TRACKING INFORMATION

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Project Title: SWG – Landscape-level in-stream habitat mapping: "Side Scan Sonar"

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ABSTRACT

Side scan sonar for benthic habitat mapping is an efficient, low-cost approach for mapping habitat features in navigable rivers and streams. It provides a means to create high resolution, spatially detailed maps of continuous, instream habitat across broad aquatic landscapes. The sub-basins selected for this project include: Lower Choctawhatchee, Lower Ochlockonee, Withlacoochee, Peace, and Lower Suwannee. The habitat maps produced will provide valuable information that can be used to identify critical habitat for numerous species. The benthic habitat maps will provide the baseline data needed for instream habitat monitoring. These maps, depicting substrate and large woody debris, will provide a measure of location and amount of various habitat types for aquatic species. Temporal changes in the location and amount can be tracked and provide a means of habitat monitoring. These maps will also identify potential areas for restoration. Additionally, mapping pre- and post-restoration efforts can aid in monitoring the outcomes of those efforts.

Approximately 693 river kilometers (RKM) have been scanned across the five river basins including image rectification. All navigable sections of the Peace, Withlacoochee, Choctawhatchee Suwannee and the Ochlockonee Rivers have been completely mapped. Accuracy assessments have been completed for the Peace, Withlacoochee, Choctawhatchee Ochlockonee, and the Suwannee Rivers.

ACKNOWLEDGMENTS

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Contents

INTRODUCTION

Although the practice of landscape ecology has flourished using spatial technologies to reveal patterns and processes at broad scales in terrestrial habitats, the investigation of riverine landscapes has lagged behind (Wiens 2002), perhaps for want of analogous tools and techniques. Landscape level habitat data are extremely valuable in research, management and monitoring of aquatic systems. A multiscale landscape perspective is necessary to enable ecological investigations at scales relevant to the life history of stream fishes (Fausch et al. 2002; Lowe et al. 2006), and to identify, protect, restore and enhance fish and aquatic invertebrate habitat. In the past, the characterization of in-stream habitat at the landscape scale has been both difficult and costly. Low-cost side-scan sonar (SSS) offers an alternative to airborne remote sensing techniques, such as LIDAR and thermal infrared systems, which are expensive and are significantly impacted by depth and turbidity (Kaeser and Litts 2010).

Side-scan sonar has been used for decades to detect and map benthic features of marine and deep freshwater systems (Newton and Stefanon 1975; Fish and Carr 1990, 2001; Prada et al. 2008). Traditional SSS is, however, expensive and typically involves towing an underwater sensor (i.e., towfish), limiting its use in relatively shallow freshwater systems. In 2005 Humminbird® released the 900-series Side Imaging (SI) system, an inexpensive (~$2,000) SSS device. The SI system employs a small, boat-mounted transducer, enabling surveys in shallow, rocky streams. This device is capable of producing very high resolution (<10 cm) imagery revealing substrate, large woody debris, and depth—all critical components of in-stream habitat. Mapping with SSS provides a comparable and effective substitute for the labor intensive, traditional field assessment of several key habitat variables. Mapping with SSS is not only more efficient, but the information generated is geospatially referenced at a level of detail that is difficult, if not impossible to achieve with traditional field collection methods. By providing a means to visualize whole-channel, underwater features, SSS mapping overcomes limitations of traditional approaches in deep, turbid, and/or non-wadeable systems. From a practical standpoint, this technique can be performed using software readily available to researchers and managers with a limited amount of training and expertise. Within the GIS environment, information contained in these maps can be integrated with a wide variety of data layers providing new ways to examine patterns and processes occurring in aquatic landscapes. Applications of SSS habitat maps include studies of habitat-organism relationships, the identification or prediction of critical habitat, the association of land cover and in-stream habitat, and the monitoring of change over time (Kaeser and Litts 2010).

In recent years the use of SSS for mapping elements of instream habitat, examining patterns of association between aquatic organisms and habitat, and assessing habitat change over time has been increasing. Side scan sonar has been used to explore habitat selection of female Barbour's map turtle in a Southwest GA creek (Sterrett 2009), study habitat relationships between three bass species in the upper Flint River (Gocklowski et al. 2013), and is being used to assess changes in substrate deposition following a 10-year flood event, model the distribution and abundance of mussels in the Apalachicola River, develop and evaluate a sonar-based approach to monitoring distribution and abundance of adult Gulf sturgeon, and evaluate alligator snapping turtle habitat use in the Suwannee River (A. Kaeser, USFWS pers. comm.). The Florida Fish and Wildlife Conservation Commission (FWC) has successfully used SSS mapping to identify substrate preference for shoal bass spawning sites, as well as the availability of spawning habitat within the Chipola River (Bitz et al, 2015.).

This project aims to map all navigable waterways (rivers and streams) in five selected sub-basins. Low-cost sonar habitat mapping has been employed to map extensive river reaches (>100 km), but not to map entire sub-basins. Doing so would enable the study of patterns and processes associated with physical habitat at a scale relevant to watershed planning and monitoring. Sub-basins were selected from the Florida Wildlife Legacy Initiative (FWLI) prioritized list; two FWLI priority preservation sub-basins (Lower Choctawhatchee and Lower Ochlocknee), two FWLI priority enhancement sub-basins (Withlacoochee and Peace), and an additional priority sub-basin for partners/stakeholders (Lower Suwannee) were selected. Physical habitat layers can be integrated with existing biological data to identify and quantify the distribution and extent of various habitat types for aquatic species. Habitat mapping will provide valuable information that can be used to identify critical habitat for numerous Species of Greatest Conservation Need (SGCN) (FWLI Species monitoring goal). The benthic maps will provide the baseline/reference data needed for monitoring habitat change over time (FWLI Habitat monitoring goal) within and across the sub-basins. With side scan sonar data available at the sub-basin scale, the FWC will be able to combine this data with existing land use/land cover data to study how land use throughout the sub-basin affects issues such as sedimentation and cover availability in the form of large woody debris. Sonar-based habitat maps will also be used in conjunction with staff knowledge of areas with a high likelihood of impact (such as unfenced pastures and unpaved stream crossings, particularly in areas that show heavy sedimentation (FWLI Freshwater goal)). Pre and post-restoration mapping can aid in monitoring the outcomes of restoration efforts. For State Wildlife Grant (SWG) funded restoration projects, these maps will aid in fulfilling the requirement of monitoring the effectiveness of how SWG funds are being allocated.

Project Objectives

The ultimate objective of this study is to develop a comprehensive in-stream habitat database composed of multiple physical habitat layers from navigable river/stream waterways within 4 - 5 HUC 8 sub-basins, depending on water levels. The following three steps are involved in a sonar habitat mapping project:

1. Sonar surveys are conducted during appropriate stream conditions to gather imagery and coordinate data.
2. Classified maps of physical habitat features are developed using ArcGIS for substrate, large woody debris, channel margins, depth, and other features of interest to be determined by the project committee (e.g., mesohabitats, riparian disturbance).
3. Accuracy assessments are conducted to evaluate map products.

Achievement of this objective will result in a validated GIS database containing detailed, seamless habitat information for approximately 1,140 river kilometers in 5 priority sub-basins.

METHODS

Study Areas

Lower Choctawhatchee River Basin.—

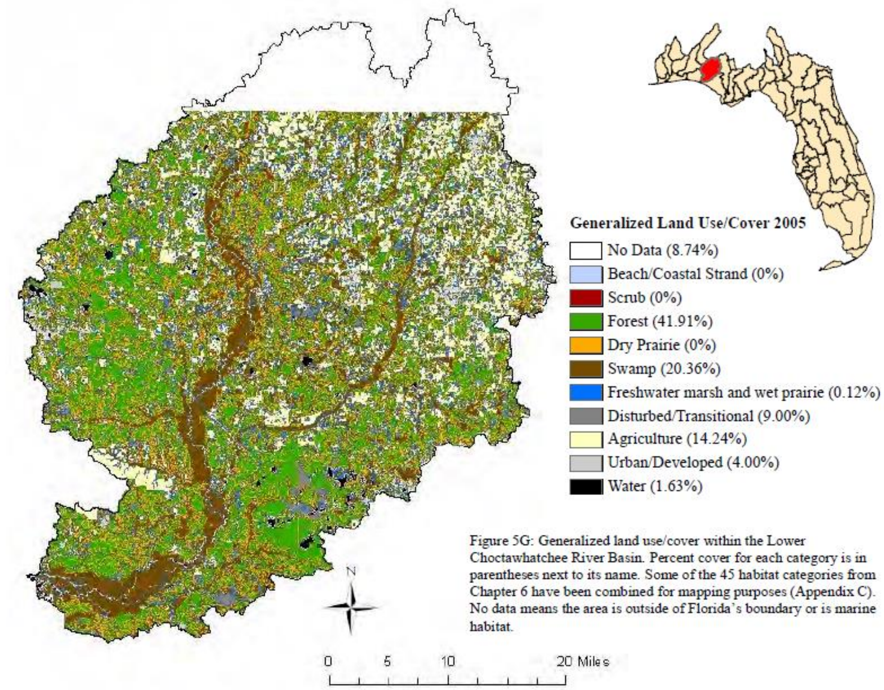

Figure 5G: Generalized land use/cover within the Lower Choctawhatchee River Basin. Percent cover for each category is in parentheses next to its name. Some of the 45 habitat categories from Chapter 6 have been combined for mapping purposes (Appendix C). No data means the area is outside of Florida's boundary or is marine habitat.

The USGS divides the Choctawhatchee River Basin into two HUC 8s, the Upper Choctawhatchee (in Alabama) and Lower Choctawhatchee River basins. The Lower Choctawhatchee River Basin covers an area of 995,139 acres (402,718 ha), approximately 91 % of which is in Florida's Panhandle and 9 % in southern Alabama. In Florida, the Lower Choctawhatchee River flows through two distinct physiographic regions: the Marianna Lowlands and the Gulf Coastal Lowlands, but cuts between the Western and Northern Highlands (FDEP 2006b). Forests, Agriculture and Swamps are the major land-cover types throughout the basin (Figure 5G). The Choctawhatchee River discharges an average of 7,198 cfs (204 m^3/sec) to the Choctawhatchee Bay (NWFWMD 1996). Classified as a Large Alluvial Stream, the Choctawhatchee River has a large floodplain, seasonal flooding and heavy sediment loads (FDEP 2006b). The basin contains 13 low magnitude springs, including Morrison, Washington Blue, Potter, Vortex and Ponce de Leon springs, contributing 160 cfs (4.5 m^3/sec) to the Choctawhatchee River (Barrios 2005). Many lakes important for recreation and native species occur throughout the basin, including Lake DeFuniak, Pate Lake, Juniper Lake, Lake Victor, Lucas Lake and Hicks Lake. Softwater Streams and Seepage/Steephead Streams occur in the basin as well. Holmes Creek, the Choctawhatchee River's major tributary, is a spring-fed Calcareous Stream, receiving water from the Sandhill Lake aquifer recharge area in Washington County (FDEP 2006b).

Ten state and one federally listed freshwater obligate SGCN occur within the basin, including four birds, two turtles, one salamander, one frog and two fish (notably the Gulf sturgeon). Though the Lower Choctawhatchee River Basin is relatively undeveloped, a portion of the landscape is classified as Disturbed/Transitional (Figure 5G). Also, the highly permeable karst topography makes the basin vulnerable to decreased water quality and quantity (Barrios 2005). Several partners have made an effort to improve or conserve the water and land resources in the Lower Choctawhatchee River Basin. Examples include the Choctawhatchee Basin Alliance's water quality monitoring and education programs; the FDEP's Watershed Restoration Program; the NWFWMD SWIM Plan; and the 94,681 acres (38,316 ha) of conservation land in the basin (FNAI 2011b). Five counties occur within the basin (Bay, Washington, Jackson, Holmes and Walton). The conservation of the basin's land and water resources is managed by the FWC's Northwest Region, the FDEP's Northwest District and the NWFWMD.

Lower Ochlockonee River Basin.—

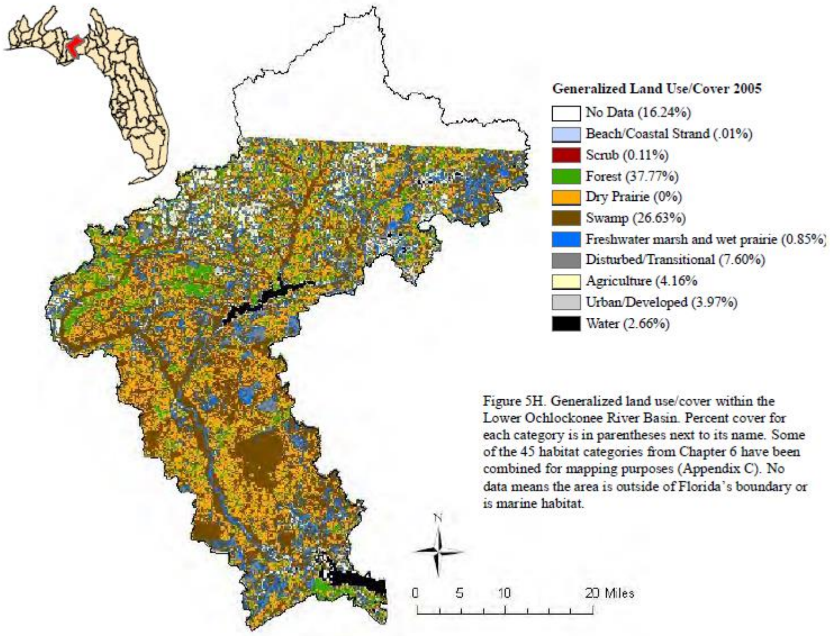

Figure 5H. Generalized land use/cover within the Lower Ochlockonee River Basin. Percent cover for each category is in parentheses next to its name. Some of the 45 habitat categories from Chapter 6 have been combined for mapping purposes (Appendix C). No data means the area is outside of Florida's boundary or is marine habitat.

The USGS divides the Ochlockonee River Basin into two HUC 8s: the Upper Ochlockonee (in Georgia) and the Lower Ochlockonee River basins. The Lower Ochlockonee River Basin covers an area of 994,445 acres (402,438 ha), approximately 84 % of which is in Florida's Panhandle and 16 % in southwest Georgia. In Florida, the Lower Ochlockonee River flows through two distinct physiographic regions: the Tallahassee Hills and the Gulf Coastal Lowlands (FDEP 2001). Forests and Swamps are the major land cover types throughout the basin (Figure 5H). After receiving increased flow from the Lake Talquin Dam, the Ochlockonee River discharges approximately 2,500 cfs (71 m^3/sec) to the Ochlockonee Bay (FDEP 2001). The Ochlockonee River and most of its tributaries are classified as Alluvial Streams, but it also receives input from several Softwater, Seepage/Steephead and Coastal Tidal Streams (FDEP 2001). The basin also contains several large lakes important for recreation and species diversity, including the Lake Talquin Reservoir, Lake Jackson and Lake Iomania (FDEP 2001).

