

**Comparison of Fine and Coarse Scale Geospatial Assessments:
Riparian Corridors of the Moodna Creek Watershed, Orange County, NY**

Final Summary Report

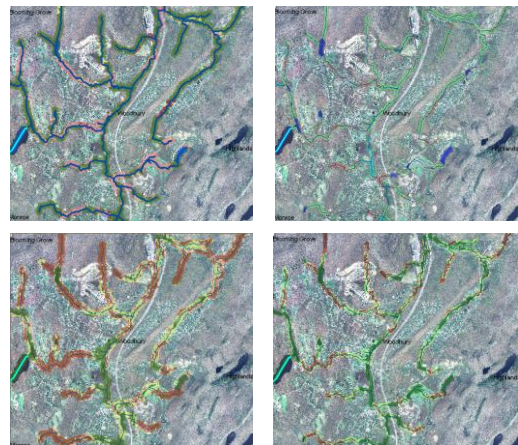
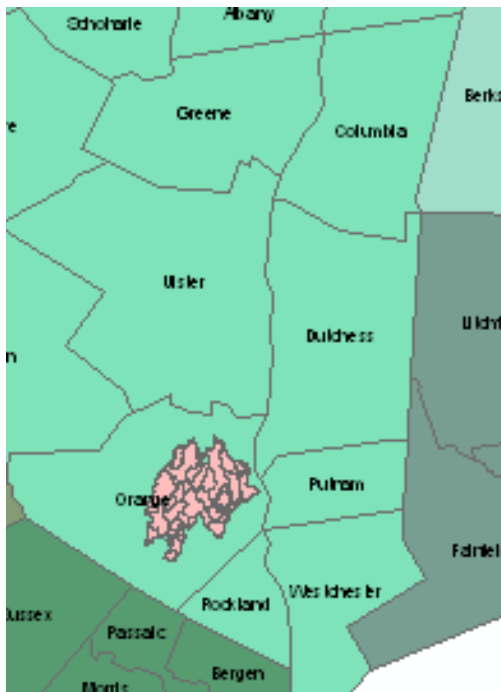
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Introduction:

Riparian (streamside) corridors serve critical functions within interwoven terrestrial and hydrologic systems. They serve as habitat for important floral and faunal populations and minimize stream impacts from neighboring land use and pollutants. They provide food, detritus and shade for aquatic systems as well as scenic and recreational domains for outdoor enthusiasts. Healthy and intact riparian systems can help ensure adequate supplies of high-quality water resources for a region's human and biotic communities.

When riparian zones are eliminated, fragmented or are encroached upon by human-dominated systems (e.g., development or farming), they tend to lose their ability to protect water resources. Knowing the specific areas where these zones are healthy and intact, or missing and compromised, can aid agencies invested with protecting public water supplies. Their programs and efforts to educate and inform local communities about the critical role riparian buffers play and the impacts our activities can have can be aided. Having timely and accurate information as to the status of a watershed's riparian buffers can allow for effective prioritization of resources dedicated to the restoration and re-vegetation of the corridors, as well as a targeted riparian protection initiative.

Project Description:

The objectives of this project were to provide a generalized assessment and comparison of specific stream health and stream vulnerability tools to evaluate riparian corridor status for the Hudson Estuary watershed by the New York Department of Environmental Conservation Hudson River Estuary Program (HREP) and its Watershed and Riparian Buffer Programs. Additionally, this effort is intended to support the Orange County Water Authority's development of a watershed plan for the Moodna Creek Watershed. Located on the eastern edge of central Orange County, this basin covers more than 47,000 ha and supports over 633 kilometers of stream corridors. As a pilot project for the efforts, a spatial assessment and characterization of the major stream corridors of the Moodna Creek Watershed; Orange County, NY (Appendix A, Plate 1.) was conducted using paired fine and coarse scale geospatial data within the context of a Geographic Information System (GIS). Additionally, a comparison of the types and detail of data and interpreted information that can be extracted from both a coarse and a fine scale analysis, relative to the effort and expense for each was performed. The intent is to support better, more cost effective decision making when considering the dedication of resources for riparian corridor restoration and watershed planning for the greater Hudson River drainage.

