High Definition Stream Surveys of Turkey Creek, AL

July 15, 2016

Submitted to:

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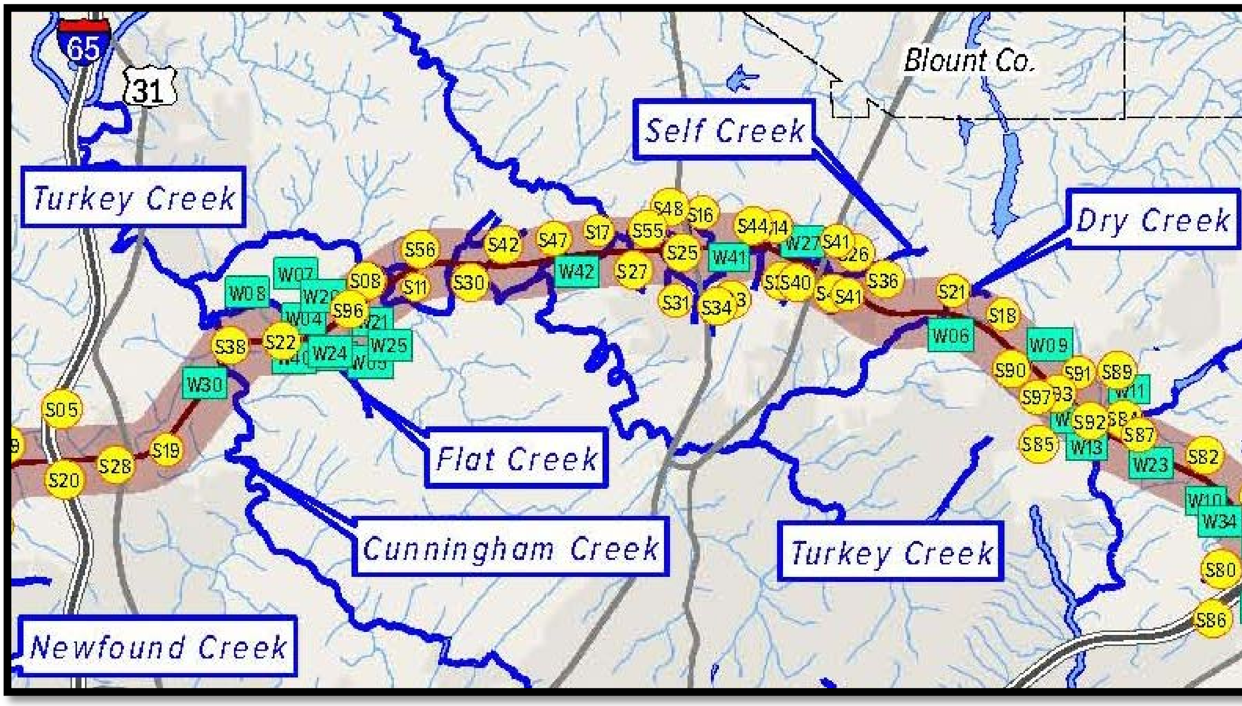


Figure 1: Birmingham Northern Beltline route through the Turkey Creek Watershed.

Introduction

The Birmingham Northern Beltline (BNB) is a large road project lead by the Alabama Department of Transportation (ALDOT). The 52 mile BNB is planned to connect I-59 in northeast Jefferson County with 1-459 near Bessemer. The proposed pathway for the BNB crosses numerous creeks and a fundamental component as part of minimizing the environmental impact of the project is documenting instream conditions within the affected creeks.

Turkey Creek is a large creek located north of Birmingham which flows generally west toward the Locust River (Figure 1). To aid in documenting the current conditions within the stream channels of Turkey Creek and to highlight the power of the High Definition Stream Survey (HDSS) approach, our team surveyed Turkey Creek to provide up-to-date, geo-referenced video and develop spatially continuous maps of bank and stream conditions. Additional information and access needed to complete this survey was provided by Rebekah Parker of the Freshwater Landtrust. Transportation and assistance during the HDSS survey was provided by Charles Yeager of the Turkey Creek Nature Preserve.

This report documents the findings of the Turkey Creek surveys and highlights several applications of the HDSS approach. The survey data can be used in many ways but this report will focus on the method's ability to:

1) provide a baseline characterization of river bank and instream conditions in April 2015,
2) develop aquatic habitat GIS layers for depth, habitat type (pool, riffle, run), substrate type, percent embeddedness, and left and right bank condition scores,
3) document areas of high habitat suitability for hypothetical darter species, and
4) identify areas that are most suitable for mitigation restoration.

Methods

<u>Equipment</u>

A standard HDSS Kayak system was used (Figure 2). It consisted of a sit-on-top kayak, three GPS-enabled video cameras mounted facing forward, left, and right (90°), a hull-mounted down-looking video camera, and a flush-mounted depth sensor. The GPS receiver provided sub three meter GPS accuracy and output time and location data (approximately one each second (1Hz)). The GPS data was combined with the depth data within the multiplexer and then was recorded onto a flash drive. The geo-referenced video was combined with the GPS and depth data such that each data point is associated with Coordinated Universal Time (UTC) and coordinate information.

The backpack-mounted HDSS system featured four different high definition video cameras with image stabilization (Figure 3). One camera was faced forward, one camera was faced downward, and a single camera was faced at the right and left banks. When using the backpack-mounted HDSS system, the surveyor moved in an upstream direction attempting to follow the thalweg of the stream. The GPS signal was collected using a Garmin 64C handheld GPS receiver. In both of these cases, the GPS NMEA data string was recorded at 1 Hz (approximately 1 sec interval). All data including the video and GPS track logs were saved to multiple external hard drives at the end of each day in the field. The track log for the GPS signal was exported in GPX format and the data was stored in a Microsoft Access database. The video was further post-processed in Adobe Premiere software to create a single view that encompassed all four video streams.

Figure 2: Brett Connell using the HDSS kayak setup at Turkey Creek, Alabama.

Figure 3: Dr. James Parham using the HDSS backpack setup at Turkey Creek, Alabama.

Data Analysis

All data were collected, organized, and classified to assess bank and instream conditions. The GPS time and location information was linked to each second of the left, right, and forward video files. This resulted in video referenced to a common location and time. The individual files were assembled to form a continuous tracklog of the survey areas. The video was classified using HDSS video coder software which allowed an appropriate assessment score to be applied to each second of the video and associated GPS location (Figure 4). Once the data was classified for all video files, the results were mapped in ArcGIS 10.1 to view the data.

With HDSS, depth is automatically linked with GPS location data and does not require further post processing. Substrate type and percent embeddedness were classified by visual observation based on the underwater video. Habitat type (pool, riffle, or run) were classified from the forward facing geo-video, and left and right bank condition was classified from the video for both the left and right bank of the river. Each streambank was viewed a single time during the classification process. The Bank Condition Score consisted of five bank condition levels ranging from 1 (streambanks in optimal condition) to 5 (streambanks in highly degraded condition). Descriptions and representative images of the different bank condition levels are described in Figure 5 - Figure 9.

To highlight the ability to quantify the quality and distribution of potential endangered darter habitat within Turkey Creek, a hypothetical darter habitat suitability index was created from the primary habitat metrics. Each parameter received a different score (Table 1) depending on how suitable that metric class was to darter habitat (1=poor to 10=good). The metrics were combined additively and divided by the total number of metrics. This approach resulted in each GPS point having a habitat suitability score for the hypothetical darter species.

Table 1: Hypothetical Darter Habitat Suitability Index used on Turkey Creek.

Hypothetical Darter Habitat Suitability Index									
Habitat Type		Substrate		Depth (ft)		Embeddedness		Bank Condition	
Class	Suitability	Class	Suitability	Class	Suitability	Class	Suitability	Class	Suitability
Pool	2	Sand	2	< 0.5	5	Excellent	10	Optimal	10
Run	9	Gravel	7	0.5-1	9	Good	8	Sub-Optimal	8
Riffle	7	Cobble	10	1-1.5	10	Marginal	4	Average	6
		Small Boulder	9	1.5-2	8	Poor	1	Marginal	3
		Large Boulder	7	2-3	5			Poor	1
		Bedrock	5	>4	3				

It is important to stress that this habitat suitability example is based on a generic darter and has not been developed or tested to represent a specific species of darter. It would be inappropriate to use the results of this suitability analysis make conclusions about a specific darter species distribution or habitat use. Delineation of suitable habitat by applying suitability criteria is a straightforward approach and could be used to determine the amount and distribution for any species of concern.

To provide an example of mitigation prioritization using the HDSS data, we show a method to locate optimal streambank restoration within close proximity to high quality darter habitat. The general concept is improving poor streambanks near high quality darter habitat would result in a greater mitigation impact than restoring streambanks near low quality darter habitat. To accomplish this task, the difference between the current streambank condition and the optimal streambank condition was compared to the local value for darter habitat suitability at each GPS point. This resulted in a range of values reflecting the potential for mitigation to improve darter habitat.