Eleven state and three federally listed freshwater obligate SGCN occur within the basin, including five birds, two turtles, two fish (the Gulf sturgeon and Suwannee bass) and two mussels. Flow of the Ochlockonee River has been altered by the Lake Talquin Reservoir was impounded in 1929 for hydroelectric power generation but is mostly used for recreation now (FDEP 2001). The large and small lakes in the basin are vulnerable to contamination from stormwater in urban areas (FDEP 2001). Several partners have made an effort to improve or conserve the water and land resources in the Lower Ochlockonee River Basin. Examples include the City of Tallahassee's water quality improvement and education programs; the interagency (NWFWMD, FDEP, FWC and Leon County) Lake Jackson Restoration Project; the FDEP's Watershed Restoration Program; the NWFWMD SWIM Plan; and the 317,492 acres (128,484 ha) of conservation land in the basin (FNAI 2011b). Five counties occur within the basin (Franklin, Wakulla, Liberty, Leon and Gadsden). The conservation of the basin's land and water resources is managed by the FWC's Northwest Region, the FDEP's Northwest District and the NWFWMD.

Peace River Basin.—

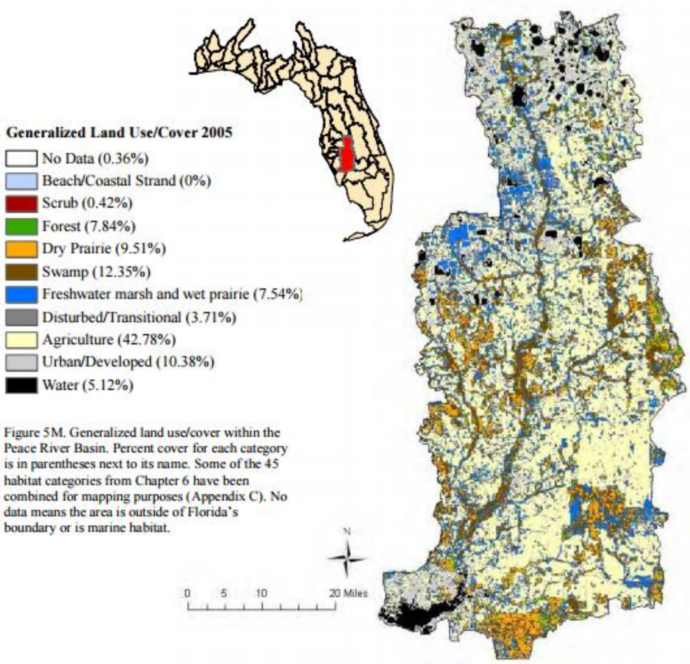

Figure 5M. Generalized land use/cover within the Peace River Basin. Percent cover for each category is in parentheses next to its name. Some of the 45 habitat categories from Chapter 6 have been combined for mapping purposes (Appendix C). No data means the area is outside of Florida's boundary or is marine habitat.

The Peace River Basin covers an area of 1,498,002 acres (606,220 ha) in West Central Florida from Winter Haven to Punta Gorda. The Peace River flows south from the Green Swamp to Charlotte Harbor, Florida's second largest estuary (FDEP 2003b). Three physiographic regions are contained within the basin: the Polk Upland, the DeSoto Plain and the Gulf Coastal Lowlands (Southwest Florida Water Management District [SWFWMD] 2002). The basin contains some of Florida's best remaining Dry Prairie habitats in the state (Figure 5M and FDEP 2003b). Classified as a Softwater Stream in its upper reaches, the Peace River receives much of its water from rainfall. Innumerable lakes important for recreation and species diversity occur in the upper part of the basin, such as lakes Ariana, Hamilton, Hancock and Parker. As it flows south, the floodplain widens, wetlands increase and it transitions to a Coastal Tidal River. The Peace River discharges an average of 2,010 cfs (57 m3 /sec) to Charlotte Harbor (Hammet 1990). Six state listed and one federally listed freshwater obligate SGCN birds (notably the snail kite) occur within the basin. The Peace River Basin has undergone many changes in landscape since the 1900s from urban development, agriculture and phosphate mining, which have all led to decreased water levels and degraded water quality in the Peace River and its tributaries (FDEP 2003b). Several partners have made an effort to improve or conserve the water and land resources in the Peace River Basin. Examples include the Charlotte Harbor National Estuary Program's conservation and restoration activities; the FDEP's Watershed Restoration Program; the SWFWMD SWIM Plans and Comprehensive Watershed Management Initiative; and the 114,339 acres (46,271 ha) of conservation land in the basin (FNAI 2011b). Four counties occur within the basin (Polk, Hardee, DeSoto and Charlotte). The conservation of the basin's land and water resources is managed by the FWC's Southwest Region, the FDEP's Southwest and South Districts and the SWFWMD.

Withlacoochee River Basin.—

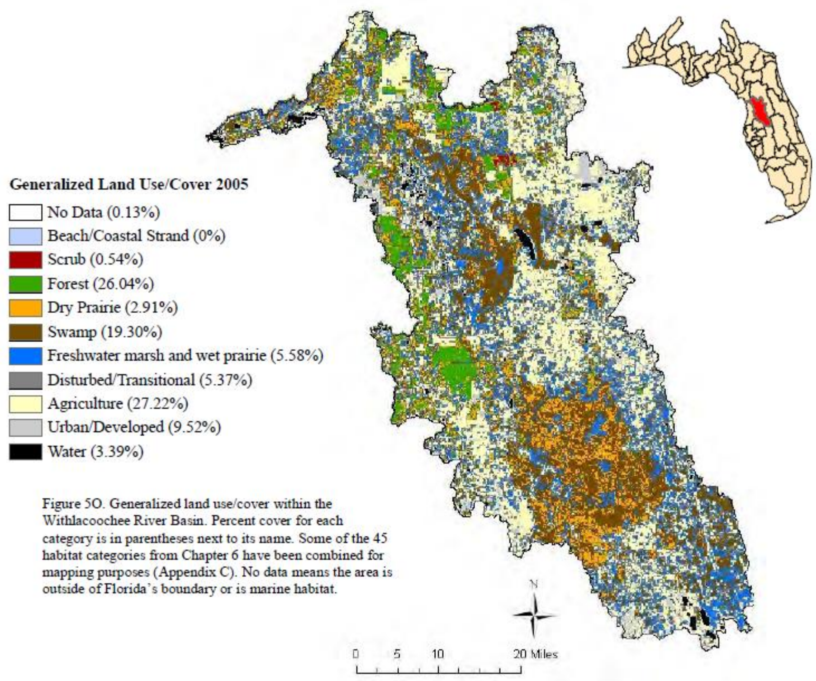

Figure 5O. Generalized land use/cover within the Withlacoochee River Basin. Percent cover for each category is in parentheses next to its name. Some of the 45 habitat categories from Chapter 6 have been combined for mapping purposes (Appendix C). No data means the area is outside of Florida's boundary or is marine habitat.

The Withlacoochee River Basin covers an area of 1,320,032 acres (534,198 ha) in West Central Florida. The Withlacoochee River originates in the Green Swamp area near Haines City and flows northwest to the Withlacoochee Bay (FDEP 2005b). The Withlacoochee River Basin has five primary physiographic regions: the Brooksville Ridge, Tsala Plain, Coastal Lowlands, Webster Limestone Plain and the Dade City Hills (FDEP 2005b). The basin hosts a diverse range of natural habitats including Forests, especially Sandhill, Swamps and Dry Prairie (Figure 5O). Generally classified as a Calcareous Stream with Softwater sections, the Withlacoochee River has several spring-fed tributaries. The basin contains numerous springs, including the fourth largest freshwater spring in Florida (tenth largest in the world): Rainbow Springs, which feeds the Rainbow River, Withlacoochee River's largest tributary) (FDEP 2005b). Several lakes important for recreation and native species occur throughout the basin, such as Lake Panasoffkee, Lake Rousseau, Lake Miona and Tsala Apopka Lake. The lower river channel was severely altered in the 1960s for the construction of the now-deactivated Cross-Florida Barge extremely variable, but averages 1,540 cfs (44 m^3/sec) (FDEP 2005b).

Six state listed and one federally listed freshwater obligate SGCN birds (notably the snail kite) occur within the basin. As a result of the high urban development and altered water regimes, the Withlacoochee River is vulnerable to pollution. Several partners have made an effort to improve or conserve the water and land resources in the Withlacoochee River Basin. Examples include the Florida Defenders of the Environment's Withlacoochee Project; the Rainbow Springs Working Group's education and conservation efforts; the FDEP's Watershed Restoration Program; the SWFWMD SWIM Plan; the several NGOs; and the 390,999 acres (158,232 ha) of conservation land in the basin (FNAI 2011b). Eight counties occur within the basin (Marion, Citrus, Sumter, Hernando, Pasco, Polk, Lake and Levy). The conservation of the basin's land and water resources is managed by the FWC's Northeast, North Central and Southwest Regions, the FDEP's Southwest and Central Districts and the SWFWMD (Fl. FWCC 2012).

Data Collection

A strategy was prepared to best utilize time and resources to ensure as much data as possible was collected on each sub-basin. At the outset of the project, it was determined that priority for data collection was given to the main-stem of each sub-basin. For the given main-stem, float plans were prepared based off of satellite imagery and local knowledge of the river system as available. The float plan determined the upper and lower-most extent that would be surveyed for a given float trip. These extents were based off of the presumed navigability of the river channel, accessibility to boat ramps, and local knowledge based on flow conditions. Deviations from the float-plan did occur while collecting data as the actual river conditions became known and more or less data were collected as a result.

Sonar imagery was collected using a Humminbird 1199ci side imaging system following the snapshot approach developed in Kaeser and Litts (2010). When possible, sonar recordings were collected simultaneously by networking a Humminbird 1199ci with a Humminbird 1198c. Sonar recordings were collected due to the development of new, inexpensive sonar processing software that could drastically reduce processing time and reduce sources of error in collecting imagery. This networking method allowed us to adhere to the original proposed sampling method and also experiment with an alternate method for potential viability in future studies. Problems encountered with the snapshot approach included missed snapshots and rectification errors in processing. The sonar recording approach alleviated these problems and filled in missing information missed by the snapshots. Photographs of features along the banks and of points of interest were also taken during the time of survey using a GPS enabled digital camera, with intentions to load into ArcGIS as a hot linked source of information to aid in habitat interpretation.

Processing

Snapshot imagery was processed using methods developed by Kaeser and Litts (2010), as well as programs developed through python code language. Python language was used to convert navigation points to lines, clean navigation data, and join waypoint and trackline attributes. Snapshot imagery was clipped and rectified using the ArcGIS Visual Basic tools developed by Kaeser and Litts (2010). Sonar recordings were processed using SonarTRX Pro and protocols were developed to optimize image quality and for loading into ArcGIS for viewing and delineation of habitat features. See Appendix F for detailed protocol.

Development of Classification System

A habitat classification scheme was developed using Kaeser and Litts (2010), and modified according to habitat features and forms that we believe possible to distinguish, relevant to species distributions, and to represent different levels of spatial hierarchy. The classification scheme detail and definitions used for mapping is in Appendix B, C, D and E. Due to the large volume of potential substrate classifications, the GIS data are housed in an ESRI file geodatabase which permits the use of subtypes and domains. Each bed composition (Level I) is assigned to the geodatabase as a subtype. As a subtype is selected, each additional attribute (Bed Hardness, Bedform Structure/Texture, Type, and Substrate Cover) is narrowed down according to that selection using domain lists. For example, if the habitat mapper classifies a polygon as "Fines", then the possible values for Bedform Structure/Texture is limited to Plane Bedform or Rippled/Duned Bedform. The use of subtypes and domains dramatically decreases the time it takes to classify a substrate and also allows the mapper to focus on a single attribute at a time.

The original classification scheme has been adapted to better quantify the habitat encountered once accuracy assessment began. The classification scheme detail and definitions used for mapping, as well as a crosswalk between the original and updated classification schemes can be found in Appendices B, C, and D. Habitat delineation was conducted using a heads-up, manual digitization approach. Bankline boundaries were fist drawn using a combination of the edge of sonar reflectance in sonar imagery and satellite imagery from ESRI's 2015 basemap service.

Digitizing Habitat Features

Sonar imagery was added to ArcGIS Desktop 10.0+. Using the editor toolset and visually inspecting the sonar imagery, lines are drawn to represent the boundaries between two differing substrates according to the classification system. After boundaries are satisfactorily drawn, line features are converted to polygon features and the classification system is applied utilizing domains and subtypes in the ArcGIS geodatabase.

Accuracy Assessment

Once a river system is classified, each classification is summarized to determine the total number of polygons and the total area covered by the substrate. This information is passed on to FWC's statistician to determine a statistically significant number of classified features to be field checked for accuracy. Using this information, points are randomly selected at the centroid of the polygon feature and visited in the field. Actual substrate type will be determined using a drop-camera, ponar grab, diving, and visual inspection where conditions permit (i.e. low water). This assessment will be used to determine the relative accuracy of the substrate map for each river.

PROGRESS

Overview

115 RKM of the Peace River have been scanned/imagery processed, habitat mapped, and assessed for accuracy. 129 RKM of the Withlacoochee River have been scanned/imagery processed, habitat mapped, and assessed for accuracy. 147 RKM of the Lower Choctawhatchee River have been scanned/imagery processed, habitat mapped and have been assessed for accuracy. 196 RKM of the Lower Suwannee River have been scanned/imagery processed, habitat mapped, and assessed for accuracy. 114 RKM of the Lower Ochlockonee River have been scanned/imagery processed and habitat mapped, and assessed for accuracy.

Peace

Data Collection.— A total of three field days were spent on the Peace River in the middle of October 2014. Continuous sonar data (snapshots only) was collected from RKM 117 to RKM 10. RKM 18-10 required a left and right bank pass to ensure bank-to-bank coverage. Data were not collected beyond RKM 10 as the river widens substantially and becomes relatively shallow (approx. 5 ft.) which contributes to lower quality sonar data. Substrate complexity is also greatly reduced at this point, primarily composed of rippled/duned sand. In total, 115 RKM of data were collected. Specific discharge conditions during the survey can be found in Appendix A.

Processing.— All of the sonar data collected on the Peace River has been processed as described by Kaiser & Litts, 2011. Only snapshots were collected as the video network was not in use at this time. The data are stored in mosaic datasets in an ESRI file geodatabase.

Mapping.— The data collected have been reviewed and habitat features have been identified, digitized, and classified according to the project classification. A classification summary by river kilometer can be found in Appendix F. A summary table of the classified substrates follows.