Stream Health (SH) was estimated as a function of the land cover types adjacent to a particular riparian zone, where land cover classes are valued and ranked by their estimated impact on local water quality and in-stream habitat dynamics. Under the model logic, streams flowing through land cover types classified as Forest, Wetland, Shrub and other undisturbed natural areas are ranked Excellent (on a scale of 1-5, with 5 being high) , while those traversing areas dominated by highly human impacted classes (Urban, Roads, Industrial, etc...) are ranked "1" or Poor. Intermediate classes are ranked along the gradient. The underlying assumption is that areas with more intact riparian corridors can better protect local water quality. *Stream*

Vulnerability (SV) is approached similarly, though also considers localized slope and soil permeability class, to calculate an estimate of a stream reach’s stability and potential for erosion and run-off. For this project, the calculated values of *Streamside Health* and *Stream Vulnerability* were summarized for each of the 17 sub-watersheds within the Moodna basin. SH and SV values were then ranked in order to compare and begin to understand the relative spatial dynamics of specific regions with healthy and intact streamside zones or areas within the Moodna basin where additional attention may be warranted to help improve water quality and in-stream habitat dynamics.

The Cornell Streamside Health and Vulnerability models, available through their website, <http://strmhlth.cfe.cornell.edu/index.html>, employ publicly available digital geospatial data and well crafted software scripts to allow users with GIS software to easily assess hydrological patterns in their local areas. Since the best widely available land cover data for our region has a spatial resolution of 30m, the models have been calibrated to utilize input data, run and output results at this pixel size. For our purposes here, we refer to products at this resolution as *Coarse Scale* (CS). A Hudson River Estuary Program (HREP) team, which has been considering riparian issues for some years, was interested in knowing how outputs from this approach might compare to one utilizing finer scale data, and so commissioned this study. The *Fine Scale* (FS) assessment calculates the same *Stream Health* and *Stream Vulnerability* layers (as defined above), but employs higher resolution data. For *Stream Health*, land cover features within the riparian corridors of the Moodna’s 17 sub-basin regions were digitized from high-resolution (6” resolution) true-color, leaf off digital air photos (2004), with minimum mapping units of under 1 hectare. In addition to this hi-res land cover, 10m (nominally 30’) elevation grids (modeled slope) and vector-based SSURGO soils data (permeability), which were rasterized to match the 10m grid cell resolution, were employed to calculate *Stream Vulnerability*.

Data

Selection. Acquisition, Processing

To calculate Stream Health and Stream Vulnerability, Cornell provides access to a series of program scripts that run within an ESRI software domain. Their suggested data inputs are:

Layer	Required For (CS)	Source
Streams	SH, SV	2000 Census\Tiger Hydrography (through CUGIR: http://cugir.mannlib.cornell.edu)
Land Cover	SH, SV	1993 NY GAP Land Cover http://www.dnr.cornell.edu/gap/gap.htm
Elevation (from which Slope is derived)	SV	7.5m quads (through CUGIR: http://cugir.mannlib.cornell.edu)
Soils (Hydrological Soil Group)	SV	http://strmhlth.cfe.cornell.edu

The above are either delivered as or resampled to match a 30m pixel resolution with the assumption that all will be projected into a UTM NAD27 (m) projection. Since our study site was quite small, we chose to utilize a UTM NAD83 (m) Zone 18 project for all data used within

the *Coarse Scale* runs. In order to more fully utilize the supplied processing scripts, for *Fine Scale* runs we projected our data (described below) into a NY State Plane NAD83 (ft) projection, with 30 ft (nominally 10m) resolution, since it would match the expected processing script value of “30”, expected for each raster layers spatial resolution. This saved enormous time recoding the scripts. Given the small size of the sample area basin, concerns of geodetic accuracy and precision due to projection and datum choices were overlooked and included in the error budget.