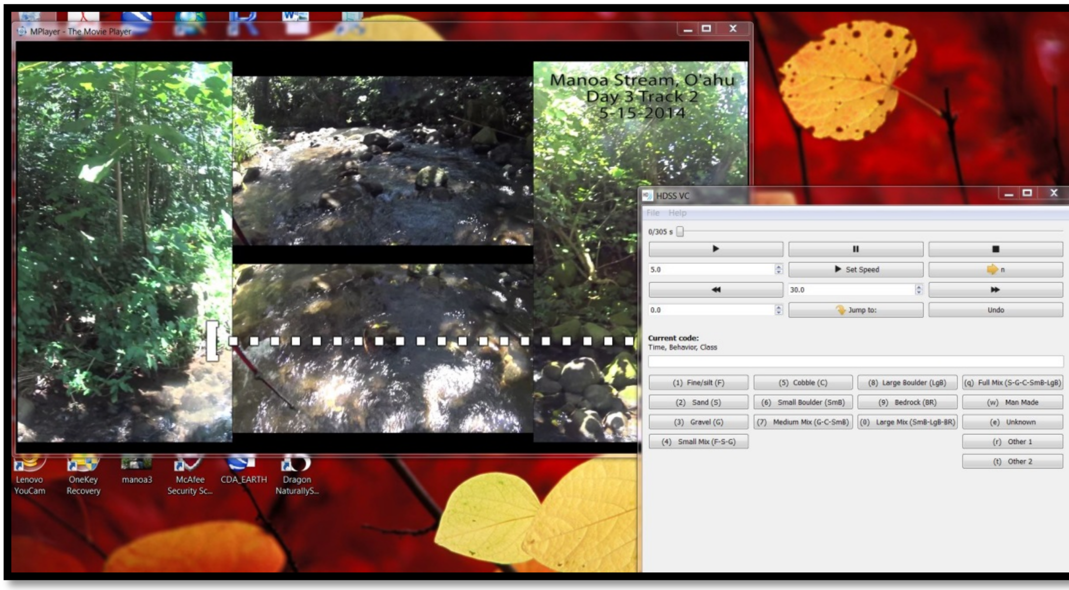


Figure 4: An example of the HDSS Video Coder Software for rapid visual classification of stream conditions.

Figure 5: Level 1, Optimal Condition: Banks currently in optimal condition with excellent surface protection and low erosion potential. Includes stabilized areas such as bedrock outcroppings, heavily wooded areas, banks with low slopes and with good access to flood plain. No action necessary.

Figure 6: Level 2, Good Condition: Banks currently in good condition with minor impacts present. Includes heavily forested areas with moderate bank angles and adequate access to flood plains. No action necessary.

Figure 7: Level 3, Fair Condition: Banks showing moderate erosion impact with limited access to flood plain and variable surface protection. Potential impacts affecting water quality and aquatic habitat. Immediate action is not necessary.

Figure 8: Level 4, Poor Condition: Banks with high erosion potential consisting of few trees and grass. Obvious impacts from cattle, agriculture, industry, with minimal connectivity to the flood plain. Source of negative impacts to water quality and aquatic habitat. Recommended action site.

Figure 9: Level 5, Very Poor Condition: Banks with the highest erosion potential and steep bank angles. Evidence of active bank failure, with very little stabilization from vegetation. Obvious impacts from cattle, agriculture, and industry with no connectivity to flood plain. Contribution of sediment is very high in these areas. High source of negative impacts to water quality and aquatic habitat. Highly recommended action site.

Results

Field Survey

This survey covered more than 17 miles in a two-day field survey conducted on April 4 & 5, 2015. Kayak HDSS were completed on April 4 and backpack HDSS were completed on April 5 (Figure 10). Additional High Definition Fish Surveys (HDFS) were also completed in the upper section on April 5.

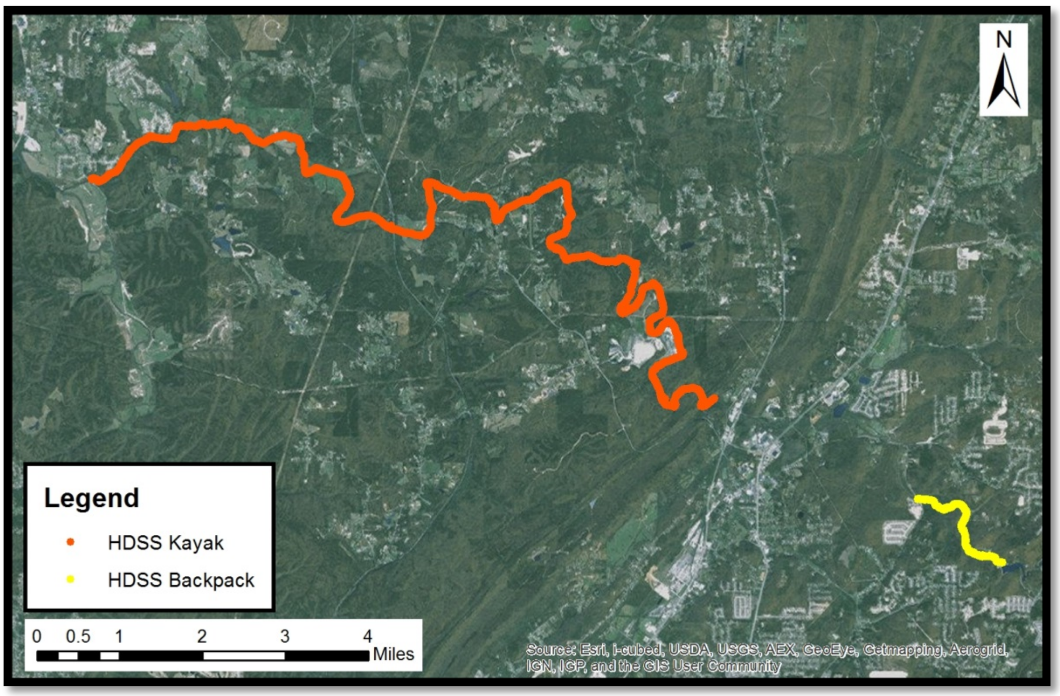


Figure 10: Tracklogs for the HDSS kayak and backpack surveys in Turkey Creek.

The first objective of this survey was to provide a baseline characterization of river bank and instream conditions. Our results from the HDSS surveys clearly document the streambank and instream conditions, and while we cannot show video within this report, the following are examples from the kayak (Figure 11 and Figure 12) and backpack mounted HDSS systems video output (Figure 13 and Figure 14).

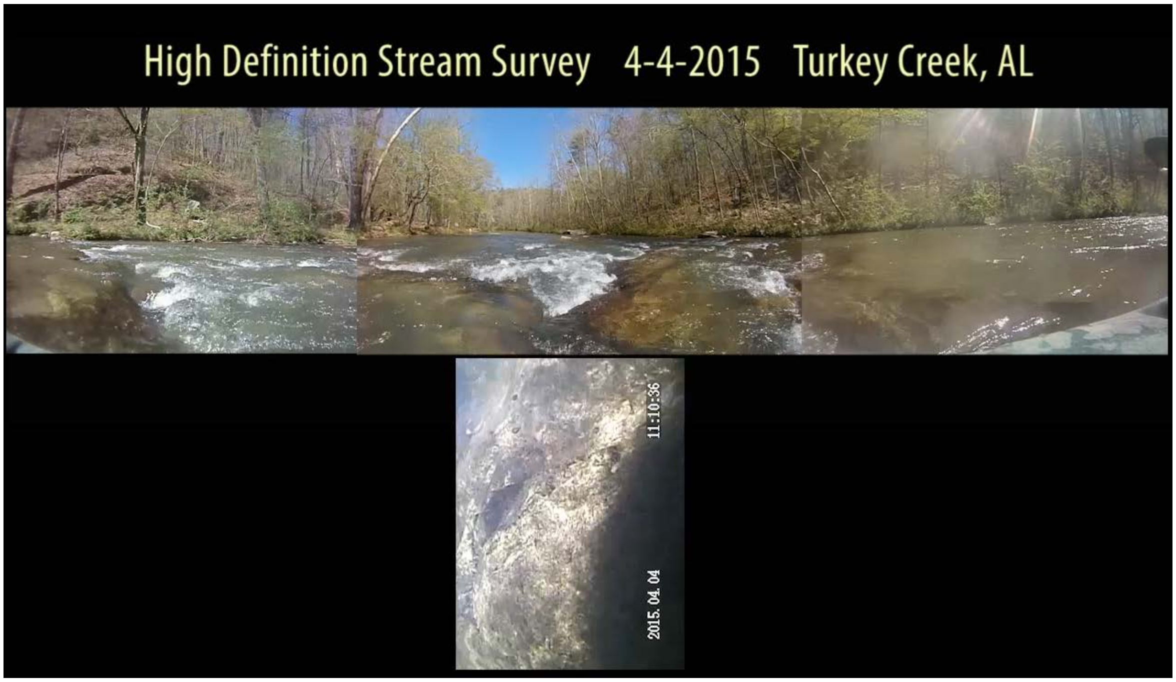


Figure 11: An example of the video from the kayak HDSS in a good section of Turkey Creek.

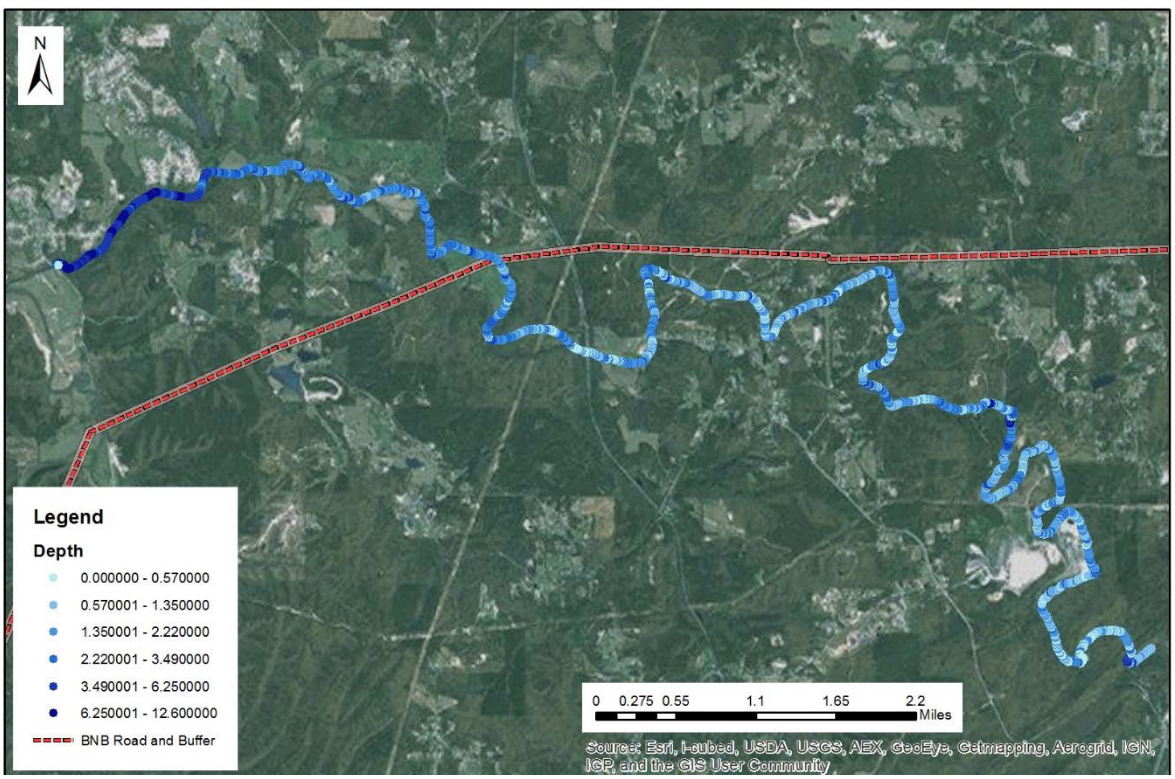
Figure 12: An example of the video from the kayak HDSS in a poor quality section of Turkey Creek. Note the bank failure on the left side of the image.

