALLSTON	503.045	-0.3891
1794	CLAYTON RD	21085	JOPPA	361.776	-0.391
8435	TURNER RD	21111	MONKTON	130.687	-0.3911
7053	JAMES RUN RD	21028	CHURCHVILLE	378.296	-0.3937
4350	FURNACE RD	21084	JARRETTSVILLE	93.5687	-0.3938
10777	COOLEY MILL RD	21078	HAVRE DE GRACE	188.726	-0.3943
13811	AYRES CHAPEL RD	21161	WHITE HALL	471.044	-0.3999
24474	WHEELER SCHOOL RD	21160	WHITEFORD	321.323	-0.4004
23	MILLER RD	21154	STREET	579.845	-0.4007

2432	NORTHCLIFF DR	21084	JARRETTSVILL E	150.508	-0.401
24473	WHEELER SCHOOL RD	21160	WHITEFORD	2073.12	-0.401
5908	POCOCK RD	21111	MONKTON	115.939	-0.4025
26063	DAVIS CORNER RD	21154	STREET	327.182	-0.4032
10080	MACPHAIL RD	21014	BEL AIR	134.381	-0.4032
12598	SCHUSTER RD	21084	JARRETTSVILL E	792.119	-0.4032
15959	NEW PARK RD	21161	WHITE HALL	747.235	-0.4033
13876	SCHUCKS RD	21015	BEL AIR	231.309	-0.4037
20798	DUNCAN RD	21161	WHITE HALL	2417.26	-0.4039
11526	BURKINS RD	21154	STREET	541.553	-0.4044
11199	ROCKSPRING CHURCH RD	21050	FOREST HILL	121.332	-0.4054
16761	ONION RD	21132	PYLESVILLE	371.424	-0.4055
7391	WAGNER WAY	21050	FOREST HILL	139.644	-0.4055
10775	WHITAKER MILL RD	21085	JOPPA	115.242	-0.4055
2964	CLAYTON RD	21085	JOPPA	100.74	-0.4057
10551	MERCEDES DR	21017	BELCAMP	101.057	-0.4058
365	WHITAKER MILL RD	21085	JOPPA	1272.58	-0.4074
1914	BANYAN RD	21040	EDGEWOOD	32.902	-0.4079

9099	PERRY AVE	21040	EDGEWOOD	25.5932	-0.4079
26461	GRANDE VIEW DR	21132	PYLESVILLE	100.11	-0.408
10794	TOLLGATE RD	21009	ABINGDON	101.386	-0.4081
5370	RUTLEDGE RD	21047	FALLSTON	962.508	-0.4084
9744	OLD JOPPA RD	21085	JOPPA	1734.9	-0.4086
3318	LAUREL BROOK RD	21047	FALLSTON	151.488	-0.4086
18406	RIDGE RD	21160	WHITEFORD	108.172	-0.4091
10287	HITCHCOCK RD	21161	WHITE HALL	336.776	-0.4095
9696	KINGS ARMS DR	21047	FALLSTON	268.487	-0.4097
9442	MOUNT CALVARY CHURCH RD	21001	ABERDEEN	176.567	-0.41
15967	CAREA RD	21161	WHITE HALL	278.338	-0.4102
2271	FLINTLOCK DR	21015	BEL AIR	106.466	-0.4103
5420	SALEM CHURCH RD	21084	JARRETTSVILLE	68.983	-0.4104
24084	RIDGE RD	21132	PYLESVILLE	220.793	-0.4106
1153	FOUNTAIN GLEN DR	21015	BEL AIR	102.687	-0.4108
10811	PRICE RD	21034	DARLINGTON	241.773	-0.4108
6571	PROSPECT MILL RD	21015	BEL AIR	236.231	-0.4109
7450	OLD JOPPA RD	21085	JOPPA	159.776	-0.4112

5384	NELSON MILL RD	21084	JARRETTSVILL E	270.519	-0.4114
1148	MILLER RD	21154	STREET	1025.88	-0.4114
7184	MEDICAL HALL RD	21015	BEL AIR	174.2	-0.4116
17163	CONSTITUTION RD	21132	PYLESVILLE	186.772	-0.4119
6782	PORTER DR	21009	ABINGDON	194.637	-0.4127
22027	UREY RD	21161	WHITE HALL	219.33	-0.4131
15971	BUTTERMILK RD	21132	PYLESVILLE	493.532	-0.4134
1200	LAUREL BROOK RD	21047	FALLSTON	1447.67	-0.5648
2435	JERICHO RD	21087	KINGSVILLE	416.507	-0.6684
13814	WINTERS RUN RD	21085	JOPPA	302.651	-0.727
11716	GREENSPRING AVE	21085	JOPPA	89.0643	-0.9964
2616	ROMNEY RD	21085	JOPPA	1397.81	-0.9964
5218	CRAIGS CORNER RD	21078	HAVRE DE GRACE	2646.74	-1.0068
835	GUYTON RD	21047	FALLSTON	1490.35	-1.0414
9218	GILBERT RD	21001	ABERDEEN	257.398	-1.0493
10478	SHARON RD	21084	JARRETTSVILL E	111.942	-1.0615
7658	OLD JOPPA RD	21085	JOPPA	454.325	-1.0622
2272	LITTLE RD	21160	WHITEFORD	837.524	-1.1217

2563	TRAPPE CHURCH RD	21034	DARLINGTON	135.343	-1.1222
7471	CHERRY HILL RD	21154	STREET	120.753	-1.124
13848	TRIMBLE RD	21085	JOPPA	171.662	-1.2951
12736	CARRS MILL RD	21047	FALLSTON	999.205	-1.4413
24064	OLD PYLESVILLE RD	21132	PYLESVILLE	113.433	-1.4481
7642	COX RD	21084	JARRETTSVILL E	54.9766	-1.4591
10355	SALEM CHURCH RD	21084	JARRETTSVILL E	40.5279	-1.4591
15563	LONG CORNER RD	21161	WHITE HALL	275.184	-1.5774
24065	OLD PYLESVILLE RD	21132	PYLESVILLE	858.376	-1.6692
13241	TOLLGATE RD	21009	ABINGDON	31.3556	-1.7602
8019	LAPIDUM RD	21078	HAVRE DE GRACE	626.835	-1.7614
19197	COOPER RD	21160	WHITEFORD	630.699	-1.8188
6217	EARLTON RD	21078	HAVRE DE GRACE	113.938	-1.8653
9169	ROCK RUN RD	21078	HAVRE DE GRACE	570.192	-1.9026
13920	ROBIN HOOD RD	21078	HAVRE DE GRACE	289.566	-1.9221
13193	BULLS LN	21085	JOPPA	35.1808	-1.9416
5566	OLD ROBIN HOOD RD	21001	ABERDEEN	230.45	-2.1677

1992	LAPIDUM RD	21078	HAVRE DE GRACE	228.472	-2.177
4106	CRAIGS CORNER RD	21078	HAVRE DE GRACE	1653.98	-2.1913
5595	SINGER RD	21009	ABINGDON	574.568	-2.2249
6588	DAY RD	21034	DARLINGTON	793.091	-2.2457