Cornell provides links for easy access to input geospatial data layers with clear instructions for step by step pre-processing of the data. Their suggestion is to utilize 1991\1993 NY State GAP data) as the land cover component into the model as it is these class codes found within the GAP land cover data that their downloadable scripts are set up to run on. Since more up-to-date land cover are currently available, in the form of National Land Cover Data (NLCD) 2001 (<http://www.mrlc.gov/>) we used the NLCD data (Appendix A: Plate 2) for our Coarse Scale model runs, and recoded the data to match the GAP land cover classes equivalents within the scripts. We performed the same recoding to GAP class equivalents for the digitized FS land cover data as well. In addition, while we began by utilizing the most current National Hydrological Data (NHD) data for our region, as the streams feature, part way into the project we were informed that the Orange County Water Authority had commissioned a more detailed streams layer, digitized from high-resolution air photos. Though we had partially completed the digitizing of riparian land cover from buffers used with the NHD data, because of the much higher resolution and spatial fidelity to the 2004 air photos we abandoned these efforts and began anew, with the high-resolution streams. These high-resolution streams were used in both CS and FS analysis.

The size of the riparian zones of analysis were adjusted for both the CS and FS analysis, to a buffer of 90 meters for Coarse Scale (SH & SV) and approximately 55 meters for Fine Scale (SV) on either side of the stream centerline. Since the digitized FS land cover product was produced as a vector layer (covering a 55 m buffer on either side of the detailed streams) in order to derive the most precision it was this detailed vector layer that was summarized by sub-basin, to produce the SH Fine Scale ranked tabular results, presented below. Converting a vector layer to a raster image will nearly always sacrifice some accuracy and precision, which we wished to avoid in this case. Fine Scale SV was produced using a modified Cornell script, using data products resampled to 30ft and all reported results utilize these resolutions. Time and effort spent developing (digitizing, coding and validating) the FS riparian land cover layer was tallied, as the largest time component of the FS analysis. Given the limited nature of the project, no field verification was performed on the land cover classes nor was an accuracy assessment run.

Digital Elevation Models (DEM), used to calculate Slope within the model, were obtained from the USGS through their web portal (<http://seamless.usgs.gov>), at 30m (1 arc second) resolution for CS and 10m (1/3 arc second) resolution for FS. Soils data were obtained from Cornell (CS) since they had already formatted the data for the necessary Hydrologic Soil Group (HSG) variable. These data are from the STATSGO data program, with a minimum mapping unit of 1500 ac. and are designed for broad planning and management purposes. For FS HSG soils input, we obtained vector SSURGO soils data for Orange County (minimum map unit of 2-20 ac.) from the NRCS online Soils Data Mart (<http://soildatamart.nrcs.usda.gov>) and rasterized (10m) and recoded them according to the embedded HYDGRP variables, to match the

ranking system used within the Cornell Scripts. With a great deal more detail spatially, these data also contained several split classes of soil drainage capabilities. The general ranking and coding (description from the Cornell site) is:

HSG Group	Description
Hydrologic Soil Group A	Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well-drained to excessively drained sands or gravels. These soils have a high rate of water transmission. (Low runoff potential)
Hydrologic Soil Group B	Soils having moderate infiltration rates when thoroughly wetted consisting chiefly of moderately deep or deep, moderately well or well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmissions.
Hydrologic Soil Group C	Soils having slow infiltration rates when thoroughly wetted, consisting chiefly of (1) soils with a layer that impedes the downward movement of water, or (2) soils with moderately fine or fine textures and slow infiltration rate. These soils have a slow rate of water transmission
Hydrologic Soil Group D	Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) clayey soils with high swelling capacity or potential, (2) soils with a high permanent water table, (3) soils with a claypan or clay layer at or near the surface, and (4) shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission. (High runoff potential)

However, within the finer scale soils data, mixed classes also exist, which represent effects of possible artificial drainage on the class. Since the Cornell scripts only run on the dominant 4 classes (A,B,C,D), the detailed SSURGO mixed classes were reclassified as their parent class, as per Table 2.