Figure 13: An example of the video from the backpack HDSS in a good section of Turkey Creek.

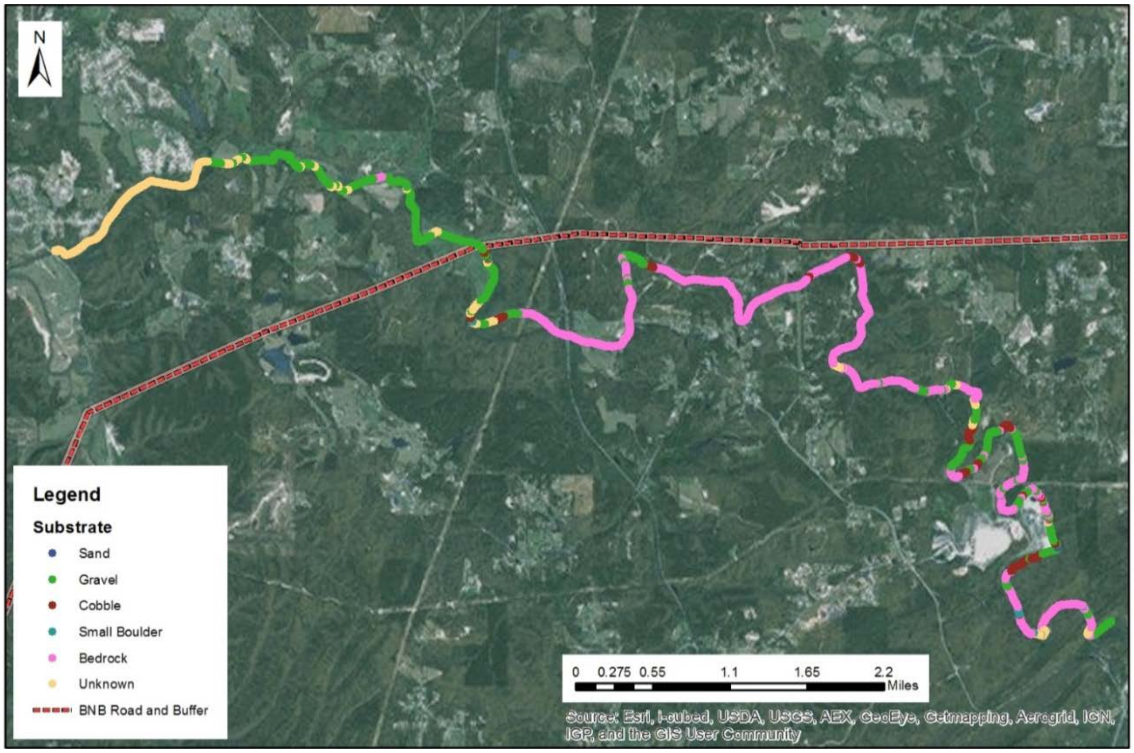
Figure 14: An example of the video from the backpack HDSS in a poor quality section of Turkey Creek. Note the bank failure on the right side of the image.

The second objective was to develop aquatic habitat GIS layers for depth, habitat type (pool, riffle, run), substrate type, percent embeddedness, and left and right bank condition scores from the HDSS field data. Following the classification of the data using our HDSS Video Coder software, we created a corresponding seamless video file and a data file and then created shapefiles for the data within ArcGIS.

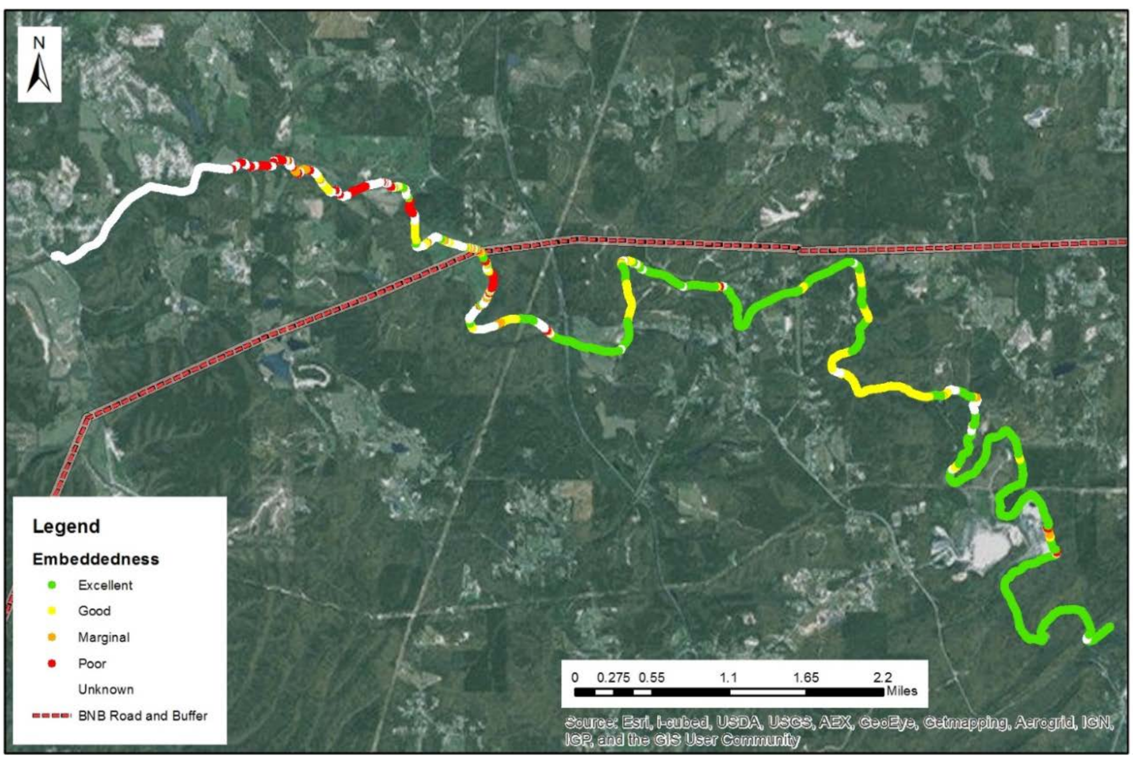
The following map images are examples of the output for the kayak HDSS and similar maps can be created for the backpack HDSS result as well. In general, we will show the whole survey extent for each metric and then zoom into the lower, middle, and upper sections of the survey track to show the results more clearly. In all of the maps, the location of the BNB road and 300ft buffer were estimated from available maps and should not be considered accurate.



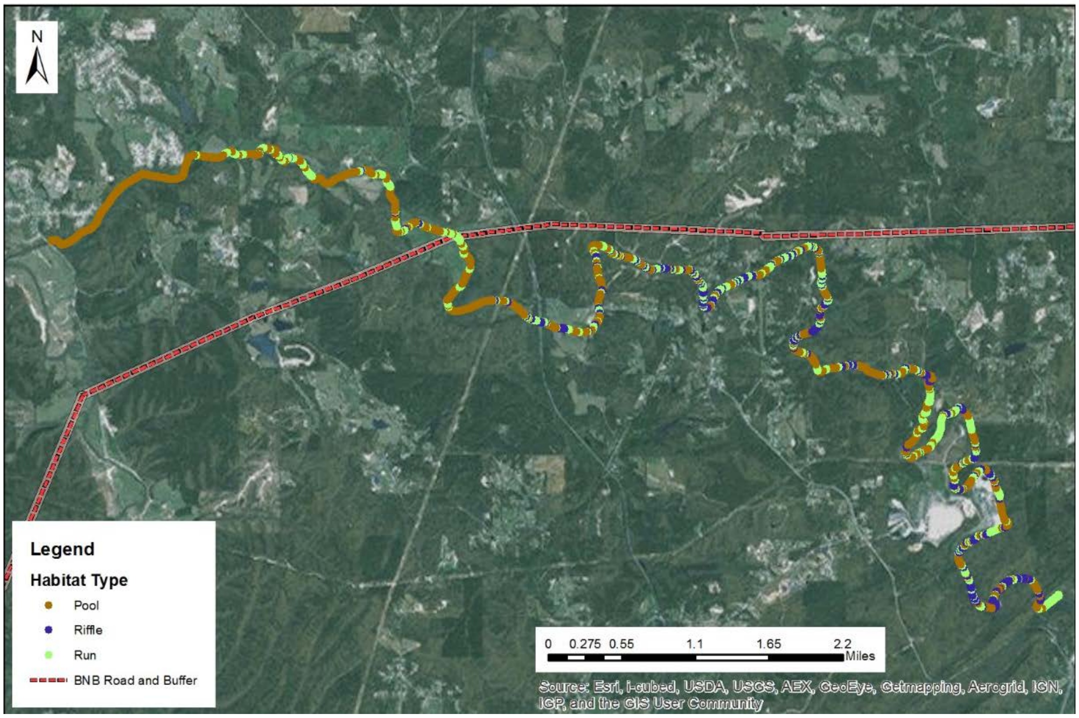
Map 1: Turkey Creek Depth (ft) output from the High Definition Stream Survey.