BED COMPOSITION LEVEL 1	# OF POLYGONS	TOTAL AREA COVERED (M2)
FINES	938	3,280,367
ROCKY FINE	77	44,851
ROCKY BOULDER	43	7,298
BEDROCK	279	327,085
FINES MIX	179	372,185
FINES/BEDROCK MIX	74	42,608
TOTAL	**1590**	**4,074,394**

SUBSTRATE TYPE LEVEL 4	# OF POLYGONS	TOTAL AREA COVERED (M2)
SILT/MUD/ORGANIC	32	17,156
CLAY	4	6,948
SAND	767	3,140,096
GRAVEL	130	115,515
SAND/SILT/MUD MIX	150	348,243
SAND/HARD CLAY MIX	1	1,479
GRAVEL/SILT/MUD MIX	2	2,021
GRAVEL/SAND MIX	26	20,442
SAND/BEDROCK MIX	42	26,735
GRAVEL/BEDROCK MIX	32	15,873
TOTAL	**1186**	**3,694,508**

Accuracy Assessment. — The tabular habitat features were sent to the agency statistician. The data include the substrate bed composition/substrate type, number of polygons, total area covered, and a general confidence level of the mapper. The statistician determined the appropriate number of sample points for each class. The initial accuracy assessment of the Peace River occurred between July 13, 2015 and July 16, 2015. Fifty-one kilometers were traversed to assess the accuracy of 157 points. A second trip was conducted between January 4, 2016 and January 8 2016 to assess the accuracy of an additional 98 points. A summary of mapped sonar imagery with accuracy assessed results can be seen in Appendix G. A summary table of the assessed substrate polygons follows.

SUBSTRATE NAME	SUBSTRATE CODE	FREQUENCY TOTAL	FREQUENCY VISITED	PERCENT VISITED
NULL	0	4	4	100.00
SILT/MUD/ORGANIC	1	7	5	71.43
CLAY	2	3	3	100.00
SAND	3	93	67	72.04
GRAVEL	4	31	21	67.74
SAND/SILT/MUD MIX	7	27	19	70.37
SAND/HARD CLAY MIX	8	1	0	0.00
GRAVEL/SILT/MUD MIX	9	2	0	0.00
GRAVEL/SAND MIX	11	11	10	90.91
SAND/BEDROCK MIX	14	8	7	87.50
GRAVEL/BEDROCK MIX	15	6	6	100.00
ROCKY FINE	22	23	20	86.96
ROCKY BOULDER	23	8	7	87.50
BEDROCK	24	33	28	84.85
TOTAL		**257**	**197**	**76.65**

Withlacoochee

Data Collection.— Continuous sonar data were collected from RKM 164 to RKM 35. A total of six field days were spent collecting sonar imagery on the Withlacoochee. The first two field days occurred in the beginning of September 2014 and covered RKM 138-113 and RKM 56-46. Only snapshots were collected for this portion. A second trip in December 2014 covered RKM 164-138, RKM 113-56, and RKM 56-46. Snapshots and video data were collected for these segments Sonar data were not collected above RKM 164 because of questionable navigability due to extensive woody debris in the river and, inability to distinguish hazards due to black water/turbidity, and river depth. Sonar data were not collected below RKM 35 because of extensive vegetation cover contributing to significantly reduced sonar data quality. In total, 129 km of sonar data were collected on the Withlacoochee. Specific discharge conditions during the survey can be found in Appendix A.

Processing.— All of the sonar data (snapshots) collected on the Withlacoochee River have been processed as described by Kaiser & Litts (2011). Where collected, the video data have been processed according to Appendix F. The data are stored in mosaic datasets in an ESRI file geodatabase.

Mapping. — The data collected have been reviewed and habitat features have been identified, digitized, and classified according to the project classification. A classification summary by river kilometer can be found in Appendix F. A summary table of the classified substrates follows.

NEW LEVEL 1 BED COMPOSITION	# OF POLYGONS	TOTAL AREA COVERED (M2)
1 - FINES	2801	4410508.99
2 – COARSE FINES	757	213186.00
3 – ROCKY BOULDER	529	147786.33
4 – HARD BOTTOM	524	324992.22
TOTAL	**4611**	**5096473.54**

NEW LEVEL 4 TYPE	# OF POLYGONS	TOTAL AREA COVERED (M2)
01 - SILT/MUD	174	95322.64
02 - SAND	708	2405250.21
03 - FINES MIX	1627	1822507.33
04 - FINES/ COARSE FINES MIX	292	87428.81
05 - GRAVEL	123	30627.28
09 - ROCKY FINE	634	182558.71
10 - BOULDERS	529	147786.33
06 - HARD CLAY	16	13179.33
07 - HARD CLAY/ FINES MIX	7	5514.42
08 - HARD CLAY/ COARSE FINES MIX	3	1733.85
11 - BEDROCK	391	225148.62
12 - BEDROCK/ FINES MIX	88	67642.98
13 - BEDROCK/ COARSE FINES MIX	19	11773.02
TOTAL	**4611**	**5096473.54**

Accuracy Assessment. — The tabular habitat features were sent to the agency statistician. The data include the substrate bed composition/substrate type, number of polygons, total area covered, and a general confidence level of the mapper. The statistician determined the appropriate number of sample points for each class. The initial accuracy assessment of the Withlacoochee River occurred between March 28, 2016 and April 1, 2016. Seventy kilometers were traversed to assess the accuracy of 98points. A second trip was conducted between April 12, 2016 and April 15, 2016 to assess the accuracy of an additional 113 points spread over 56 kilometers. A summary of mapped sonar imagery with accuracy assessed results can be seen in Appendix H. A summary table of the assessed substrate polygons follows.

SUBSTRATE NAME	SUBSTRATE CODE	FREQUENCY TOTAL	FREQUENCY VISITED	PERCENT VISITED
NULL	0			
01 - SILT/MUD	1	10	10	100.00
02 - SAND	2	25	26	100.00
03 - FINES MIX	3	54	60	100.00
04 - FINES/ COARSE FINES MIX	4	21	16	76.19
05 - GRAVEL	5	10	9	90.00
06 - HARD CLAY	6	3	3	100.00
07 - HARD CLAY/ FINES MIX	7	3	3	100.00
08 - HARD CLAY/ COARSE FINES MIX	8	2	1	50.00
09 - ROCKY FINE	9	22	23	100.00
10 - BOULDERS	10	19	10	52.63
11 - BEDROCK	11	21	23	100.00
12 - BEDROCK/ FINES MIX	12	6	5	83.33
13 - BEDROCK/ COARSE FINES MIX	13	3	3	100.00
TOTAL		**199**	**192**	**96.48**

Lower Choctawhatchee

Data Collection.— Continuous sonar data were collected from RKM 150 to RKM 0. This extended from the Alabama/Florida border to the Choctawhatchee Bay. A total of five field days were spent of the Choctawhatchee in February 2015. Snapshot and video data were collected for the entire extent of the river. Approximately 9.3 km of Holmes Creek, a tributary in the Lower Choctawhatchee sub-basin, were scanned. At RKM 55, the river has deviated from its historic channel and is now in a new channel and the new channel was scanned. From RKM 45 to RKM 31, two passes were needed to cover the entire channel. In total, 165 km of sonar data were collected on the Choctawhatchee and Holmes Creek. Specific discharge conditions during the survey can be found in Appendix A.

Processing.**—** All of the sonar data (snapshots) collected on the Choctawhatchee River and Holmes Creek have been processed as described by Kaiser & Litts, 2011. Where collected, the video data have been processed according to Appendix F. The data are stored in mosaic datasets in an ESRI file geodatabase.

Mapping.**—** The data collected have been reviewed and habitat features have been identified, digitized, and classified according to the project classification. A classification summary by river kilometer can be found in Appendix F. A summary table of the classified substrates follows.

New Level 1 Bed Composition	# of Polygons	Total Area Covered (m2)
1 - Fines	1,669	9,682,485
2 - Coarse Fines	392	293,039
3 - Boulders	137	166,810
4 - Hard Bottom	353	608,136
Total	**2,551**	**10,750,470**

New Level 4 Type	# of Polygons	Total Area Covered (m2)
1 - Silt/ Mud	72	51,135
2 - Sand	251	7,420,868
3 - Fines Mix	1,151	1,932,664
4 - Fines/ Coarse Fines Mix	195	277,818
5 - Gravel	108	98,151
9 - Rocky Fine	284	194,888
10 - Boulders	137	166,810
6 - Hard Clay	16	40,368
7 - Hard Clay/ Fines Mix	2	16,627
11 - Bedrock	234	431,325
12 - Bedrock/ Fines Mix	30	79,270
13 - Bedrock/ Coarse Fines Mix	10	16,190
Cultural	61	24,356
Total	**2,551**	**10,750,470**

Accuracy Assessment. **—** The tabular habitat features were sent to the agency statistician. The data include the substrate bed composition/substrate type, number of polygons, total area covered, and a general confidence level of the mapper. The statistician determined the appropriate number of sample points for each class. The initial accuracy assessment of the Choctawhatchee River occurred between September 19, 2016 and September 23, 2016. Seventy kilometers were traversed to assess the accuracy of 98 points. A second trip was conducted between September 27, 2016 and September 29, 2016 to assess the accuracy of an additional 113 points spread over 56 kilometers. A summary of mapped sonar imagery with accuracy assessed results can be seen in Appendix H. A summary of the accuracy assessment procedure with results for each river can be seen in Appendix I. A summary table of the assessed substrate polygons follows.

SUBSTRATE NAME	SUBSTRATE CODE	FREQUENCY TOTAL	FREQUENCY VISITED	PERCENT VISITED
NULL	0			
01 - SILT/MUD	1	11	10	90.91
02 - SAND	2	6	6	100.00
03 - FINES MIX	3	50	52	100.00
04 - FINES/ COARSE FINES MIX	4	26	26	100.00
05 - GRAVEL	5	17	16	94.12
06 - HARD CLAY	6	5	6	100.00
07 - HARD CLAY/ FINES MIX	7	2	2	100.00
08 - HARD CLAY/ COARSE FINES MIX	8	0	0	
09 - ROCKY FINE	9	22	21	95.45
10 - BOULDERS	10	12	13	100.00
11 - BEDROCK	11	17	20	100.00
12 - BEDROCK/ FINES MIX	12	5	5	100.00
13 - BEDROCK/ COARSE FINES MIX	13	3	3	100.00
TOTAL		176	180	

Lower Suwannee

Data Collection.— Continuous sonar data were collected from RKM 205 to RKM 9. A total of eight field days were spent on the Suwannee on three different float trips. The first trip occurred in the middle of September 2014. Sonar data collection support was provided by the U.S. Fish and Wildlife Service and the U.S. Geological Survey. Multiple passes were performed on RKM 116 to RKM 29 to ensure bank-to-bank coverage. Only snapshot data were collected on this trip. A second trip at the end of January 2015 focused on RKM 205 to RKM 116. Two passes were required to ensure bank-to-bank coverage. Snapshot and video sonar data was collected on this trip. A third trip at the beginning of April 2015 focused on RKM 73 to RKM 9. The remaining gaps from the first trip were completed and right and left bank passes were continued from RKM 24 to RKM 9. During this trip, approximately 26 km of the Santa Fe River (tributary) were collected. Snapshot and video sonar data were collected on this trip. In total, 497 km of sonar data were collected on the Suwannee and Sante Fe rivers. Specific discharge conditions during the survey can be found in Appendix A.

Processing.— All of the sonar data (snapshots) collected on the Suwannee River and Santa Fe River have been processed as described by Kaiser & Litts, 2011. Where collected, the video data have been processed according to Appendix F. The data are stored in mosaic datasets in an ESRI file geodatabase.

Mapping.— The data collected have been reviewed and habitat features have been identified, digitized, and classified according to the project classification. A classification summary by river kilometer can be found in Appendix F. A summary table of the classified substrates follows.

	# of Polygons	Total Area Covered (m2)
1 - Fines	1,272	19,689,761
2 - Coarse Fines	468	654,981
3 - Boulders	519	1,261,373

4 - Hard Botto	663	2,230,638
Total	**2,922**	**New Level 1 Bed Composition**

New Level 4 Type	# of Polygons	Total Area Covered (m2)
2 - Sand	809	18,760,772
3 - Fines Mix	457	920,049
4 - Fines/ Coarse Fines Mix	6	8,939
5 - Gravel	208	276,084
9 - Rocky Fine	260	378,897
10 - Boulders	519	1,261,373
6 - Hard Clay	3	10,420
11 - Bedrock	589	2,136,215
12 - Bedrock/ Fines Mix	8	60,436
13 - Bedrock/ Coarse Fines Mix	2	1,286
Cultural	123	29,782
Total	**2,984**	**23,844,253**

***Accuracy Assessment.* —** The tabular habitat features were sent to the agency statistician. The data include the substrate bed composition/substrate type, number of polygons, total area covered, and a general confidence level of the mapper. The statistician determined the appropriate number of sample points for each class. The initial accuracy assessment of the Suwannee River occurred between March 7, 2017 and March 10, 2017. Sixty - eight kilometers were traversed to assess the accuracy of 106 points. A second trip was conducted between March 16, 2017 and March 17, 2017to assess the accuracy of an additional 45 points spread over 35 kilometers. A summary of mapped sonar imagery with accuracy assessed results can be seen in Appendix H. A summary table of the assessed substrate polygons follows.

SUBSTRATE NAME	SUBSTRATE CODE	FREQUENCY TOTAL	FREQUENCY VISITED	PERCENT VISITED
NULL	0			
01 - SILT/ MUD	1	0	0	
02 - SAND	2	11	13	100.00
03 - FINES MIX	3	25	27	100.00
04 - FINES/ COARSE FINES MIX	4	2	2	100.00
05 - GRAVEL	5	21	22	100.00
06 - HARD CLAY	6	2	3	100.00
07 - HARD CLAY/ FINES MIX	7	0	0	
08 - HARD CLAY/ COARSE FINES MIX	8	0	0	
09 - ROCKY FINE	9	26	24	92.31
10 - BOULDERS	10	34	36	100.00
11 - BEDROCK	11	48	49	100.00
12 - BEDROCK/ FINES MIX	12	3	3	100.00
13 - BEDROCK/ COARSE FINES MIX	13	2	2	100.00
TOTAL		175	181	

Lower Ochlockonee

Data Collection.— Sonar data were collected on the following stretches: RKM 185-158, RKM 148-134, RKM 107-75, RKM 60-45, and RKM 42-16. All sonar data were collected throughout March 2015. The Ochlockonee has been difficult due to large variations in runoff events as well as the volume of woody debris in the river channel. A total of five field days were spent on the Ochlockonee. Data have been collected on the following stretches: RKM 185-158, RKM 148-134, RKM 107-75, RKM 60-45, and RKM 42-16. The gap from RKM 134 to RKM 107 is Lake Talquin. The gap from RKM 158 to RKM 148 was impassable at the time of the survey due to woody debris in the channel. The gap from RKM 45 to RKM 42 was impassable because the channel closed up and had overhanging trees. Multiple passes will be required at the mouth of the river due to the width of the channel. Snapshot and video sonar data were collected. In total, 114 km of sonar data were collected on the Ochlockonee. Specific discharge conditions during the survey can be found in Appendix A.