HYDGRP	COUNT	PCT	CODE (grid VALUE)	RECODE TO
A (1)	226670	4.05	6	1
A/D	171945	3.07	2	1
B (2)	181784	3.25	4	2
C (3)	3254260	58.2	1	3
C/D	353966	6.3	5	3
D (4)	1293024	23.1	3	4
TOTAL	5592938			

Table 2. Hydrologic Soil Group (HSG) Codes and Recoding Table

This left us with the follow matrix of input data, which were used for our model runs:

Project Layer	Used For	Source
Streams	SH (CS, FS), SV (CS, FS)	Detailed stream features: Orange County Water Authority
Land Cover (CS)	SH (CS), SV (SV)	NLCD 2001 (http://www.mrlc.gov)
Land Cover (FS)	SH (FS), SV (FS)	Digitized by and for this project.
Elevation (CS)	SV (CS)	http://seamless.usgs.gov/ (30m)
Elevation (FS)	SV (FS)	http://seamless.usgs.gov/ (10m)
Soils (CS)	SV (CS)	http://strmhlth.cfe.cornell.edu
Soils (FS)	SV (FS)	http://soildatamart.nrcs.usda.gov/

Table 1. Project Data Matrix

Methods\Processing

Stream Health

Production of the 55m FS Stream Health riparian buffer layer was accomplished simply by assigning the closest land cover class within the digitized FS land cover layer, with a Cornell SH Code value. GAP equivalent codes (or cross-walk values) for these values were chosen to represent the application of the appropriate SH or SV metric to the class, as per the Cornell script, not to exactly represent an equivalent land cover output product. The purpose was to create an accurate SH or SV coding proxy, not a land cover product. The detailed FS land cover layer as delivered contains the GAP equivalent codes for those interested in further inspection.

Coarse Scale SH was produced by recoding the 30m NLCD 2001 land cover grid to an equivalent GAP class value, which the SH script then interpreted to produce the gridded SH layer.. As mentioned, we increased the buffer width for the CS products to 90m and the high resolution Streams layer from OCWA was used as the stream centerline layer from which the buffer was calculated from, on either side.

Since Open Water is ranked as No Data within the Cornell SH script, the same as actual no data, this variable was left as it existed within both the FS and CS datasets. It should be noted (as can be seen within the ranked charts to follow), that sub-basins with large lakes within them will exhibit a bit skewed percent cover distribution. To note, there are three such basins: Cromline Creek (with Tomahawk Lake in Blooming Grove), Beaver Dam Lake (with its name sake, Beaver Dam Lake, in Windsor, Blooming Grove and Cornwall) and Silver Stream Reservoir (with Browns Pond)). Since open water as a feature is significant to hydrological patterns and considerations within the model, it was left in.

Stream Vulnerability

Fine Scale SV was calculated by running the modified Cornell Script (adjusted to produce a 55m buffer feature) on the 10m gridded, GAP-code matched FS land cover grid, the 10m DEM and the 10m HSG SSURGO Soils grid, using the high resolution Streams layer as the centerline of the buffer zone.. Coarse Scale SV was run identically, using the 30m recoded

NLCD land cover, 30m soils HSG, 30m DEM and high-resolution Streams centerline layer. All SV outputs are raster layers.