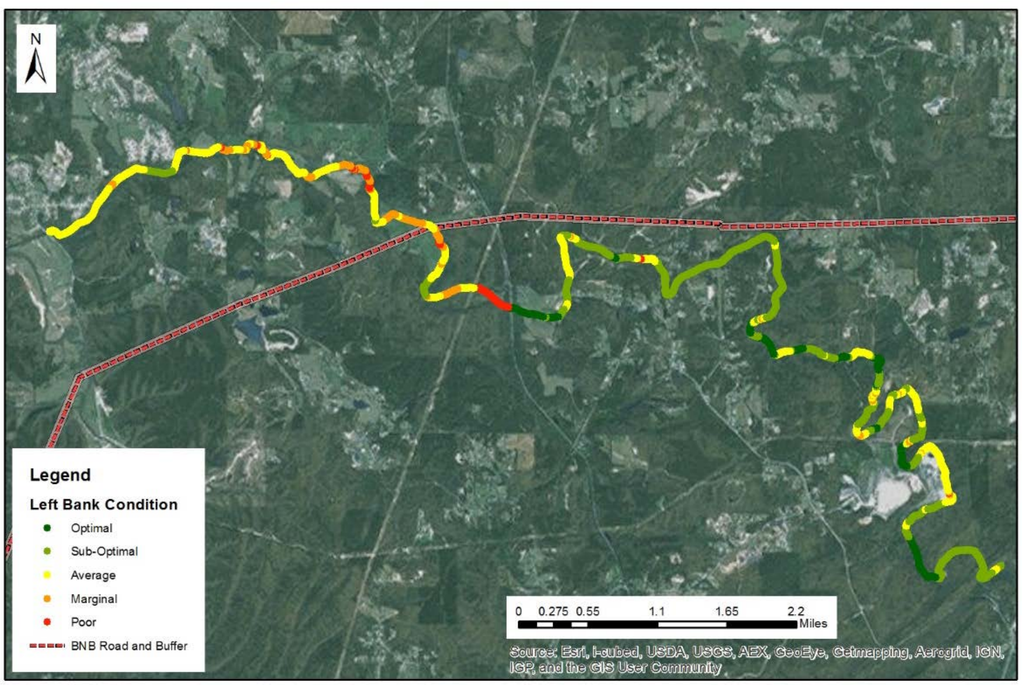
Map 2: Turkey Creek Substrate Type output from the High Definition Stream Survey.



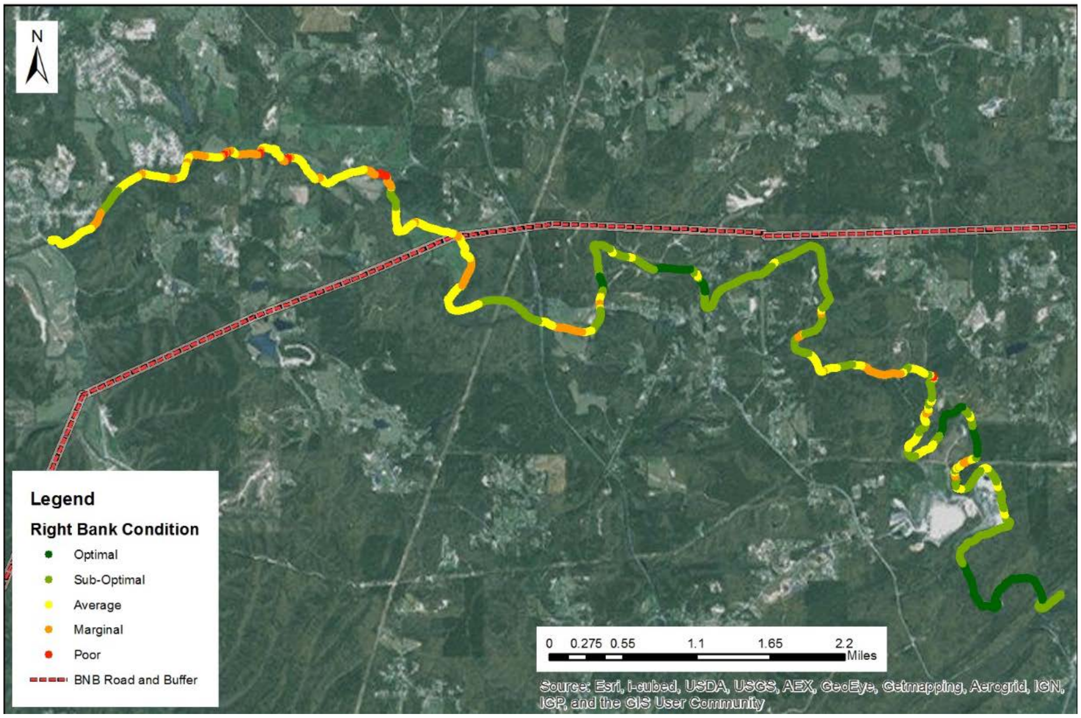
Map 3: Turkey Creek Embeddedness output from the High Definition Stream Survey.



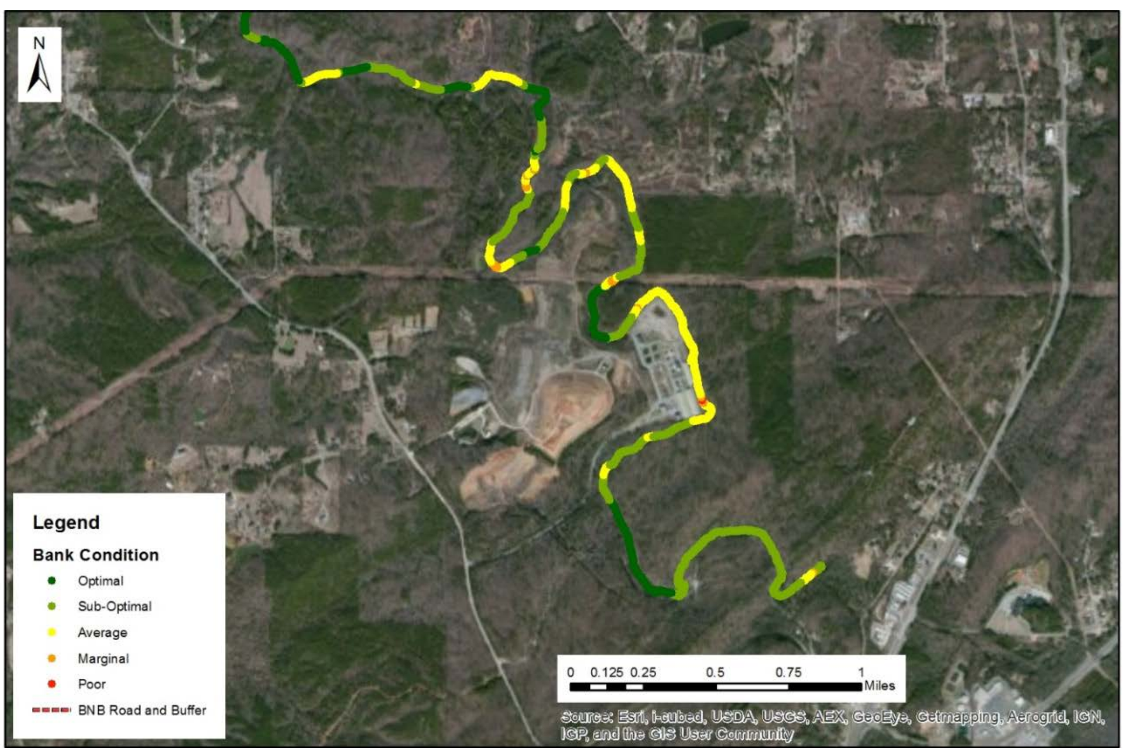
Map 4: Turkey Creek Habitat Type output from the High Definition Stream Survey.



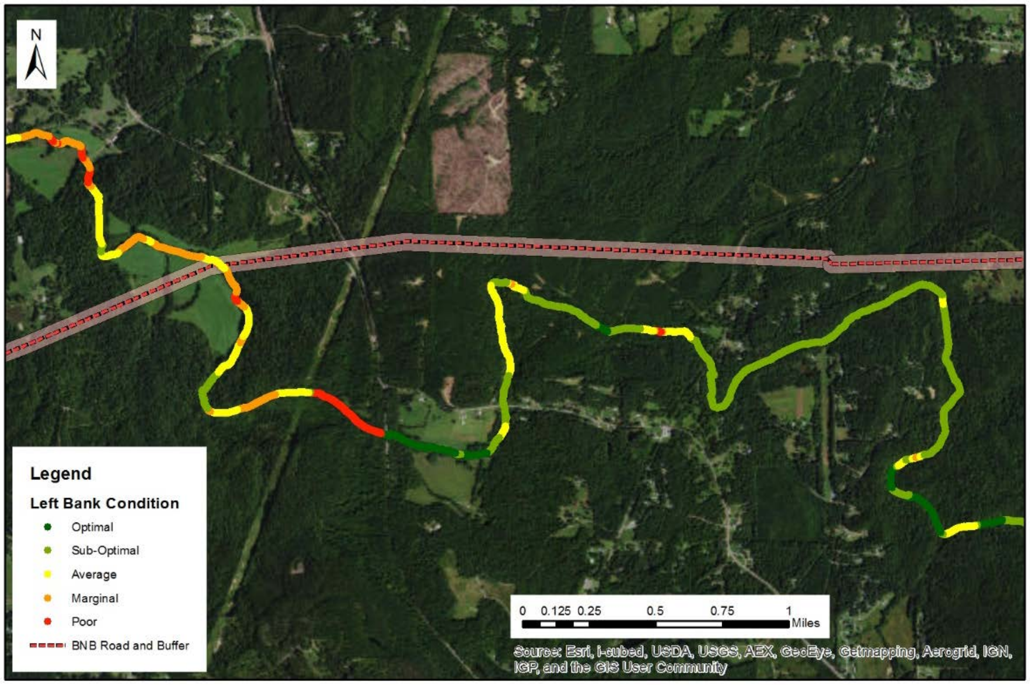
Map 5: Turkey Creek Left Bank Condition output from the High Definition Stream Survey.