Processing.— All of the sonar data (snapshots) collected on the Ochlockonee River have been processed as described by Kaiser & Litts, 2011. Where collected, the video data have been processed according to Appendix F. The data are stored in mosaic datasets in an ESRI file geodatabase.

Mapping.— The data collected have been reviewed and habitat features have been identified, digitized, and classified according to the project classification. A classification summary by river kilometer can be found in Appendix F.

Accuracy Assessment. — The tabular habitat features were sent to the agency statistician. The data include the substrate bed composition/substrate type, number of polygons, total area covered, and a general confidence level of the mapper. The statistician determined the appropriate number of sample points for each class. The initial accuracy assessment of the Ochlockonee River occurred between October 10, 2016 and October 27, 2016. Seventy kilometers were traversed to assess the accuracy of 98points. A second trip was conducted between November 7, 2016 and November 9, 2016 to assess the accuracy of an additional 113 points spread over 56 kilometers. A summary of mapped sonar imagery with accuracy assessed results can be seen in Appendix H. A summary table of the assessed substrate polygons follows.

SUBSTRATE NAME	SUBSTRATE CODE	FREQUENCY TOTAL	FREQUENCY VISITED	PERCENT VISITED
NULL	0			
01 - SILT/MUD	1	3	3	100.00
02 - SAND	2	25	24	96.00
03 - FINES MIX	3	56	61	100.00
04 - FINES/ COARSE FINES MIX	4	2	2	100.00
05 - GRAVEL	5	13	13	100.00
09 - ROCKY FINE	9	12	11	91.67
10 - BOULDERS	10	12	7	58.33
06 - HARD CLAY	6	3	3	100.00
07 - HARD CLAY/ FINES MIX	7	3	3	100.00
11 - BEDROCK	11	41	45	100.00
12 - BEDROCK/ FINES MIX	12	5	4	80.00
08 - HARD CLAY/ COARSE FINES MIX	8	0	0	
13 - BEDROCK/ COARSE FINES MIX	13	0	0	
TOTAL		**175**	**176**	**99.43**

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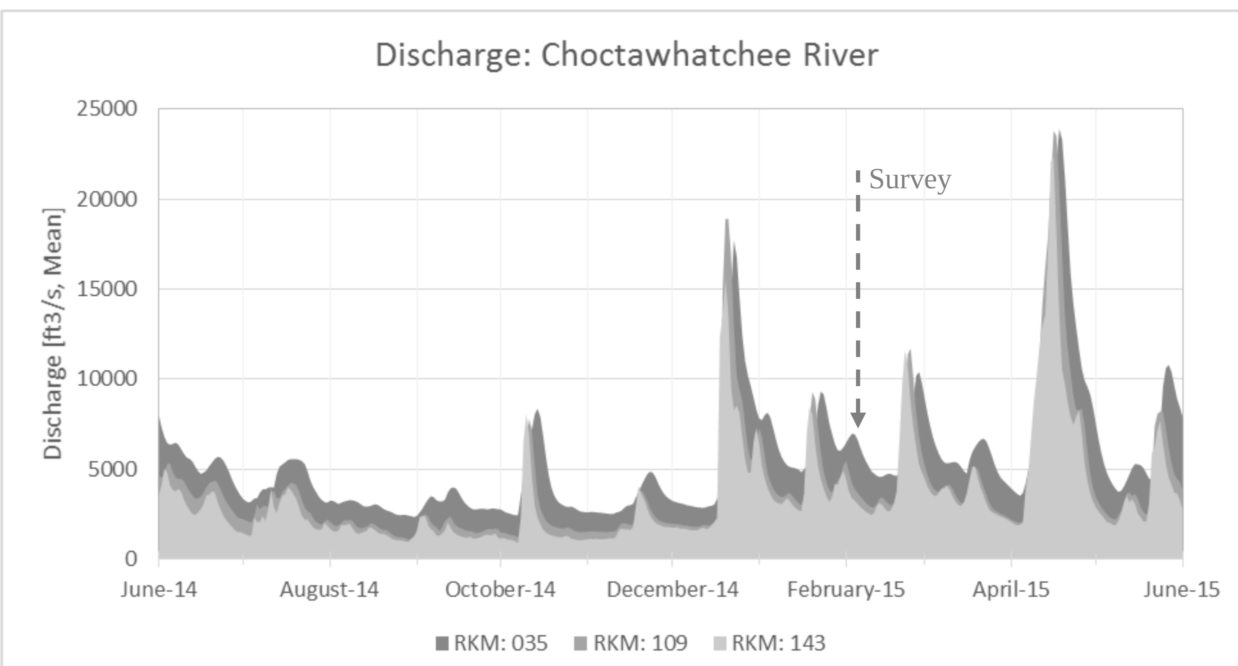
APPENDICES

A) Survey Summaries

Lower Choctawhatchee River Survey Summary.—

SURVEY DAYS	RKM START	RKM END	RKM DIFFERENCE	LENGTH [KM]	LENGTH [MI]	NOTES
2/9/2015	31	1	30	29.64	18.42	
2/10/2015	150	87	63	62.01	38.53	
2/11/2015	87	44	43	35.90	22.31	New river channel scanned
2/11/2015	0	0	0	9.30	5.78	Holmes Creek Tributary, not main stem
2/12/2015	45	31	14	27.96	17.37	Two passes, left bank and right bank
			TOTAL	**165**	**102**	

RKM **STAID**	**143** **02365200**	**109** **02365500**	**35** **02366500**
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
1/31/2015	3480	4280	8410
2/1/2015	3180	3860	7560
2/2/2015	3450	3700	6960
2/3/2015	4200	4020	6410
2/4/2015	4130	4380	6050
2/5/2015	4570	4620	6030
2/6/2015	4920	5210	6210
2/7/2015	4440	5460	6470
2/8/2015	3770	4870	6740
2/9/2015	3410	4260	6960
2/10/2015	3250	3920	6950
2/11/2015	3100	3720	6670
2/12/2015	2910	3510	6220
2/13/2015	2780	3320	5800
2/14/2015	2640	3150	5460
2/15/2015	2550	3000	5180
2/16/2015	2450	2880	4890
2/17/2015	2580	2900	4750
2/18/2015	2980	3080	4630
2/19/2015	3130	3410	4570
2/20/2015	3000	3430	4590

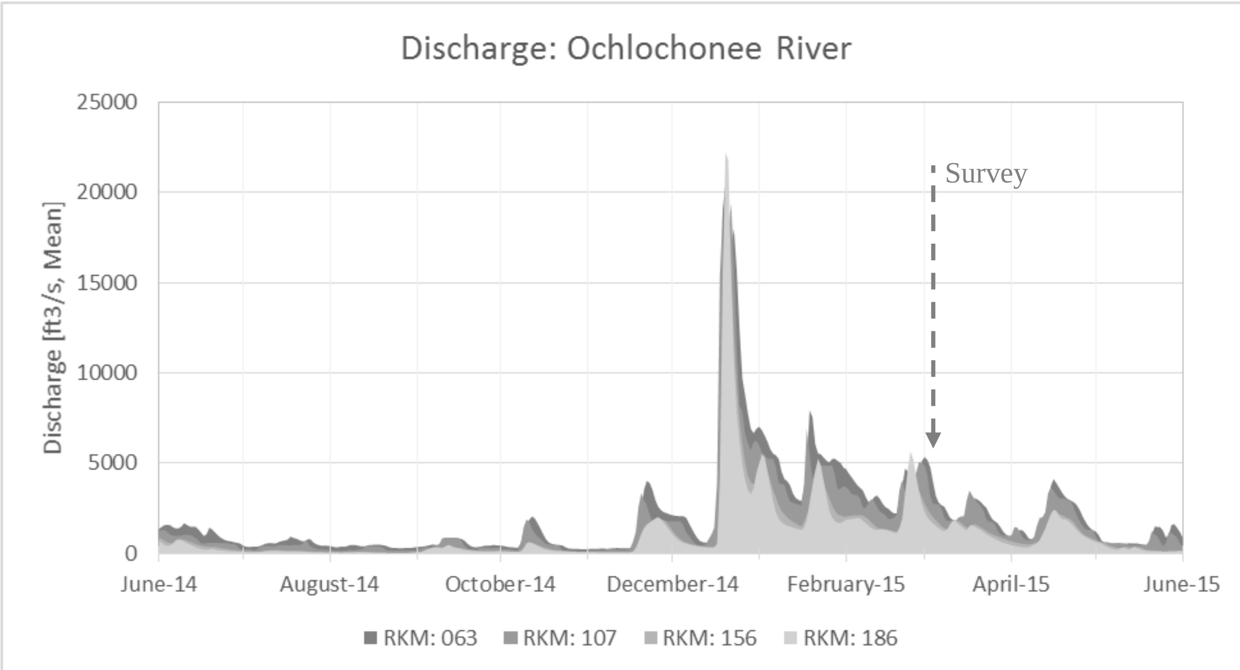


Lower Ochlockonee River Survey Summary.—

SURVEY DAYS	RKM START	RKM END	RKM DIFFERENCE	LENGTH [KM]	LENGTH [MI]
3/3/2015	107	75	32	33.42	20.77
3/4/2015	42	16	26	28.82	17.91
3/10/2015	60	45	15	13.52	8.40
3/11/2015	164	158	6	5.58	3.47
3/11/2015	148	134	14	12.09	7.51
3/18/2015	185	164	21	20.29	12.61
			TOTAL	**114**	**71**

RKM STAID	**186 02328522**	**156 02329000**	**107 02330000**	**63 02330150**
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
2/21/2015	1310	1360	2130	2580
2/22/2015	1280	1330	1930	2490
2/23/2015	1220	1290	1920	2350
2/24/2015	1170	1250	1990	2230
2/25/2015	1140	1200	2170	2240
2/26/2015	1420	1350	3510	2930
2/27/2015	1950	1490	4100	3680
2/28/2015	3310	1860	3510	4700
3/1/2015	4730	2560	3330	4570
3/2/2015	5660	3580	3320	4220
3/3/2015	5180	4290	3610	4070
3/4/2015	4270	4030	4500	4060
3/5/2015	3420	3510	5080	4340
3/6/2015	2790	3130	5020	5130
3/7/2015	2320	2760	4880	5350
3/8/2015	2010	2460	4360	5180
3/9/2015	1820	2230	3200	4790
3/10/2015	1670	2030	2780	3970
3/11/2015	1540	1850	2740	3190
3/12/2015	1420	1680	2720	2830
3/13/2015	1320	1530	2510	2680
3/14/2015	1250	1410	2020	2600
3/15/2015	1330	1340	1800	2310
3/16/2015	1610	1340	1830	2000
3/17/2015	1820	1520	1810	1870
3/18/2015	1800	1760	1810	1820
3/19/2015	1660	1810	1990	1780
3/20/2015	1510	1710	2060	1800
3/21/2015	1400	1560	2070	1890
3/22/2015	1280	1450	2970	1930
3/23/2015	1540	1430	3500	2150
3/24/2015	1570	1600	3200	2810
3/25/2015	1490	1630	2990	3070
3/26/2015	1390	1550	2800	2980

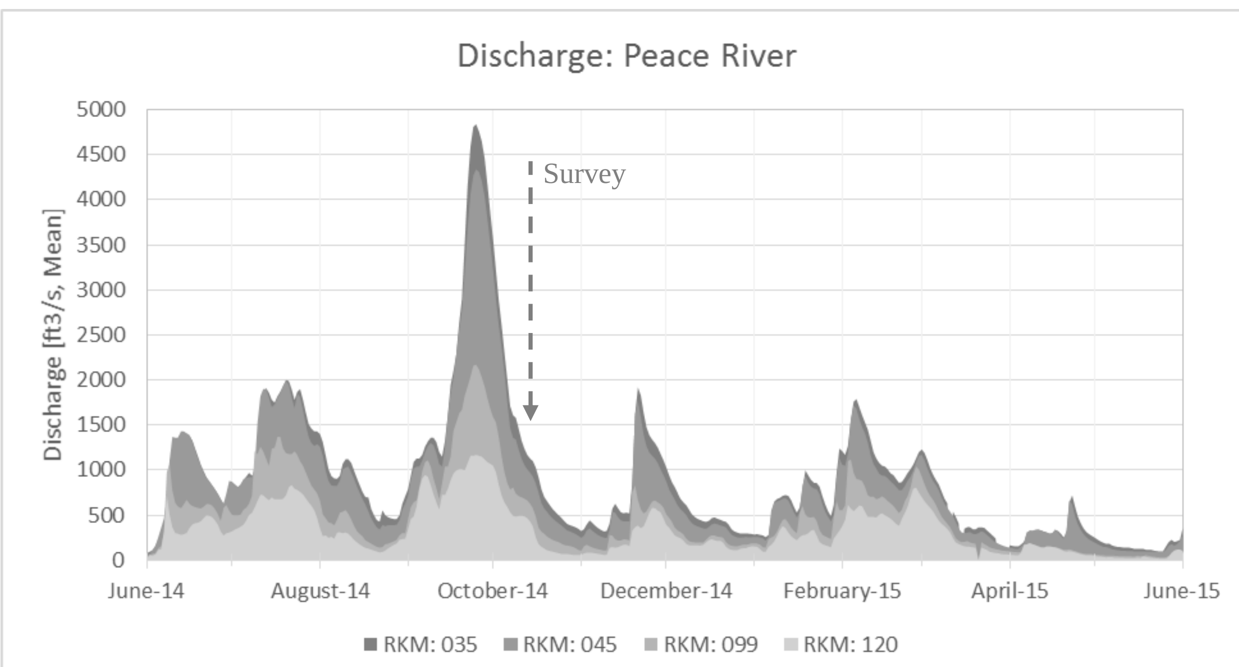
Lower Ochlockonee River Survey Summary Continued.—



Peace River Survey Summary.—

SURVEY DAYS	RKM START	RKM END	RKM DIFFERENCE	LENGTH [KM]	LENGTH [MI]	NOTES
10/14/2014	117	77	40	40.84	25.38	
10/15/2014	77	30	47	46.86	29.12	
10/16/2014	18	10	8	27.19	16.89	Two passes, left bank and right bank
			TOTAL	115	71	

RKM	120	99	45	35
STAID	02295194	02295637	02296750	02297105
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
10/4/2014	1150	2030	4210	4650
10/5/2014	1120	1930	4040	4460
10/6/2014	1090	1800	3790	4170
10/7/2014	1070	1680	3510	3850
10/8/2014	1050	1590	3220	3560
10/9/2014	977	1530	2890	3210
10/10/2014	839	1370	2610	2880
10/11/2014	717	1150	2360	2600
10/12/2014	642	978	2080	2300
10/13/2014	591	857	1750	2000
10/14/2014	534	784	1470	1710
10/15/2014	494	809	1360	1610
10/16/2014	484	740	1340	1580
10/17/2014	493	715	1230	1460
10/18/2014	494	699	1130	1330
10/19/2014	488	684	1060	1240
10/20/2014	469	665	1010	1170
10/21/2014	432	630	976	1130
10/22/2014	376	577	928	1100
10/23/2014	258	488	854	1030
10/24/2014	179	362	752	921