Results:

The Moodna drainage area is fairly representative of land cover distribution classes found within Orange County (Appendix A, Plate 2). It contains significant parcels of unbroken forest lands together with abundant developed, agricultural areas and wetlands. According to National Land Cover Data (NLCD) product from 2001, the approximate Anderson level 1 class percentages for the basin are : Forest, 46%, Ag, 20%, Developed, 17%, Wetland, 15% with minor amounts of grass\field and open water. While the southeastern edge of the Moodna basin, from West Point back towards Warwick, contains expanses of large block forestlands, the majority of land cover types within the remainder are quite diversely distributed, with human impacts and fragmentation clearly apparent and frequently clustered, especially in the eastern I-87 corridor. With over 633 km. of streams winding northeast through the basin, (Appendix A, Plate 1) to the mouth of the Moodna at the Hudson, the likelihood that such a diversely patched landscape could affect riparian water quality is high.

Considered as a whole, the riparian zones within the Moodna basin appear to have been left fairly intact, though with a varying range of conditions. Comparison of the SH values of the CS and FS runs (Appendix A. Plates 3 & 4) show remarkable similarity, especially for the percentages of each basin classified as Excellent. This parallel extends through a pair-wise comparison across the 17 sub-basins. With minor differences, the Coarse Scale method seems to do a credible job of approximating the same Stream Health patterns broken out by the Fine Scale. Not surprisingly though, the FS data capture much more detail within the remaining classes, including Good, Moderate, Fair and Poor, obviously due to the finer grain input data. The FS data will clearly provide a more accurate and precise accounting of the compromised end of the range. But for this sample area, the CS data and methodology clearly performs well, giving a good approximation of general (upper end) Stream Health patterns.

To consider the range and order of FS *Stream Health* values of all 17 sub-basins, the percentages of the top two classes (Excellent and Good) were summed and the combined values ranked, high to low (Appendix A: Table 1). At the top of the list at 84%, indicating roughly the highest *percentage* of intact land cover within any of the sub-basins 55m riparian zone, is Mineral Spring Brook (towns of Woodbury, Cornwall) (Appendix A: Plate 5, lower right). Located within the heavily forested southeast edge of the Moodna, it contains a minimal urban\suburban footprint and no agricultural lands at all. The similarly ranked CS table (Appendix A: Table 2) also scores Mineral Spring Brook at the top, and displays similar trend groupings to the FS chart.

Going down the FS ranked list, the large middle group of a dozen sub-basins vary nominally from 62% - 73% (combined Excellent\Good) and dominate the spatial extent of the Moodna basin. All have varying levels of riparian disturbance and fragmentation, owing to a range of patterns; agricultural activity, housing, roads and urban areas. At the bottom end of the ranked scale, four basins, ranging from 51% to 58%, include Black Meadow Creek (towns of Warwick, Chester, Goshen), on the western border and three of the Moodna Creek sub-basins (East, West and Central) clustered around Blooming Grove, Hamtonburgh and New Windsor. In these regions, an inspection of riparian parcels ranked *Fair*

to *Poor* (Appendix A: Plate 3) show strong spatial relationships with proximity to roads, urban centers and housing complexes and account for the basins occurring toward the compromised end of the scale.

A similar ranking by combined Excellent\Good *Stream Health* values was performed, but with the land area (hectares) of those classes summarized and ranked, rather than percentages (Appendix A: Table 4). This ordination highlights regions within the Moodna drainage that contain the most *hectares* of intact (Excellent\Good) riparian corridor cover. The Otter Kill North sub-basin, for example, with nearly 600 hectares, constitutes a region which could be considered worthy of prioritizing protection efforts, due to the amount of high quality, intact streamside cover remaining. Once again, while the absolute values differ a bit, the CS ranking provides a similar gradient and approximate ranking (Appendix A: Table 4).