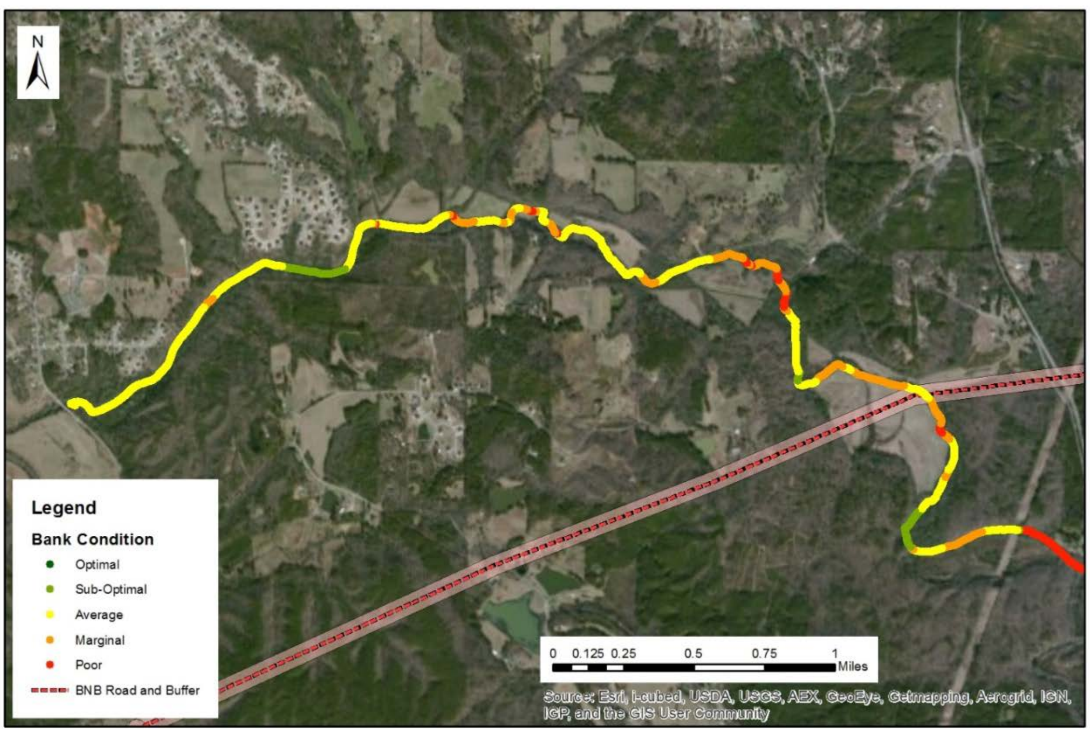
Map 6: Turkey Creek Right Bank Condition output from the High Definition Stream Survey.



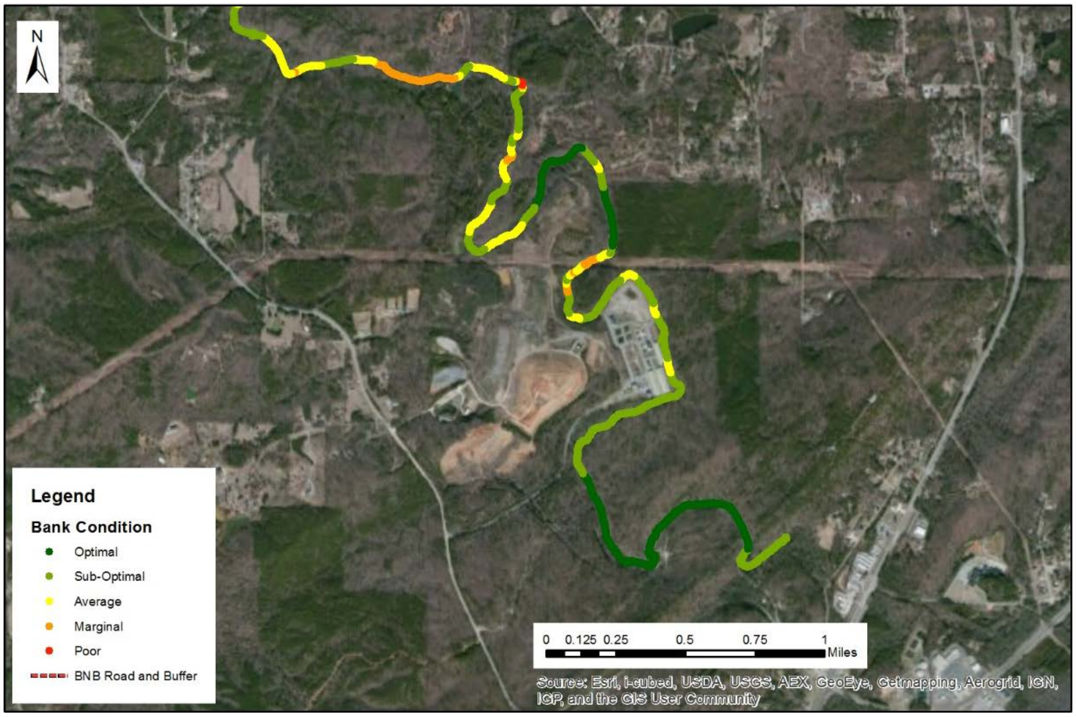
Map 7: Turkey Creek left bank condition output from the High Definition Stream Survey (upper section).



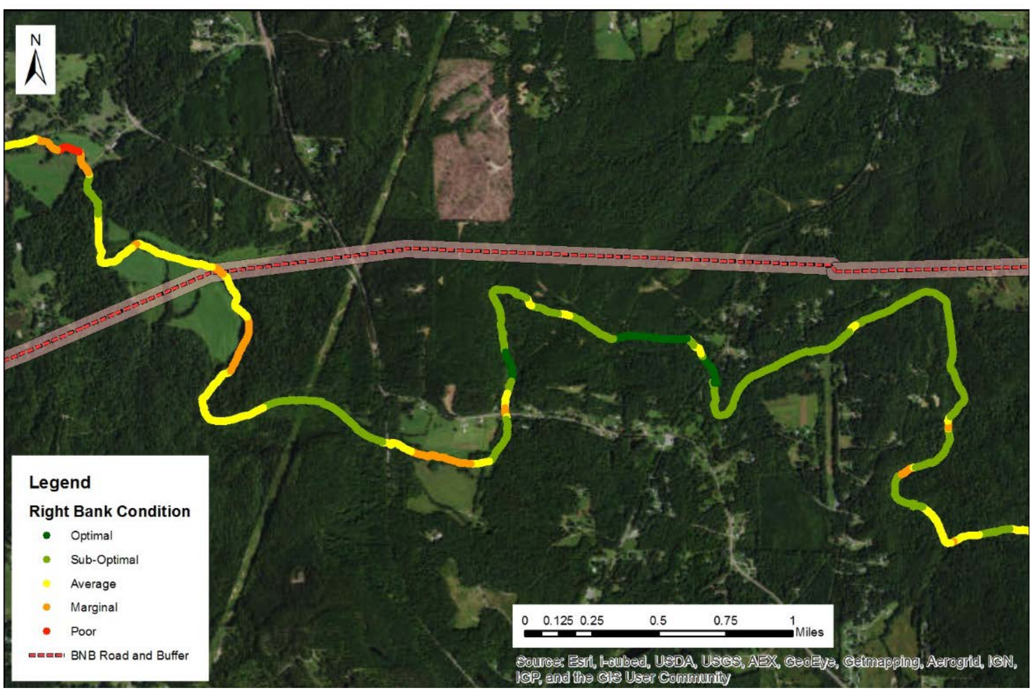
Map 8: Turkey Creek left bank condition output from the High Definition Stream Survey (mid section).



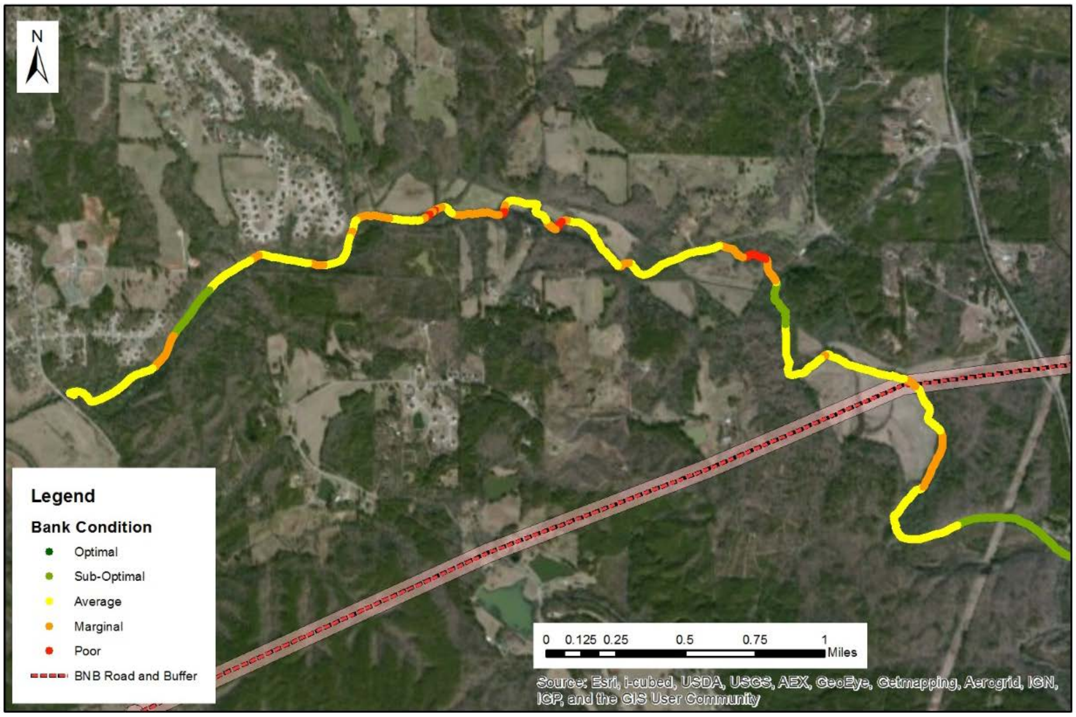
Map 9: Turkey Creek left bank condition output from the High Definition Stream Survey (lower section).