Lower Suwannee River Survey Summary.—

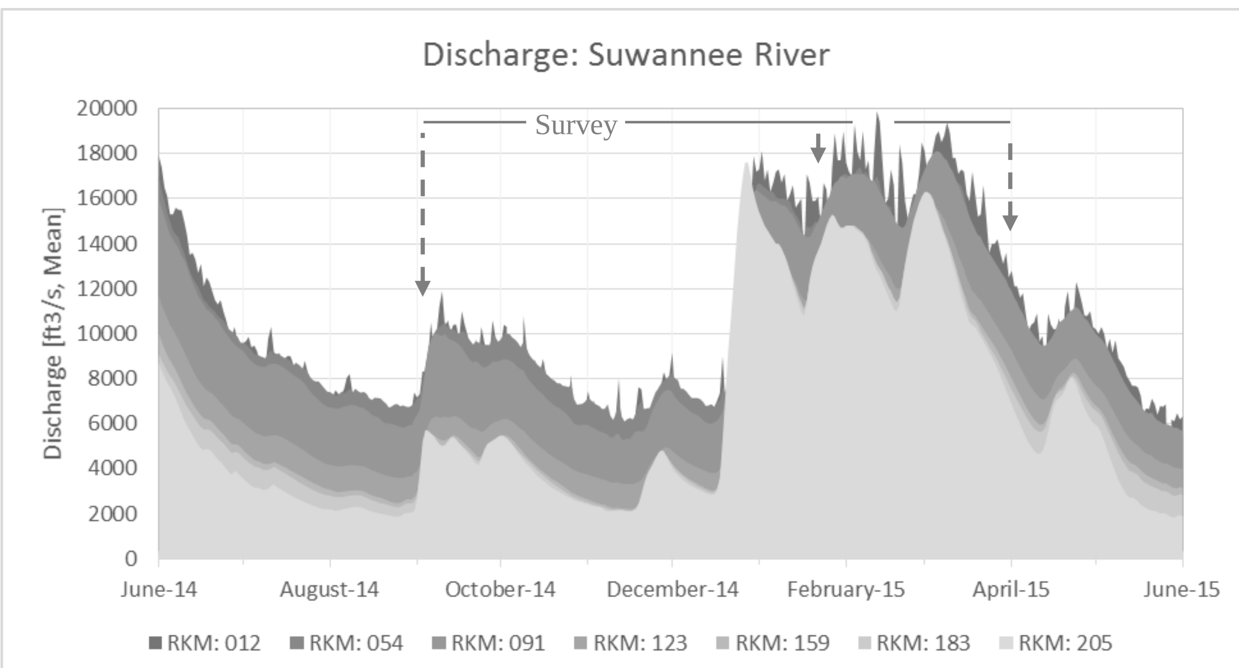
SURVEY DAYS	RKM START	RKM END	RKM DIFFERENCE	LENGTH [KM]	LENGTH [MI]	NOTES
9/18/2014	116	61	55	153.44	95.34	Support from FWS, USGS; left/right bank and middle passes
9/19/2014	65	29	36	70.44	43.77	Support from FWS; right bank and middle passes
1/20/2015	205	158	47	48.16	29.92	Begin middle, switch to right bank at RKM 183
1/21/2015	183	128	55	55.55	34.51	Left bank
1/22/2015	128	123	5	4.95	3.08	Left bank
1/22/2015	159	123	36	36.20	22.49	Right bank
3/31/2015	123	116	7	14.86	9.23	Two passes, left bank and right bank
3/31/2015	0	0	0	25.85	16.06	Tributary, Santa Fe
4/1/2015	73	24	49	49.19	30.57	Begin right bank, switch to left bank at RKM 63
4/1/2015	29	24	5	8.53	5.30	Two passes, right bank and middle
4/2/2015	24	9	15	30.29	18.82	Two passes, left bank and right bank
			TOTAL	**497**	**309**	

RKM STAID	**205 02319500**	**183 02319800**	**159 02320000**	**123 02320500**	**91 02323000**	**54 02323500**	**12 02323592**
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
9/8/2014	3880	3630	3560	4140	6670	7190	7320
9/9/2014	5200	4700	4490	4760	7430	7840	8320
9/10/2014	5730	5300	5220	5480	8470	8550	8340
9/11/2014	5690	5420	5470	5950	9260	9310	9080
9/12/2014	5580	5400	5500	6190	9730	9800	10500
9/13/2014	5460	5330	5490	6300	9960	9990	9290
9/14/2014	5280	5230	5420	6320	10000	10200	9980
9/15/2014	5090	5090	5310	6270	9940	10300	11200
9/16/2014	4990	5040	5270	6290	9920	10400	11900
9/17/2014	5060	5050	5260	6330	9990	10500	10300
9/18/2014	5220	5140	5330	6280	9830	10300	10600
9/19/2014	5380	5250	5430	6300	9740	10200	10100
9/20/2014	5420	5310	5510	6330	9690	10200	10400
9/21/2014	5300	5260	5450	6330	9620	10100	10400
9/22/2014	5140	5150	5360	6270	9520	10000	9750
9/23/2014	5000	5030	5250	6190	9400	10100	11000
9/24/2014	4870	4920	5130	6080	9200	10100	10400
9/25/2014	4720	4810	5000	5970	9000	9860	9950
9/26/2014	4570	4690	4880	5870	8830	9690	9410
9/27/2014	4400	4550	4750	5790	8730	9520	9190

RKM STAID	**205 02319500**	**183 02319800**	**159 02320000**	**123 02320500**	**91 02323000**	**54 02323500**	**12 02323592**
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
1/10/2015	14600	14400	13600	13500	16000	16400	17300
1/11/2015	14400	14200	13500	13400	15900	16300	16300
1/12/2015	14200	14100	13300	13300	15900	16300	16700
1/13/2015	14000	13900	13200	13300	15900	16100	17200
1/14/2015	14000	13800	13100	13200	15800	16000	17300
1/15/2015	13800	13700	13000	13200	15700	16000	16700
1/16/2015	13500	13500	12900	13100	15700	16000	17100
1/17/2015	13100	13200	12600	12900	15600	15900	15900
1/18/2015	12700	12800	12300	12700	15400	15900	16200
1/19/2015	12200	12400	12000	12500	15300	15500	16600
1/20/2015	11800	12100	11600	12300	15000	15300	15600
1/21/2015	11400	11700	11300	12000	14800	15100	15800
1/22/2015	11000	11400	10900	11700	14500	14800	16000
1/23/2015	10800	11100	10700	11500	14400	14300	13200
1/24/2015	11400	11500	10800	11500	14300	14800	17100
1/25/2015	12400	12300	11400	11700	14300	14700	16700
1/26/2015	13000	12800	11900	12100	14500	14800	15900
1/27/2015	13400	13200	12300	12400	14800	15000	15900
1/28/2015	13700	13500	12600	12700	15000	14900	16100
1/29/2015	14000	13800	12900	12900	15300	15200	14800
1/30/2015	14400	14200	13200	13200	15600	15300	16700

Lower Suwannee River Survey Summary.—

RKM STAID	205 02319500	183 02319800	159 02320000	123 02320500	91 02323000	54 02323500	12 02323592
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
3/21/2015	11300	11700	11800	12900	15900	16200	17200
3/22/2015	10900	11200	11500	12500	15600	15600	16200
3/23/2015	10500	10900	11100	12200	15200	15100	15900
3/24/2015	10400	10700	10900	11900	14900	14900	17200
3/25/2015	10300	10600	10800	11800	14600	14700	16200
3/26/2015	10100	10400	10600	11600	14400	14200	15200
3/27/2015	9880	10100	10400	11500	14300	14100	15300
3/28/2015	9660	9890	10200	11300	14000	14000	16600
3/29/2015	9430	9680	10000	11100	13800	13600	15100
3/30/2015	9200	9440	9820	10900	13600	13400	13600
3/31/2015	8970	9240	9640	10700	13400	13200	14000
4/1/2015	8740	9040	9450	10500	13200	13200	14000
4/2/2015	8450	8820	9240	10300	13000	12700	14200
4/3/2015	8150	8550	9000	10100	12800	12700	13600
4/4/2015	7840	8300	8770	9910	12600	12400	13100
4/5/2015	7510	8050	8530	9700	12400	12200	13600
4/6/2015	7190	7780	8270	9480	12100	11900	12500
4/7/2015	6900	7530	8030	9280	11900	11700	12800
4/8/2015	6580	7300	7770	9010	11600	11600	12100
4/9/2015	6290	7050	7520	8760	11400	11200	12100
4/10/2015	6010	6810	7280	8530	11100	11000	11600



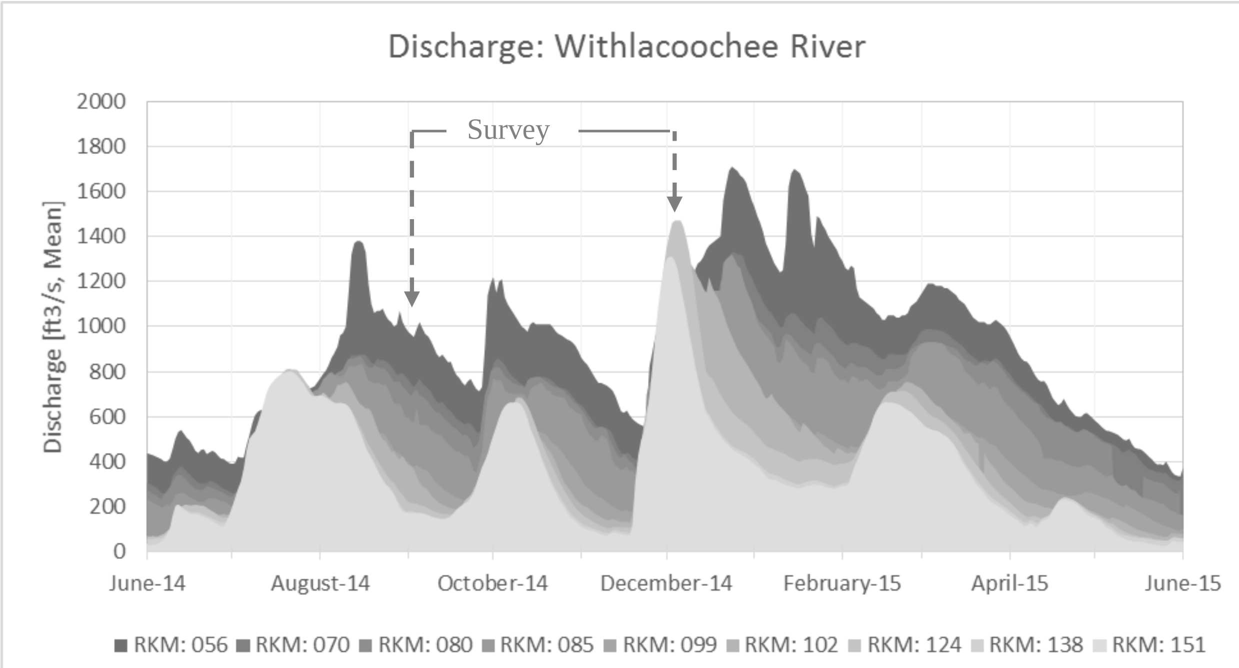
Withlacoochee River Survey Summary.—

DATE	RKM START	RKM END	RKM DIFFERENCE	LENGTH [KM]	LENGTH [MI]
9/4/2014	138	113	25	24.97	15.51
9/5/2014	56	46	10	10.54	6.55
12/8/2014	46	35	11	10.82	6.72
12/9/2014	164	138	26	26.76	16.63
12/10/2014	113	74	39	38.38	23.85
12/11/2014	74	56	18	17.99	11.18
			TOTAL	**129**	**80**

RKM STAID	151 02312000	138 02312300	124 02312500	115 02312558	102 02312598	99 02312600	85 02312720	80 02312722	70 02312762	56 02313000
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
8/24/2014	441	415	478	590	637	527	741	817	852	1080
8/25/2014	421	392	456	572	623	518	744	816	847	1050
8/26/2014	395	373	433	545	588	497	720	811	839	1030
8/27/2014	369	354	411	521	554	476	693	797	825	1020
8/28/2014	343	332	390	499	522	453	661	776	806	1000
8/29/2014	321	311	369	482	500	444	656	754	787	1010
8/30/2014	302	294	351	473	494	440	658	757	791	1070
8/31/2014	291	281	331	456	471	423	636	756	795	1020
9/1/2014	276	272	317	443	446	402	598	732	780	996
9/2/2014	254	258	307	441	447	402	599	726	766	977
9/3/2014	227	234	288	417	425	384	580	705	746	965
9/4/2014	198	212	268	402	411	377	578	694	731	954
9/5/2014	182	193	256	405	427	388	644	713	750	991
9/6/2014	176	182	237	391	407	377	567	723	769	1020
9/7/2014	174	178	224	381	387	369	564	696	749	991
9/8/2014	175	181	218	375	382	366	565	690	735	967
9/9/2014	173	178	217	368	368	358	561	680	725	957
9/10/2014	172	175	214	358	337	340	543	669	713	936
9/11/2014	172	175	209	342	307	321	533	648	686	909
9/12/2014	171	173	206	331	293	306	524	631	667	879
9/13/2014	168	169	202	322	286	298	522	621	660	864

RKM STAID	151 02312000	138 02312300	124 02312500	115 02312558	102 02312598	99 02312600	85 02312720	80 02312722	70 02312762	56 02313000
DATE	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]	Discharge [ft3/s]
11/28/2014	495	461	471	477	415	420	728	770	768	953
11/29/2014	531	505	569	571	506	472	734	784	787	1000
11/30/2014	597	553	629	661	598	526	745	796	799	1030
12/1/2014	695	625	676	743	674	580	756	807	806	1040
12/2/2014	822	726	747	823	752	634	847	835	815	1050
12/3/2014	955	843	860	913	847	694	897	880	850	1050
12/4/2014	1080	961	1010	1000	927	754	909	897	884	1080
12/5/2014	1180	1070	1140	1070	1010	806	928	915	903	1110
12/6/2014	1260	1160	1260	1130	1070	849	954	935	918	1140
12/7/2014	1300	1220	1350	1180	1130	886	980	953	934	1160
12/8/2014	1310	1250	1410	1220	1170	919	1010	970	952	1180
12/9/2014	1310	1270	1460	1240	1210	945	1030	992	970	1190
12/10/2014	1290	1270	1470	1260	1240	970	1050	1010	987	1210
12/11/2014	1250	1240	1470	1260	1270	992	1070	1020	998	1230
12/12/2014	1170	1190	1470	1260	1280	1000	1090	1030	1010	1250
12/13/2014	1110	1120	1440	1250	1290	1010	1110	1040	1020	1280
12/14/2014	1040	1060	1390	1230	1290	1020	1120	1050	1030	1290
12/15/2014	965	986	1330	1200	1280	1010	1140	1060	1040	1310
12/16/2014	900	915	1250	1170	1270	1000	1150	1070	1060	1340
12/17/2014	824	844	1160	1130	1250	991	1160	1080	1070	1360
12/18/2014	767	779	1060	1090	1220	976	1160	1090	1080	1370
12/19/2014	714	723	972	1040	1200	959	1160	1100	1080	1380