To better understand potential impairments, a ranking was performed of the 17 sub-basins, based on combined FS values of Fair and Poor *Stream Health* percentage scores per basin (Appendix A: Table 5). While it might seem that they would represent the simple inverse of the Excellent\Good ranking, with a middle Moderate Health class available, differing rank options exist. Here we find that Silver Stream, Moodna Creek Washingtonville (Wa), Moodna Creek East and Woodbury Creek form the top four occurrences, with the highest combined Fair\Poor *Stream Health* scores. While the ranked sort order is different, it should be noted that the basins here with the highest combined Fair or Poor classes are also again located in the heavily built eastern edge of the Moodna basin. Inspection of the map clarifies once again that proximity to roads, impervious surfaces (parking lots, etc...) accounts for the ranking placement. An ordination of the CS percentages of the same combined Fair and Poor percentages (Appendix A: Table 6) again produce a very similar ranking pattern, when considering all basins.

We shift gears as we consider *Stream Vulnerability*. While *Stream Health* can be thought of as indicating a *current* status of corridor integrity and condition, *Stream Vulnerability* also suggests a need for the consideration of *future* planning and development scenarios. *Stream Health* simply reflects a coded land cover metric, roughly along a gradient of human impact. In addition to this, *Stream Vulnerability* also includes consideration of naturally occurring conditions and constraints (slope and soil permeability) and various permutations of them as well. So while one parcel could be highly developed, thus increasing its streams vulnerability, another zone could occur in a pristine, natural setting, and, by virtue of the local terrain (steep) and soil permeability (shallow to bedrock), also be ranked High on the Vulnerability scale. Consequently, interpretation of the implications of this mapped variable is complex and suggestions as to remedial action or restoration based on a Vulnerability map would logically differ according to site-specific considerations. It should also be noted that while the *Stream Health* and *Stream Vulnerability* share land cover as an input variable, the resulting output data produce differing spatial patterns and should be considered independently. Numerous examples within the study site exist where a basin received a high *Stream Health* score but also a high *Stream Vulnerability* score, and vice versa. Basin and place-specific inquiries are highly recommended to fully understand the patterns.

And it is also here where the similarity between paired sub-basin outputs of CS and FS approaches depart. While *Stream Health* percentages scaled very similarly, percentage comparisons of *Stream Vulnerability* bear little apparent relationship (Appendix A: Plates 6 & 7). Resolution of the input layers clearly plays a major role in the dynamics. As we saw previously, land cover at 30m does not capture

the small grained details that digitized land cover with a 1 ha minimum map does. Resolution of elevation data, from which slopes (percent) are calculated internally by the Cornell scripts in calculating Vulnerability, (Appendix A: Plates 8 & 9) will also affect the spatial dynamics as well those of soils (Appendix A: Plates 10 & 11) at the differing scales.

As an example, Idlewild Creek is located on the far-east edge of the Moodna basin, largely within the town of Cornwall. The southern headwaters occur within US Military Academy lands, atop Whitehorse Mountain and adjacent to the Storm King State Park. These steep, thin, rocky soils contribute greatly to the basins Vulnerability factor. As the stream winds north towards the mouth of the Moodna, it traverses a developed urban land cover zone, through the village. Collectively these factors push the sub-basin to the top of the most vulnerable list, with nearly 40% of the riparian zone classified as High or Very Highly Vulnerable. Even though the headwaters of this basin are intact, for local engineers and municipal officials, knowledge of the overall vulnerable nature of the streams within the basin could support effective planning efforts to ensure that storm water, run off or non-point sources don't contribute needlessly to poor down-stream water quality, eroded stream banks or high levels of sedimentation into the systems aquatic habitats.

According to the output data, compared to the FS SV, the CS approach would appear to overestimate High vulnerability rankings and underestimate Low Vulnerability. Without field verification, and especially, water quality sample data which could be used to calibrate and validate the patterns and better understand the dynamics, it is hard to say which approach most accurately captures the regions streamside vulnerability dynamics. It is also likely that the CS approach is designed to be used on and would be more appropriate for assessing such patterns for a much larger area, perhaps an entire county.