Map 10: Turkey Creek right bank condition output from the High Definition Stream Survey (upper section).

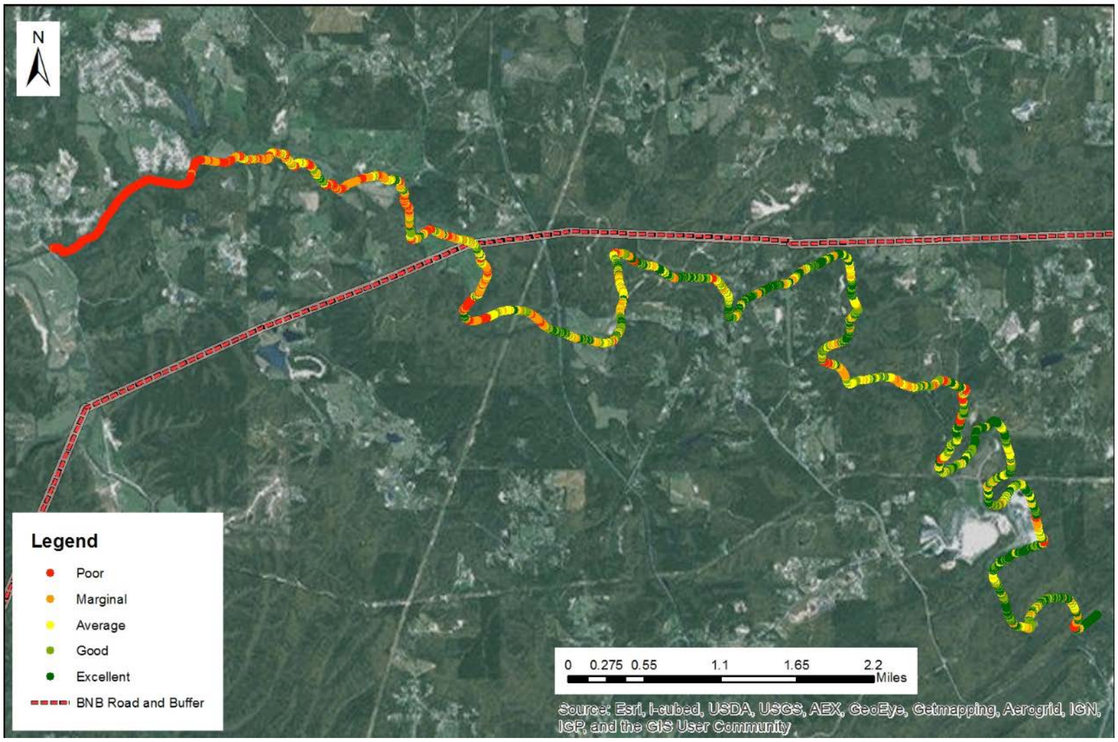


Map 11: Turkey Creek right bank condition output from the High Definition Stream Survey (mid section).

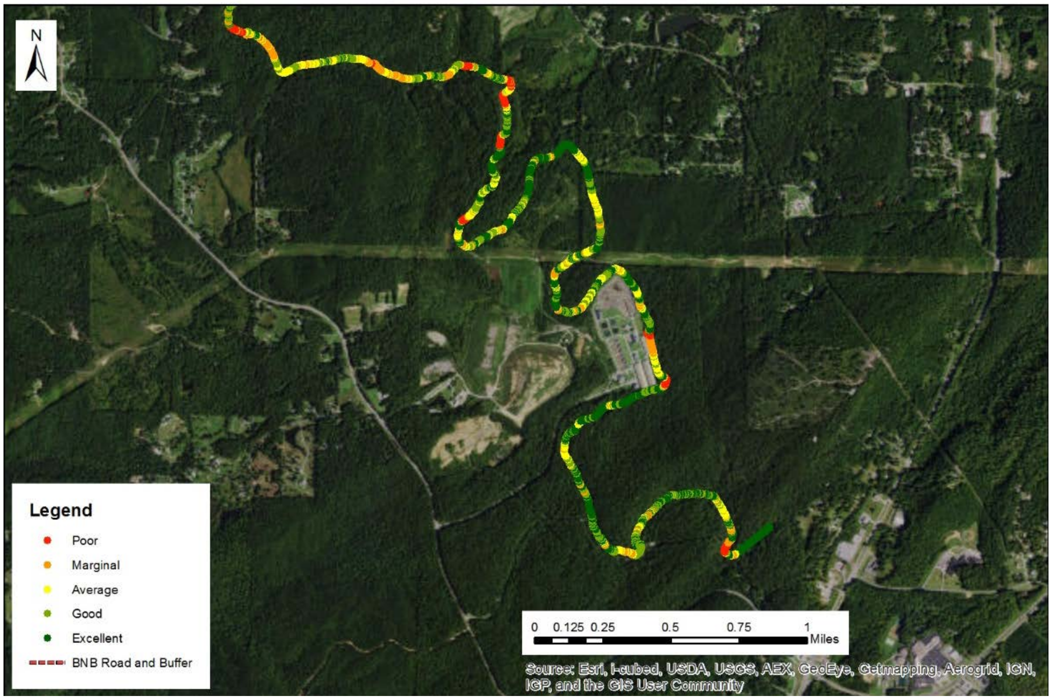


Map 12: Turkey Creek right bank condition output from the High Definition Stream Survey (lower section).

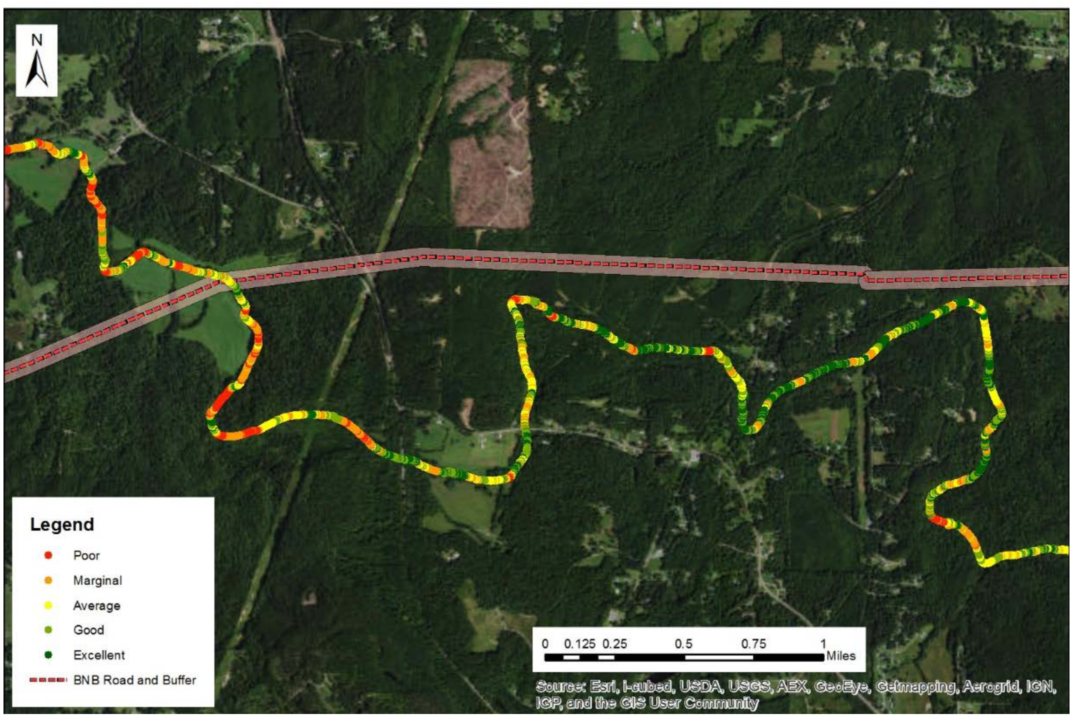
The third objective of this project was to show how we can potentially document areas of high habitat suitability for endangered darter species. For this we used hypothetical darter habitat suitability criteria to combine the primary metrics into a single value representing habitat suitability. In general, the hypothetical darter habitat suitability favored water less than 2 ft deep, with some current, larger substrates with lots of crevices, low embeddedness, and streambanks in optimal condition. This description of darter habitat would be considered typical for many species of darters, although not necessarily suitable for any particular species. The results showed that this type habitat was more common in the upper sections of Turkey Creek. The road crossing area for the BNB is not located in particularly good darter habitat, and the lower end of this segment is generally poor quality darter habitat. Map 13 - Map 16 show the Kayak HDSS project area as well as three additional maps for the upper, mid, and lower section. Map 17 show suitability for the backpack HDSS.