Withlacoochee River Survey Summary Continued.—



B) Classification System Schematic

Bed Composition	Bed Hardness		Type	Bedform	Relief	Substrate Cover
Dominant	Hard/ Soft	Mixture	Dominant	(Soft Substrates Only)	(Hard Substrates Only)	
1 Fines	1 Soft	1 Soft Fines - No Mix	1 Silt/Mud	1 Flat 2 Rippled/Duned	0 None	0 None 1 Submerged Aquatic Veg 2 Emergent Aquatic Veg 3 Woody Aggregation - Embedded 4 Woody Aggregation - Uncovered 5 Vegetated Bank
			2 Sand	1 Flat 2 Rippled/Duned	0 None	
		2 Soft Fines - Mix	3 Fines Mix	1 Flat 2 Rippled/Duned	0 None	
			4 Fines/ Coarse Fines Mix	1 Flat 2 Rippled/Duned	0 None	
2 Coarse Fines	2 Hard	3 Coarse Fines - No Mix	5 Gravel	0 None	1 Flat 2 Low/ Moderate 3 High	
			9 Rocky Fine	0 None	1 Flat 2 Low/ Moderate 3 High	
3 Rocky Boulder	2 Hard	6 Rock - No Mix	10 Boulders	0 None	1 Flat 2 Low/ Moderate 3 High	
4 Hard Bottom	2 Hard	4 Hard Fines - No Mix	6 Hard Clay	0 None	1 Flat 2 Low/ Moderate 3 High	
		5 Hard Fines - Mix	7 Hard Clay/ Fines Mix	0 None	1 Flat 2 Low/ Moderate 3 High	
			8 Hard Clay/ Coarse Fines Mix	0 None	1 Flat 2 Low/ Moderate 3 High	
		6 Rock - No Mix	11 Bedrock	0 None	1 Flat 2 Low/ Moderate 3 High 4 Wall/ Shelf	
		7 Rock - Mix	12 Bedrock/ Fines Mix	0 None	1 Flat 2 Low/ Moderate 3 High	
			13 Bedrock/ Coarse Fines Mix	0 None	1 Flat 2 Low/ Moderate 3 High	
		8 Cultural - Other	14 Rip Rap 15 Boat Ramp 16 Other	0 None	0 None	
0 NA	0 NA	0 NA	17 Unsure 18 Sonar Shadow 19 No Data 20 Island	0 NA	0 NA	

C) Classification List

10000000 Fines
- 11000000 Soft
  - 11100000 Soft Fines – No Mix
    - 11101000 Silt/ Mud
      - 11101100 Flat
        - 11101100 Relief – None
          - 11101100 None
          - 11101101 Submerged AV
          - 11101102 Emergent AV
          - 11101103 WD – Embedded
          - 11101104 WD – Uncovered
          - 11101105 Vegetated Bank
      - 11101200 Rippled/ Duned
        - 11101200 Relief – None
          - 11101200 None
          - 11101201 Submerged AV
          - 11101202 Emergent AV
          - 11101203 WD – Embedded
          - 11101204 WD – Uncovered
          - 11101205 Vegetated Bank
    - 11102000 Sand
      - 11102100 Flat
        - 11102100 Relief – None
          - 11102100 None
          - 11102101 Submerged AV
          - 11102102 Emergent AV
          - 11102103 WD – Embedded
          - 11102104 WD – Uncovered
          - 11102105 Vegetated Bank
      - 11102200 Rippled/ Duned
        - 11102200 Relief – None
          - 11102200 None
          - 11102201 Submerged AV
          - 11102202 Emergent AV
          - 11102203 WD – Embedded
          - 11102204 WD – Uncovered
          - 11102205 Vegetated Bank
  - 11200000 Soft Fines – Mix
    - 11203000 Fines Mix
      - 11203100 Flat
        - 11203100 Relief – None
          - 11203100 None
          - 11203101 Submerged AV
          - 11203102 Emergent AV
          - 11203103 WD – Embedded
          - 11203104 WD – Uncovered
          - 11203105 Vegetated Bank
      - 11203200 Rippled/ Duned
        - 11203200 Relief – None

- 11203200 None
- 11203201 Submerged AV
- 11203202 Emergent AV
- 11203203 WD – Embedded
- 11203204 WD – Uncovered
- 11203205 Vegetated Bank

11204000 Fines/ Coarse Fines Mix
- 11204100 Flat
  - 11204100 Relief – None
    - 11204100 None
    - 11204101 Submerged AV
    - 11204102 Emergent AV
    - 11204103 WD – Embedded
    - 11204104 WD – Uncovered
    - 11204105 Vegetated Bank
- 11204200 Rippled/ Duned
  - 11204200 Relief – None
    - 11204200 None
    - 11204201 Submerged AV
    - 11204202 Emergent AV
    - 11204203 WD – Embedded
    - 11204204 WD – Uncovered
    - 11204205 Vegetated Bank

20000000 Coarse Fines
- 22000000 Hard
  - 22300000 Coarse Fines – No Mix
    - 22305000 Gravel
      - 22305000 Bedform – None
        - 22305010 Flat
          - 22305010 None
          - 22305011 Submerged AV
          - 22305012 Emergent AV
          - 22305013 WD – Embedded
          - 22305014 WD – Uncovered
          - 22305015 Vegetated Bank
        - 22305020 Low/ Moderate
          - 22305020 None
          - 22305021 Submerged AV
          - 22305022 Emergent AV
          - 22305023 WD – Embedded
          - 22305024 WD – Uncovered
          - 22305025 Vegetated Bank
        - 22305030 High
          - 22305030 None
          - 22305031 Submerged AV
          - 22305032 Emergent AV
          - 22305033 WD – Embedded
          - 22305034 WD – Uncovered
          - 22305035 Vegetated Bank
    - 22309000 Rocky Fine
      - 22309000 Bedform – None

22309010 Flat
22309010 None
22309011 Submerged AV
22309012 Emergent AV
22309013 WD – Embedded
22309014 WD – Uncovered
22309015 Vegetated Bank
22309020 Low/ Moderate
22309020 None
22309021 Submerged AV
22309022 Emergent AV
22309023 WD – Embedded
22309024 WD – Uncovered
22309025 Vegetated Bank
22309030 High
22309030 None
22309031 Submerged AV
22309032 Emergent AV
22309033 WD – Embedded
22309034 WD – Uncovered
22309035 Vegetated Bank
30000000 Rocky Boulder
32000000 Hard
32600000 Rock – No Mix
32610000 Rocky Boulder
32610000 Bedform – None
32610010 Flat
32610010 None
32610011 Submerged AV
32610012 Emergent AV
32610013 WD – Embedded
32610014 WD – Uncovered
32610015 Vegetated Bank
32610020 Low/ Moderate
32610020 None
32610021 Submerged AV
32610022 Emergent AV
32610023 WD – Embedded
32610024 WD – Uncovered
32610025 Vegetated Bank
32610030 High
32610030 None
32610031 Submerged AV
32610032 Emergent AV
32610033 WD – Embedded
32610034 WD – Uncovered
32610035 Vegetated Bank
40000000 Hard Bottom
42000000 Hard
42400000 Hard Fines – No Mix
42406000 Hard Clay

42406000 Bedform – None
42406010 Flat
42406010 None
42406011 Submerged AV
42406012 Emergent AV
42406013 WD – Embedded
42406014 WD – Uncovered
42406015 Vegetated Bank
42406020 Low/ Moderate
42406020 None
42406021 Submerged AV
42406022 Emergent AV
42406023 WD – Embedded
42406024 WD – Uncovered
42406025 Vegetated Bank
42406030 High
42406030 None
42406031 Submerged AV
42406032 Emergent AV
42406033 WD – Embedded
42406034 WD – Uncovered
42406035 Vegetated Bank
42500000 Hard Fines – Mix
42507000 Hard Clay/ Fines Mix
42507000 Bedform – None
42507010 Flat
42507010 None
42507011 Submerged AV
42507012 Emergent AV
42507013 WD – Embedded
42507014 WD – Uncovered
42507015 Vegetated Bank
42507020 Low/ Moderate
42507020 None
42507021 Submerged AV
42507022 Emergent AV
42507023 WD – Embedded
42507024 WD – Uncovered
42507025 Vegetated Bank
42507030 High
42507030 None
42507031 Submerged AV
42507032 Emergent AV
42507033 WD – Embedded
42507034 WD – Uncovered
42507035 Vegetated Bank
42508000 Hard Clay/ Coarse Fines Mix
42508000 Bedform – None
42508010 Flat
42508010 None
42508011 Submerged AV

- 42508012 Emergent AV
- 42508013 WD – Embedded
- 42508014 WD – Uncovered
- 42508015 Vegetated Bank

42508020 Low/ Moderate
- 42508020 None
- 42508021 Submerged AV
- 42508022 Emergent AV
- 42508023 WD – Embedded
- 42508024 WD – Uncovered
- 42508025 Vegetated Bank

42508030 High
- 42508030 None
- 42508031 Submerged AV
- 42508032 Emergent AV
- 42508033 WD – Embedded
- 42508034 WD – Uncovered
- 42508035 Vegetated Bank

42600000 Rock – No Mix
- 42611000 Bedrock
  - 42611000 Bedform – None
    - 42611010 Flat
      - 42611010 None
      - 42611011 Submerged AV
      - 42611012 Emergent AV
      - 42611013 WD – Embedded
      - 42611014 WD – Uncovered
      - 42611015 Vegetated Bank
    - 42611020 Low/ Moderate
      - 42611020 None
      - 42611021 Submerged AV
      - 42611022 Emergent AV
      - 42611023 WD – Embedded
      - 42611024 WD – Uncovered
      - 42611025 Vegetated Bank
    - 42611030 High
      - 42611030 None
      - 42611031 Submerged AV
      - 42611032 Emergent AV
      - 611033 WD – Embedded
      - 42611034 WD – Uncovered
      - 42611035 Vegetated Bank
    - 42611040 Wall/ Shelf
      - 42611040 None
      - 42611041 Submerged AV
      - 42611042 Emergent AV
      - 42611043 WD – Embedded
      - 42611044 WD – Uncovered
      - 42611045 Vegetated Bank

42700000 Rock – Mix
- 42712000 Bedrock/ Fines Mix

42712000 Bedform – None
42712010 Flat
42712010 None
42712011 Submerged AV
42712012 Emergent AV
42712013 WD – Embedded
42712014 WD – Uncovered
42712015 Vegetated Bank
42712020 Low/ Moderate
42712020 None
42712021 Submerged AV
42712022 Emergent AV
42712023 WD – Embedded
42712024 WD – Uncovered
42712025 Vegetated Bank
42712030 High
42712030 None
42712031 Submerged AV
42712032 Emergent AV
42712033 WD – Embedded
42712034 WD – Uncovered
42712035 Vegetated Bank
42713000 Bedrock/ Coarse Fines Mix
42713000 Bedform – None
42713010 Flat
42713010 None
42713011 Submerged AV
42713012 Emergent AV
42713013 WD – Embedded
42713014 WD – Uncovered
42713015 Vegetated Bank
42713020 Low/ Moderate
42713020 None
42713021 Submerged AV
42713022 Emergent AV
42713023 WD – Embedded
42713024 WD – Uncovered
42713025 Vegetated Bank
42713030 High
42713030 None
42713031 Submerged AV
42713032 Emergent AV
42713033 WD – Embedded
42713034 WD – Uncovered
42713035 Vegetated Bank
42800000 Cultural – Other
42814000 Rip Rap
42815000 Boat Ramp
42816000 Other
00017000 Unsure
00018000 Sonar Shadow

00019000 No Data
00020000 Island

D) Classification Definitions

Bankline: The bankline is digitized using visual interpretation of the channel ridge and the inner edge (towards center of channel) of terrestrial/riparian vegetation (trees, willows, etc.). Source data includes side scan sonar and aerial imagery.

MMU: Minimum mapping unit. The minimum area for features in a river to be mapped as polygons is 28 m^2 or a circle with a 3 m radius. Unless otherwise stated, ≥ 75% of the MMU must be covered by the classified substrate.

Bed Composition:

Fines: Area composed of particles < 64 mm diameter. Types of fines include silt, mud, organics, clay, and sand.

Coarse Fines: ≥ 25% of the MMU composed of rocks and gravel >4mm but <500mm diameter across the longest axis.

Rocky Boulder: Area that includes three or more boulders, each ≥ 500 mm diameter across longest axis, each boulder within 1.5 m of the next adjacent boulder.

Hard Bottom: Substrates composed of solid rock or compacted clay.

Bed Hardness:

Soft: Areas composed of loosely bound substrates such as sand and silt which can be easily moved by foot. Unconsolidated substrates are expected to have higher mobility then consolidated substrates. These areas result in plane (smooth), rippled, or duned bedforms.

Hard: Areas composed of hard substrates consisting of gravel, rock (including boulders and bedrock) as well as compacted clay. Hard substrates are expected to have lower mobility then unconsolidated substrates. These areas result in flat, low/moderate, or high relief beds.

Type:

Silt/Mud: Type of bed composed of the finest particle sizes. Sonar signature is typically dark image tone, flat texture, and located in depositional zones of the river channel

Sand: Type of bed composed of sand particles. Sonar signature is bright image tone and ripple/dune or flat texture.

Fines Mix: Type of bed composition that contains combinations of sand and silt substrates where no single substrate is readily identifiable.

Coarse Fines Mix: Type of bed composition that contains combinations of gravel, sand and silt substrates where no single substrate is readily identifiable.

Gravel: Type of bed composed of particle sizes 4mm – 64mm with a sonar signature containing a bright image tone, flat texture, and located in areas of the channel that could contain moderate deposition of heavier particles.

Rocky Fine: ≥ 25% of the MMU composed of rocks >64mm but <500mm diameter across the longest axis.

Rocky Boulder: Area that includes three or more boulders, each ≥ 500 mm diameter across longest axis, each boulder within 1.5 m of the next adjacent boulder.

Hard Clay: Type of bed composed of compact clay particles. Sonar signature is darker image tone, flat texture, and located in less depositional areas.

Hard Clay/ Fines Mix: Type of bed composition that contains combinations of sand/silt and hard clay substrates.

Hard Clay/ Coarse Fines Mix: Type of bed composition that contains combinations of gravel/rocky fine and hard clay substrates.