Cost\Effort Comparison

Between the CS and FS runs, clearly digitizing and creating the detailed land cover data accounted for the largest difference in invested time and effort. Once the detailed stream features were acquired and buffered, it required the better part of 3 weeks (120 hrs) to complete the process of digitizing, labeling and validating and checking each of the ~6400 parcels that represent the 5835 ha that comprise the riparian zones within the Moodna basin. With 633 km of streams within the Moodna basin Streams layer, that represents a rate of just over 5.25 km/hr for the 55m buffer area, or 42 km/day or 211 km/week. The remaining activities of undertaking such a project--data discovery, acquisition and pre-processing -- will be roughly equal for each scale approach as are running the models, once the data are prepared. While the coarser scale data produce arguably simpler patterns, interpreting and understanding them should require less time. This project spent considerable time in attempting to summarize the resulting datasets, for both scales, according to a useful and logical geography (sub-basin) that would help both of the sponsoring agencies understand gradient dynamics within the study area as well as the resulting data themselves.

The benefit of utilizing automated geospatial scripts cannot be understated. Not only do they make the results more easily checked, since they are repeatable and avoid operator error, but they save enormous time resources when approaching projects of this sort. It should be

mentioned that the scripts themselves require time and effort as does recoding, compiling and checking, especially since scripting languages change so fast. But again, the investment will be equal between the two methods.

Next Steps:

The model runs and analysis have produced results which will hopefully help inform a better understanding of the general spatial dynamics, indicators and trends within the stream corridors of the Moodna basin. While the complete analysis and interpretation of the detailed dynamics for each specific sub-basin is beyond the scope of this project, clearly the results warrant further exploration. It is the goal of the researcher that, when combined with local expert knowledge, corroboration data (e.g. impervious surface analysis), water quality measurements, monitoring and other supporting spatial information, that place-specific decision support baselines and priorities for planners and water quality engineers can be established for the basin. From that current, informed, hydrological snap-shot, ideally, additional detailed spatial thresholds, as are now emerging linking water quality to impervious surface cover, can evolve from measures or indicators of Stream Health and Vulnerability.

References:

Cornell University Project on Stream Health and Stream Vulnerability

<http://strmhlth.cfe.cornell.edu/index.html>

<http://strmhlth.cfe.cornell.edu/strmhlth-readme.doc>

<http://strmhlth.cfe.cornell.edu/strmvuln-readme.doc>

Multi-Resolution Land Characteristics Consortium (NLCD land cover)

<http://www.mrlc.gov/>

Penn State Guide to Hydrological Soils Group

<http://www.pa.nrcs.usda.gov/techguide/sec2/hydro-groups.htm>

Disclaimer: the project and its resulting data are intended as general planning tools and should not be used to enact policy or suggest financial encumbrances without further assessments, considerations and site-specific analysis. The author assumes no responsibility for errors in analysis or the resulting data and makes no claims as to the accuracy and precision of such data.

Appendix A:

Plate 1. Sub-basins and High Resolution Streams

Plate 2. NLCD Land Cover Data and Riparian Corridors

Plate 3. Coarse Scale Stream Health (pie chart) PCT %

Plate 4. Fine Scale Stream Health (pie chart) PCT %

Table 1. Ranked Stream Health: Excellent\Good Fine Scale (PCT)

Table 2. Ranked Stream Health: Excellent\Good Coarse Scale (PCT)

Plate 5. Sub-basins with Low SH V Values (Fair\Poor) Combined

Table 3. Ranked Stream Health: Excellent\Good Fine Scale (HA)

Table 4. Ranked Stream Health: Excellent\Good Coarse Scale (HA)

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Table 6. Ranked Stream Health: Excellent\Good Coarse Scale (PCT)

Plate 6. Coarse Scale Stream Vulnerability (pie chart) PCT %

Plate 7. Fine Scale Stream Vulnerability (pie chart) PCT %

Plate 8. Sub-basins with Low SH V Values (Fair\Poor) Combined

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