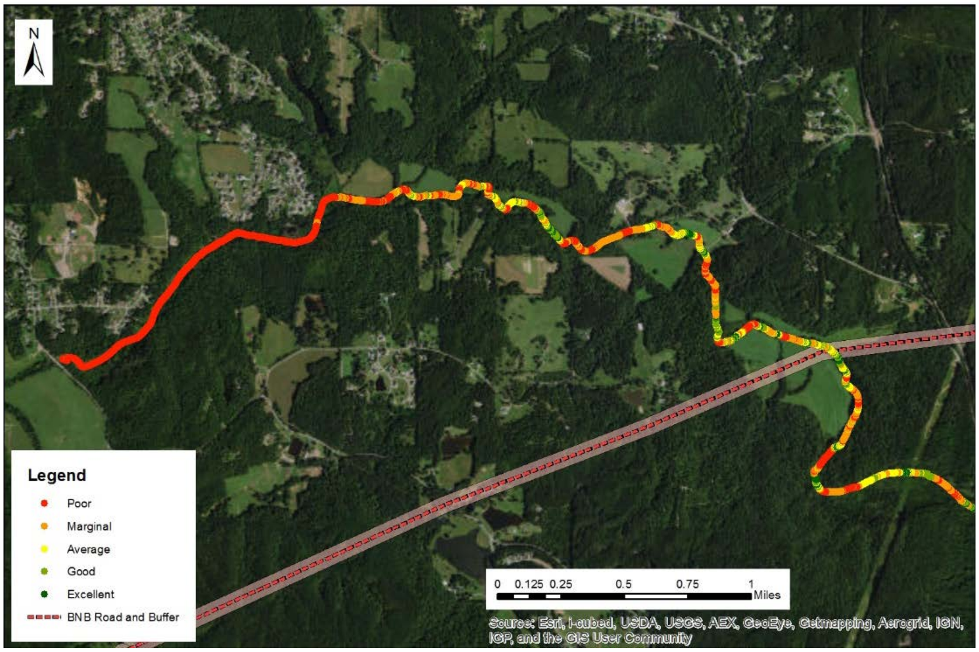
Map 13: Turkey Creek darter habitat suitability output from the High Definition Stream Survey



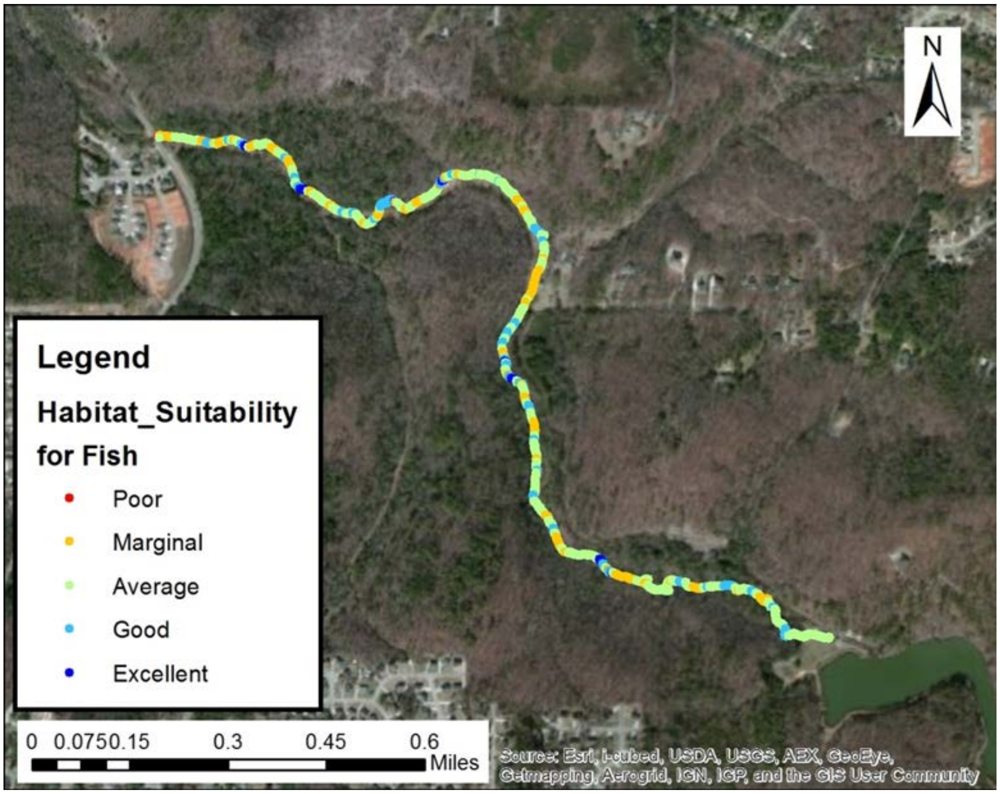
Map 14: Turkey Creek darter habitat suitability output from the High Definition Stream Survey (upper section).



Map 15: Turkey Creek darter habitat suitability output from the High Definition Stream Survey (mid section).



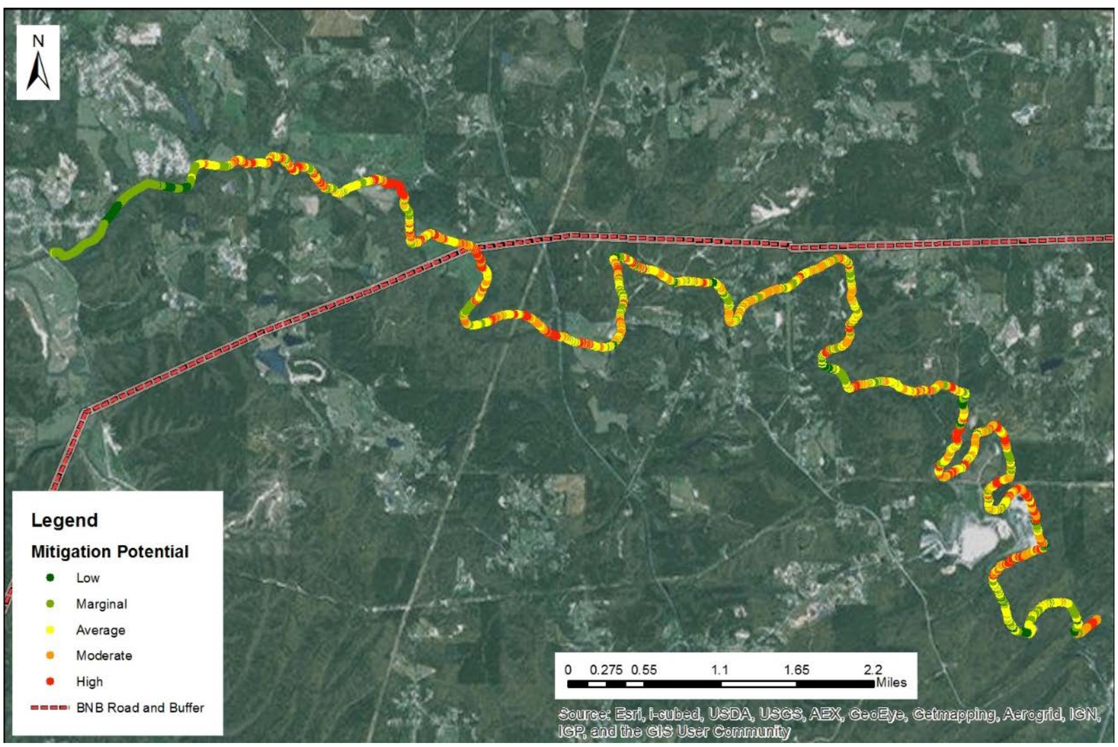
Map 16: Turkey Creek darter habitat suitability output from the High Definition Stream Survey (lower section).



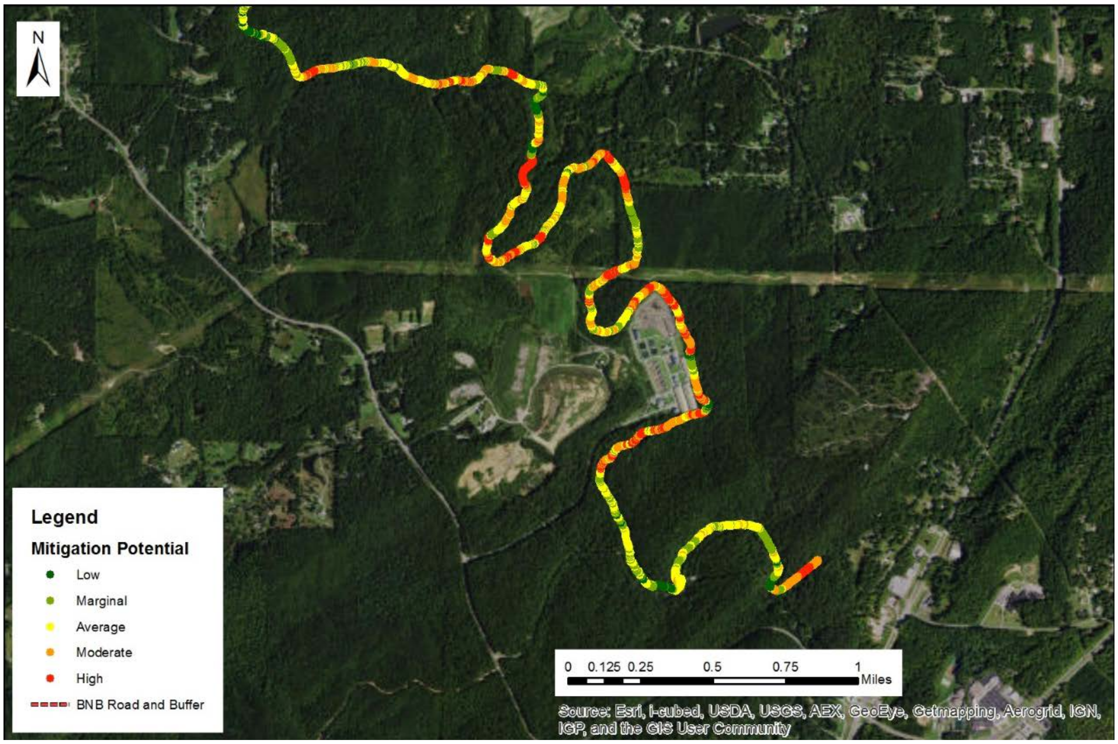
Map 17: The upstream section of Turkey Creek displaying habitat suitability from the backpack HDSS.

The final project objective was to identify areas that are most suitable for habitat mitigation. To optimize areas for streambank restoration mitigation, we selected for areas that had poor streambank condition location near high quality darter habitat.