Bedrock: Substrate composed of solid rock.

Bedrock/ Fines Mixture: Type of bed composition that contains combinations of sand/silt and bedrock substrates.

Bedrock/ Coarse Fines Mix: Type of bed composition that contains combinations of gravel and bedrock substrates.

Rip Rap: Type of unnatural/cultural bed composition that includes rock and concrete put in place by people for bank stability.

Boat Ramp: Type of unnatural/cultural bed composition that is a submerged slab of concrete used to launch watercraft from the bank.

Other (Cultural): Any other feature not natural and placed in the river by people.

Unsure: Area difficult to classify due to reduced image resolution.

Sonar Shadow: Area within sonar range that was not imaged because the sonar signal was blocked by object(s).

No Data: An area beyond sonar range but within the boundaries of the river channel.

Bedform Structure or Relief:

Plane Bedform: A soft substrate with a smooth surface resulting in little to no sonar shadow. Plane bedforms can only be composed of fines.

Rippled/Duned: A soft substrate with an undulating/mounded surface which causes sonar shadows to exist on the far side of the feature. Rippled/Duned bedforms can only be composed of fines.

Flat Relief: A hard substrate with a smooth surface resulting in little to no sonar shadow. Low relief bedforms are composed of gravel beds, smooth bedrock, or hard clay.

Low/Moderate Relief: A hard substrate with a moderately rough surface resulting in some sonar shadows on the surface. Low/Moderate relief bedforms are composed of rocky fine, small rocky boulder, and coarse textured bedrock.

High Relief: A hard substrate with a rough surface resulting in wide range sonar shadows on the surface. Coarse textured bedforms are composed of large rocky boulders and very coarse textured bedrock.

Wall/Shelf: A hard substrate composed of bedrock shelf that can return a very hard signal from the banks or cast a very large shadow on a bedrock surface from large variations in elevation. These include overhanging bedrock where identifiable.

Substrate Cover:

Submerged Aquatic Vegetation: Types of aquatic vegetation that remains submerged as part of the vegetation's life cycle.

Emergent Aquatic Vegetation: Types of aquatic vegetation that emerges from the surface of the water as part of the vegetation's life cycle.

Wood Aggregation – Embedded: Aggregations of wood that are partially buried in the bed.

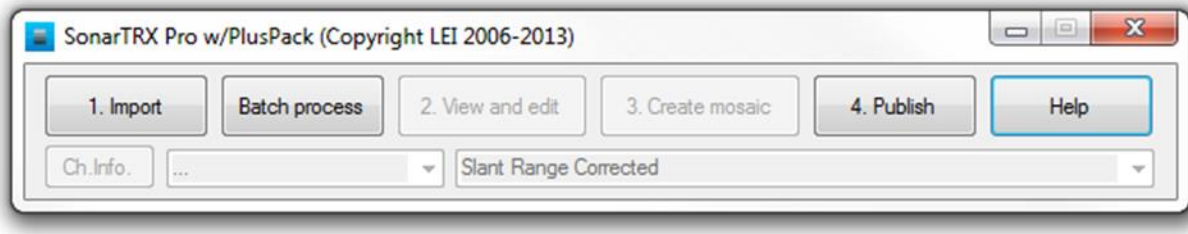
Wood Aggregation – Uncovered: Aggregations of wood that are exposed and resting on the bed.

Vegetated Bank: River bank that is inundated during high flow events which is covered in a mixture of riparian and terrestrial vegetation.

E)

Old Classification				New Classification			
Old Level 1	Old Level 2	Old Level 3	Old Level 4	New Level 1	New Level 2	New Level 3	New Level 4
Bed Composition Level 1	Bed Hardness	Bedform Structure/Texture	Substrate Type Level 4	Bed_Composition	Bed_Hardness	Mixture	Type
1 - Fines	Unconsolidated	Plane or Rippled/Duned	1 - Silt/Mud/Organic	1 - Fines	Soft Fines	01 - Fines - No Mix	01 - Silt/Mud
1 - Fines	Unconsolidated		2 - Clay				
1 - Fines	Unconsolidated		3 - Sand	1 - Fines	Soft Fines	01 - Fines - No Mix	02 - Sand
1 - Fines	Unconsolidated		4 - Gravel	2 - Coarse Fines	Hard Fines	03 - Coarse Fines - No Mix	05 - Gravel
2 - Rocky Fine	Consolidated	Coarse	22 - Rocky Fine	2 - Coarse Fines	Hard Fines	03 - Coarse Fines - No Mix	09 - Rocky Fine
3 - Rocky Boulder	Consolidated	Coarse	23 - Rocky Boulder	3 - Rocky Boulder	Hard Rock	06 - Rock - No Mix	10 - Boulders
4 - Bedrock	Consolidated	Smooth or Coarse	24 - Bedrock	4 - Hard Bottom	Hard Rock	06 - Rock - No Mix	11 - Bedrock
5 - Bedrock Shelf	Consolidated		25 - Bedrock Shelf				
6 - Fines Mix	Mixed	Plane or Rippled/Duned	7 - Sand/Silt/Mud Mix	1 - Fines	Soft Fines	02 - Fines - Mix	03 - Fines Mix
6 - Fines Mix	Mixed		8 - Sand/Hard Clay Mix	4 - Hard Bottom	Hard Fines	05 - Hard Fines - Mix	07 - Hard Clay/ Fines Mix
6 - Fines Mix	Mixed		9 - Gravel/Silt/Mud Mix	1 - Fines	Soft Fines	02 - Fines - Mix	04 - Fines/ Coarse Fines Mix
6 - Fines Mix	Mixed		11 - Gravel/Sand Mix				
6 - Fines Mix	Mixed		10 - Gravel/Hard Clay Mix	4 - Hard Bottom	Hard Fines	05 - Hard Fines - Mix	08 - Hard Clay/ Coarse Fines Mix
7 - Fines/Bedrock Mix	Mixed	Smooth or Coarse	14 - Sand/Bedrock Mix	4 - Hard Bottom	Hard Rock	07 - Rock - Mix	12 - Bedrock/ Fines Mix
7 - Fines/Bedrock Mix	Mixed		13 - Clay/Bedrock Mix				
7 - Fines/Bedrock Mix	Mixed		15 - Gravel/Bedrock Mix	4 - Hard Bottom	Hard Rock	07 - Rock - Mix	13 - Bedrock/ Coarse Fines Mix
Accuracy Assesment Level			Accuracy Assesment Level	Accuracy Assesment Level			Accuracy Assesment Level

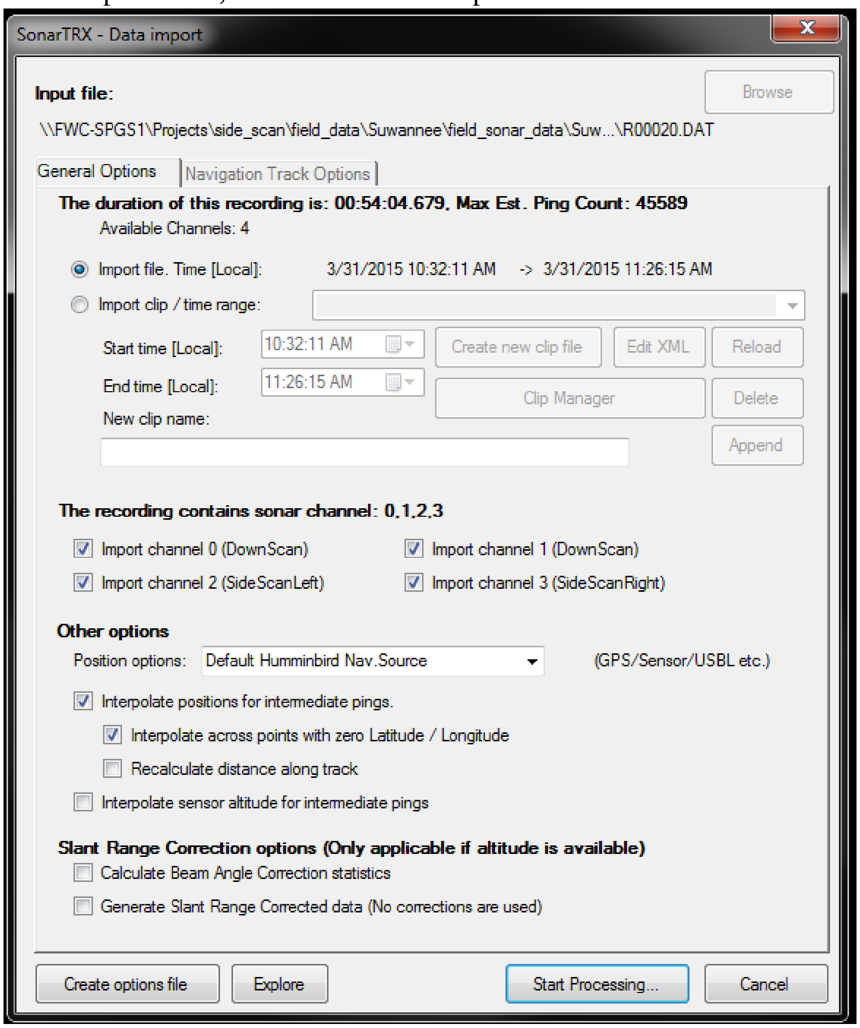
F) SonarTRX X64 Pro Procedure



Download the recording files from the “RECORD” folder on the SD card of the sonar unit. The .DAT file, along with the associated folder with the same name are necessary to the TRX processing. For example, the “0001.DAT” file as well as the folder “0001”in the “RECORD” folder on the SD card should be downloaded.

<u>Import Recording File</u>

- Click the "Import" button
  - Navigate to the location of the recording file to be processed.
    - This is the .DAT file
    - Inspect the date and duration of the recording to be sure it makes sense with the target area. The following example shows a recording that is about 54 minutes long, and collected on 3/31/2015. There is no limit to the duration of recording that can processed, but be aware of computer limitations.

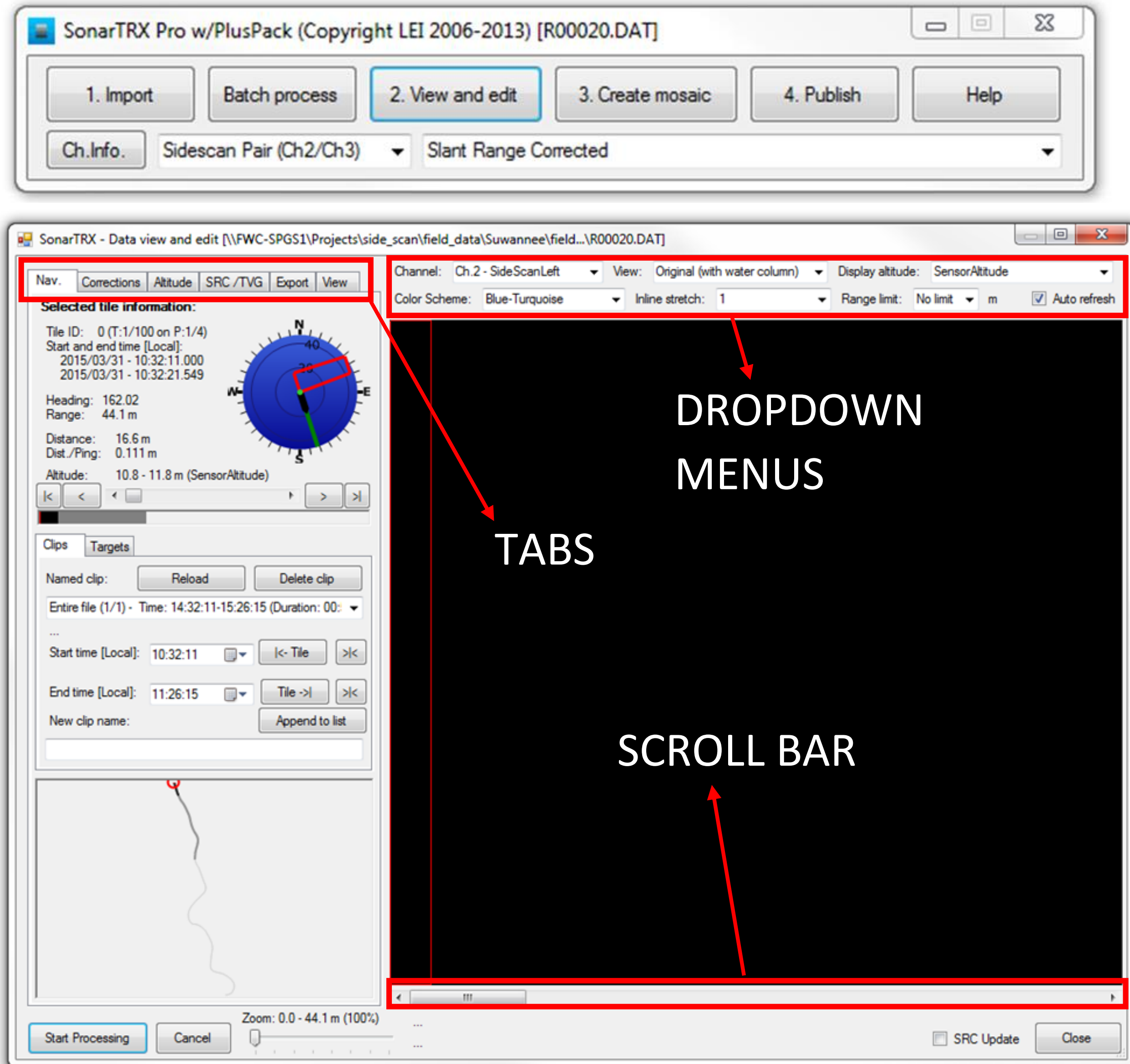


    - <u>Clipping</u> (OPTIONAL): A portion of the recording may be processed using the clip functions if the time period of the targeted imagery is known (this can also be done more easily later in the "View/Edit step").
      - Select the "Import clip / time range" bubble
      - Click "Create new clip file"
        - A default list of predefined clips will be displayed, these can be useful for very large files
      - To create a custom clip range:
        - Change the Start and End time values

        - Enter a clip name
            - Click “Append”
    - The new clip will be added to the drop down list and can be selected manually
- The program’s defaults for everything else in this window are usually acceptable. You will want to import all channels available, and you can calculate slant range correction later in the View window, which I think is easier.
- Click “Start Processing”
- Processing time will depend on the file size and computer processing power computer