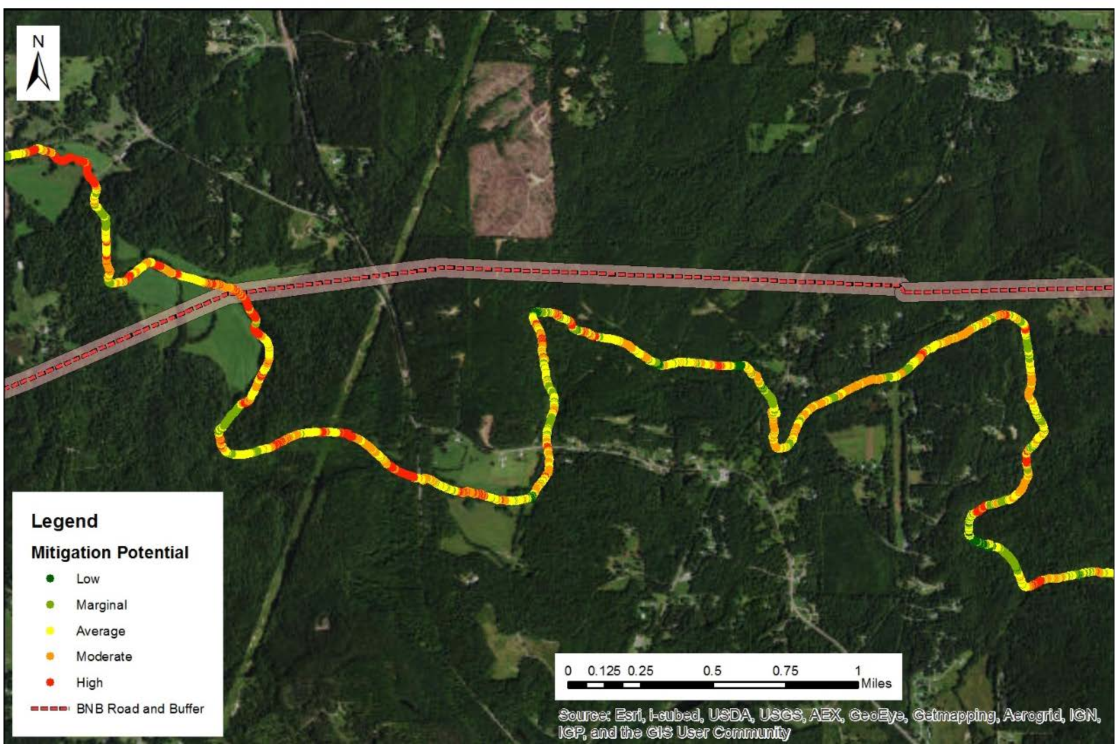
Map 18 - Map 21 show the whole project area as well as three additional maps for the upper, mid, and lower section associated with potential mitigation locations. The results show that restoration areas may be found throughout the stream segment and some are in close proximity to the BNB crossing location. Combining these results with land ownership, access, and other information would further aid in selecting the most cost effective mitigation locations.



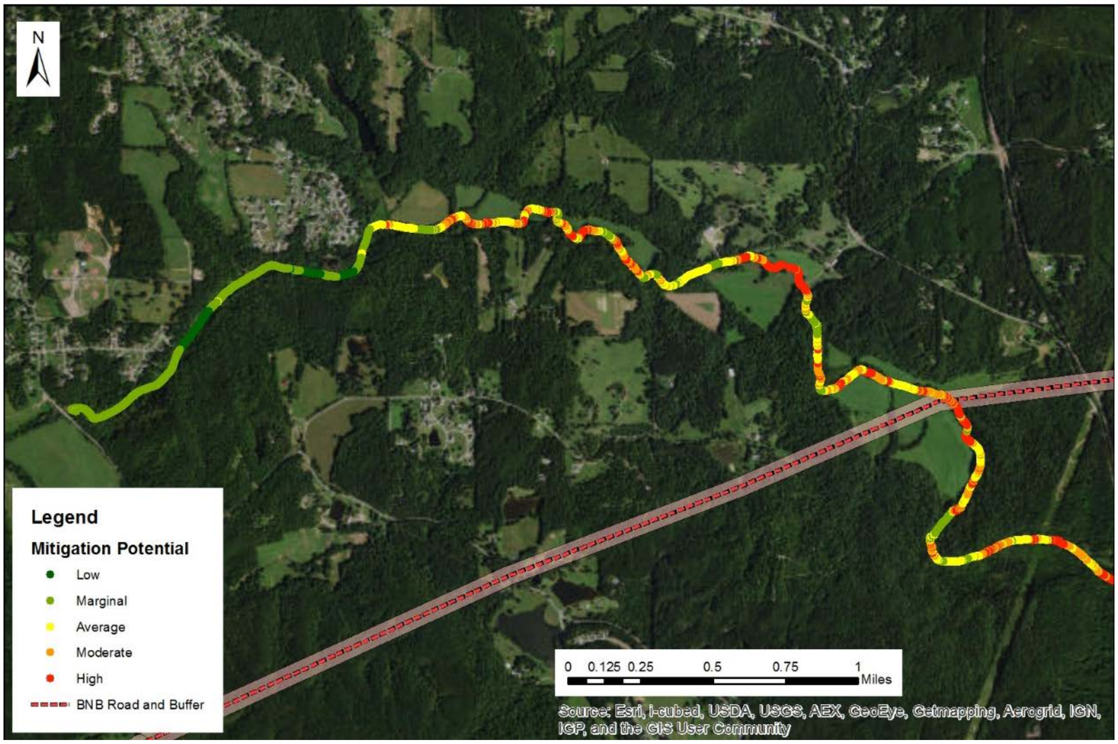
Map 18: Turkey Creek darter habitat mitigation potential output from the High Definition Stream Survey.



Map 19: Turkey Creek darter habitat mitigation potential output from the High Definition Stream Survey (upper section).



Map 20: Turkey Creek darter habitat mitigation potential output from the High Definition Stream Survey (mid section).



Map 21: Turkey Creek darter habitat mitigation potential output from the High Definition Stream Survey (lower section).

In addition to the HDSS habitat surveys conducted on Turkey Creek, we also conducted High Definition Fish Surveys (HDFS) in the upper reach of Turkey Creek to test their applicability in surveying for darters and other small fishes. While the HDFS effort is outside the scope of this project, we felt it would be informative to show how aquatic biota surveys could be completed rapidly and with low impact in conjunction with the HDSS habitat documentation approach.

The HDFS approach utilized pole-mounted, high-definition, underwater video cameras to capture images of fish or other aquatic animals at a specific location. The underwater cameras were also geo-referenced so that specific time and place information was recorded for all video observations. By logging GPS data with underwater video, the HDFS results can easily be integrated with the HDSS habitat information gathered at the same location.

Figure 15: Underwater geo-referenced video camera used during the HDFS observations.

In general, the HDFS sample could be considered a point sample. The cameras are moved into position, slowly lowered to the bottom, and then remain in position for approximately 30 seconds to capture a sample of animals at that location. This process is repeated at sites distributed evenly throughout the available habitat. To document the animals observed in the videos, the HDSS video coder software, with a list of potential animal species, was used. During classification, a start code was inserted when the camera was in position. Next, all species were recorded and then a stop code was recorded. This process allowed only high-quality underwater video samples to be used and to link the appropriate GPS data for that location. Habitat data associated with the fish samples was linked from the HDSS data collection.

The HDFS proved to be very effective for surveying fish in Turkey Creek. We covered approximately 1 km of stream and observed 9 different species with many individuals in less than two hours. In addition to species identification, we could determine size, density, behavior, and habitat preferences from the videos. The following two images show examples of the quality of the images collected during the survey.

Figure 16: Blackbanded darter observed during HDFS effort in Turkey Creek.

Figure 17: Multiple species observed during HDFS effort in Turkey Creek

Conclusions

Numerous state and federal organizations were interested in acquiring the baseline documentation and habitat conditions of Turkey Creek. The HDSS approach proved highly effective at documenting and quantifying the streambank and instream conditions in Turkey Creek. The HDSS method was fast, with approximately 17 miles of habitat surveyed in only two days and only required two surveyors. The HDSS approach was versatile in that we were able to survey both small wadeable sections with the backpack HDSS and larger floatable sections with the Kayak HDSS. In conjunction with the HDFS, we were able to document habitat, fish species occurrence, and develop habitat suitability criteria quickly and with very low impact.

This project exhibited the HDSS platform as a reliable monitoring tool for acquiring geo-referenced video in order to assess streambank and in-channel condition. Every meter within the 17 mile segment was surveyed, assessed, and archived. Every second of video has scores for habitat type, substrate type, depth, embeddedness, and bank condition that will be useful for numerous applications. The conversion of the data into shapefiles allows the results of this Turkey Creek HDSS effort to be easily integrated into other GIS-based projects.

We were able to use the classified results from the surveys to show that habitat suitability assessments could be completed for any aquatic species including the Threatened and Endangered darter species found in the Turkey Creek watershed. This approach would allow organizations to document the possible extent and location of T&E species for locating additional populations as well as optimizing future re-introduction efforts. The HDFS approach could further support these results in a rapid and cost effective way by providing reviewable geo-located species occurrence information.

The development of a mitigation prioritization approach would also be highly useful to numerous organizations. The ability to locate the areas with the most potential to improve aquatic habitat would be viewed as a positive approach during mitigation determinations with Federal permitting agencies. Being able to score and prioritize long stream segments at high resolution will reduce the subjectivity when trying to justify future restoration areas. By combining these results with other factors such as land ownership, access points, right-of-ways, county lines, etc., organizations would be able to select mitigation actions that would be most effective and also least expensive.

Another benefit of the HDSS approach is the archived videos. The videos provide everyone with important documentation of the conditions within any surveyed stream. These will help provide insurance in the future when questions arise about the condition of this stretch of Turkey Creek in 2015. Additionally, the data rich excel files can be shared with others to support the collaborative efforts of federal and state agencies, private landowners, and non-governmental organizations in this watershed to achieve long-term water quality, habitat and species benefits.

Compared to traditional erosion or instream assessments which tend be costly, isolated, restricted by access, and at times inaccurate due to extrapolation, the HDSS approach allows us to survey more streambank, in less time, and with fewer people and resources. The power of using HDSS is being able to use the video archive anytime in the future to re-assess conditions using any set of parameter needed. State, federal, private, and NGOs all may have different methods of scoring streambank and channel conditions, but the ability to share data will result in more useful results, at lower cost.