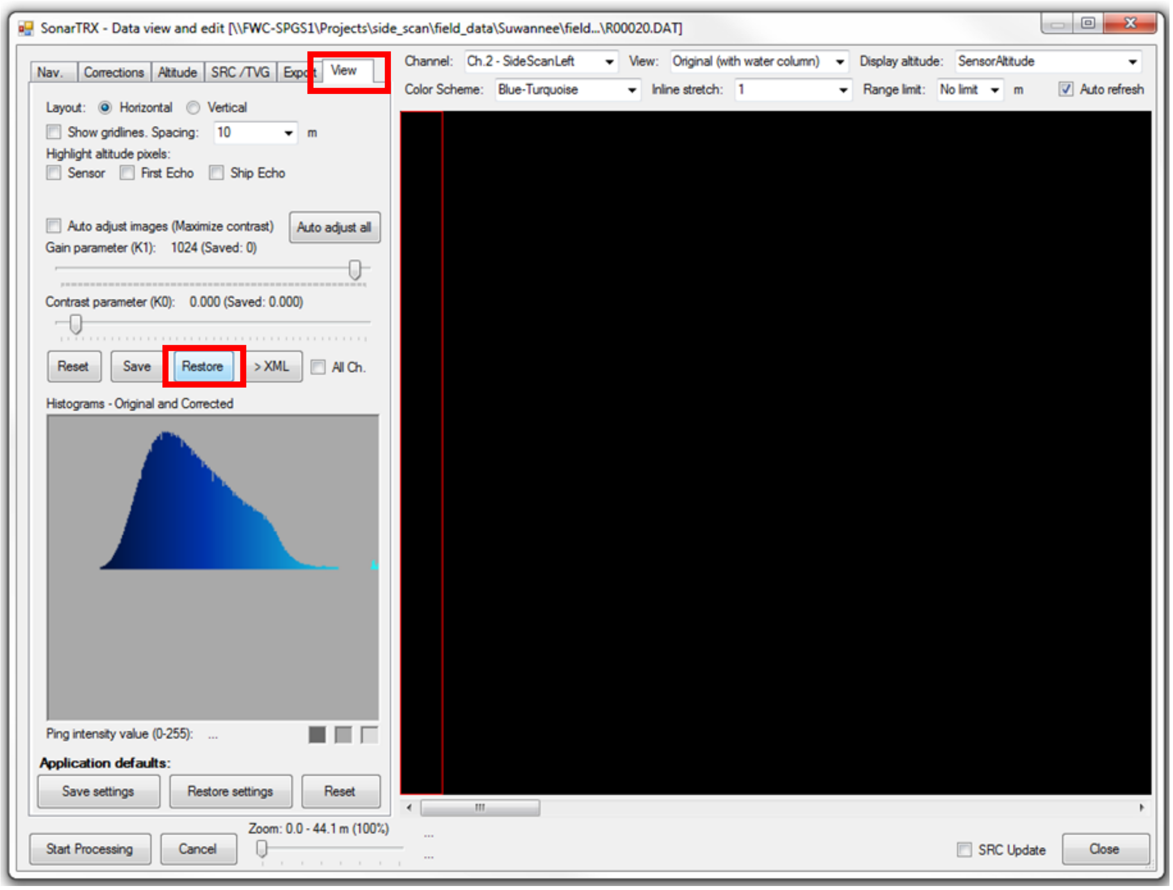
View and Adjust Imagery

The View and edit window

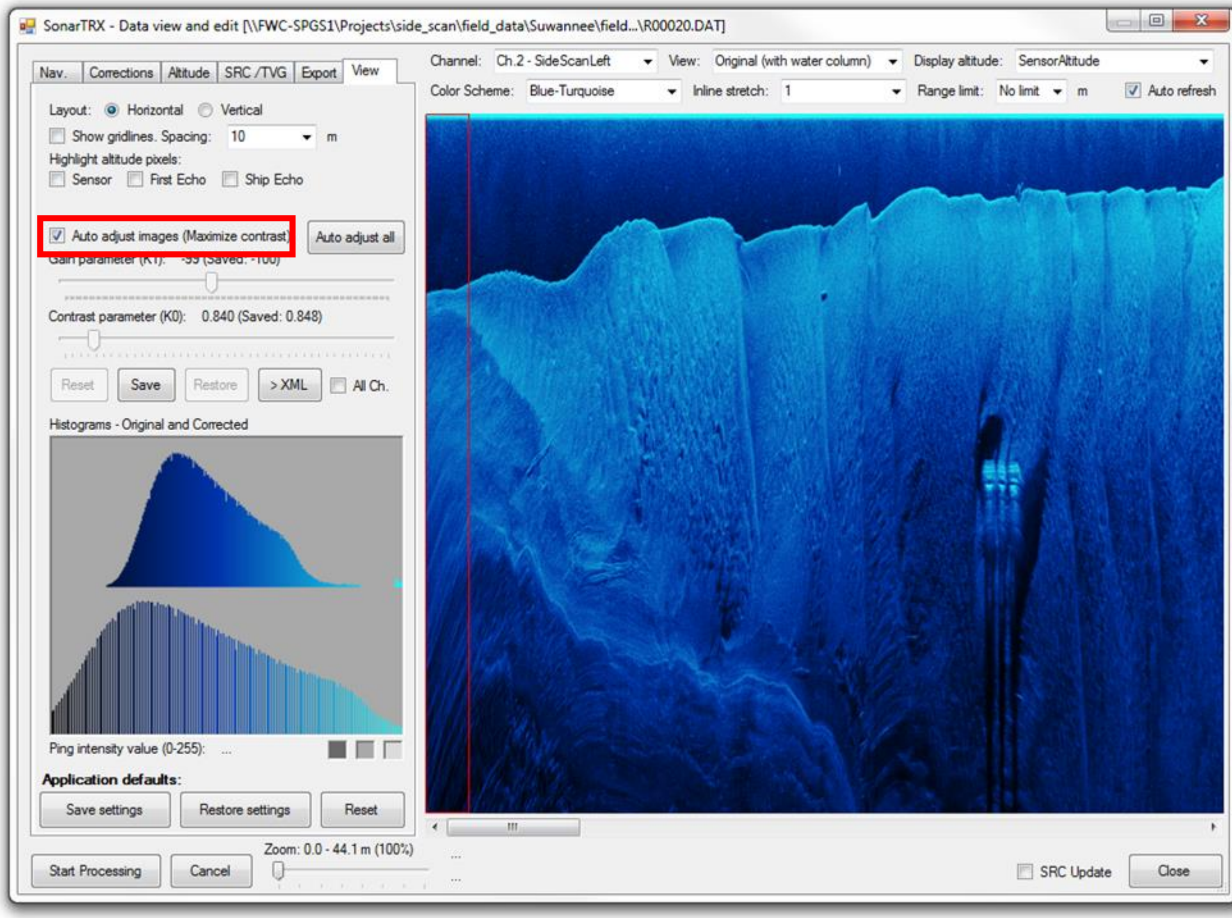


- Slant range correction calculations and adjustments to the imagery are made in the View and edit window, as well as exporting track points and depth data.

- In order to view the imagery, go to the “View” tab in the View window.
  - Click the “Restore” button



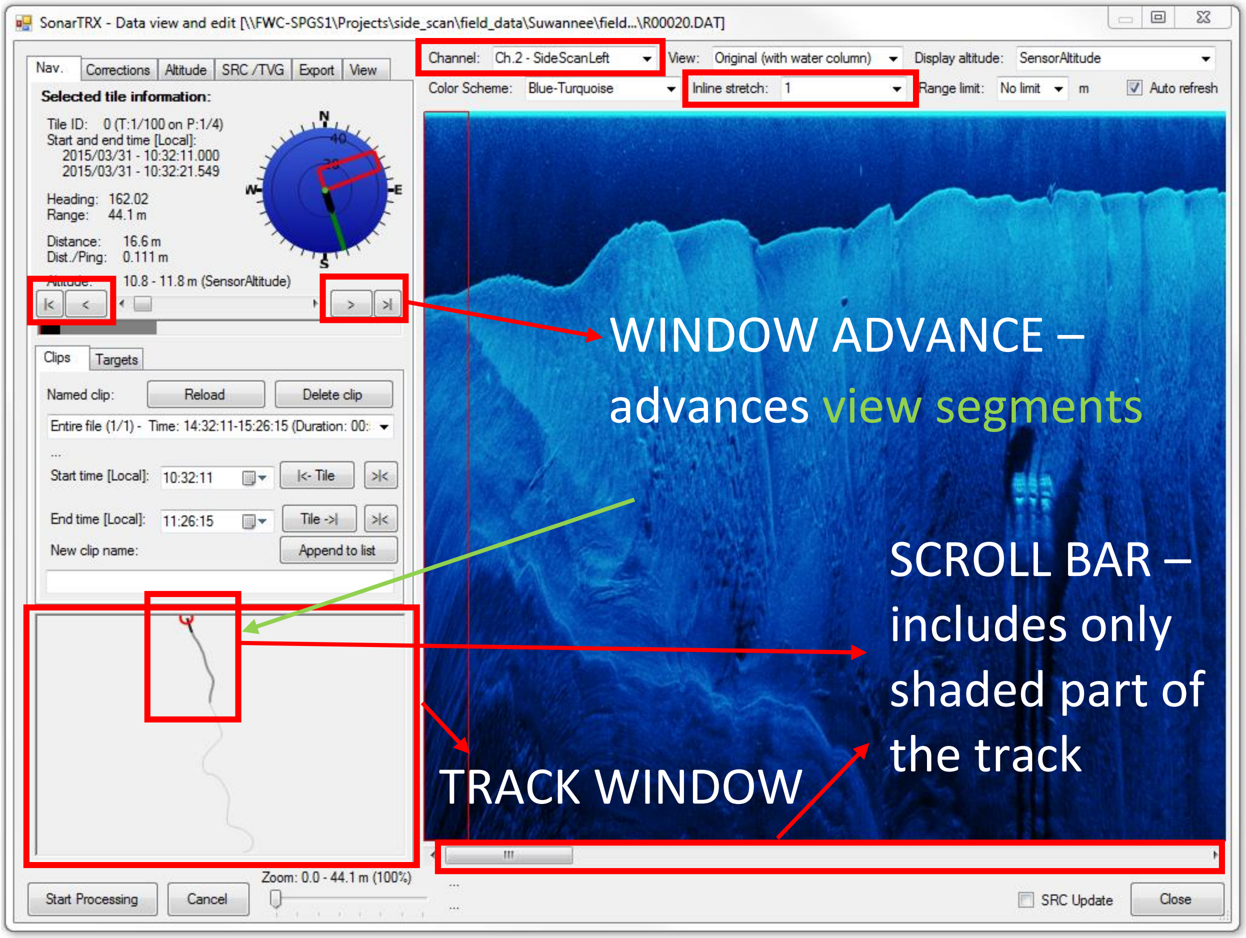
- Check the “Auto adjust images (Maximize contrast)” box
  - Although the imagery should look good at this point, unchecking the Auto adjust images box enables adjustments to be made using the sliders. However, the sliders can be difficult to manipulate with mouse and arrow keys and personal experience has shown that Auto adjust gives the best balance for the Original (with water column) imagery.



- You can scroll through the recording with the scroll bar below the image window
- If the imagery looks acceptable at this point, it is acceptable to skip directly to the "**<u>Exporting Imagery</u>**" step. However, performing additional manipulations can remove the water column and improve the image in general.

General review of imagery

- Go to the Nav. tab



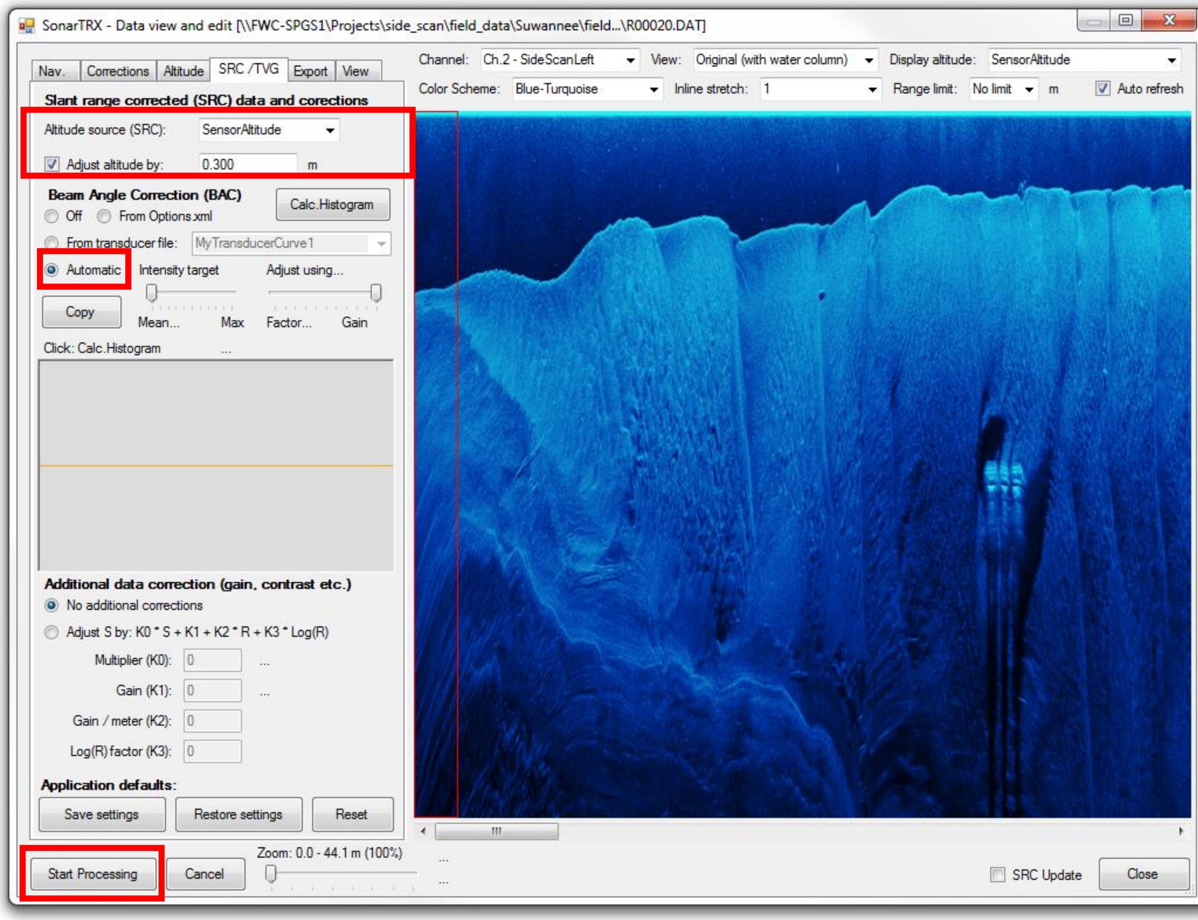
- The Nav. tab allows you to view the imagery of the entire recording, and displays the path of the survey vessel (Track Window). The dark shaded part of the track is the part of the recording visible in the window, and the lighter shaded part is the part of the track viewable with the scroll bars. Click the Window Advance buttons to advance down the track and view other parts of the recording.

- Use the “Channel:” dropdown menu to select which side of the sonar to view (Left or Right)

- Change the “Inline Stretch” dropdown menu to “Speed Corrected” to get a more realistic view of the size of features in the imagery

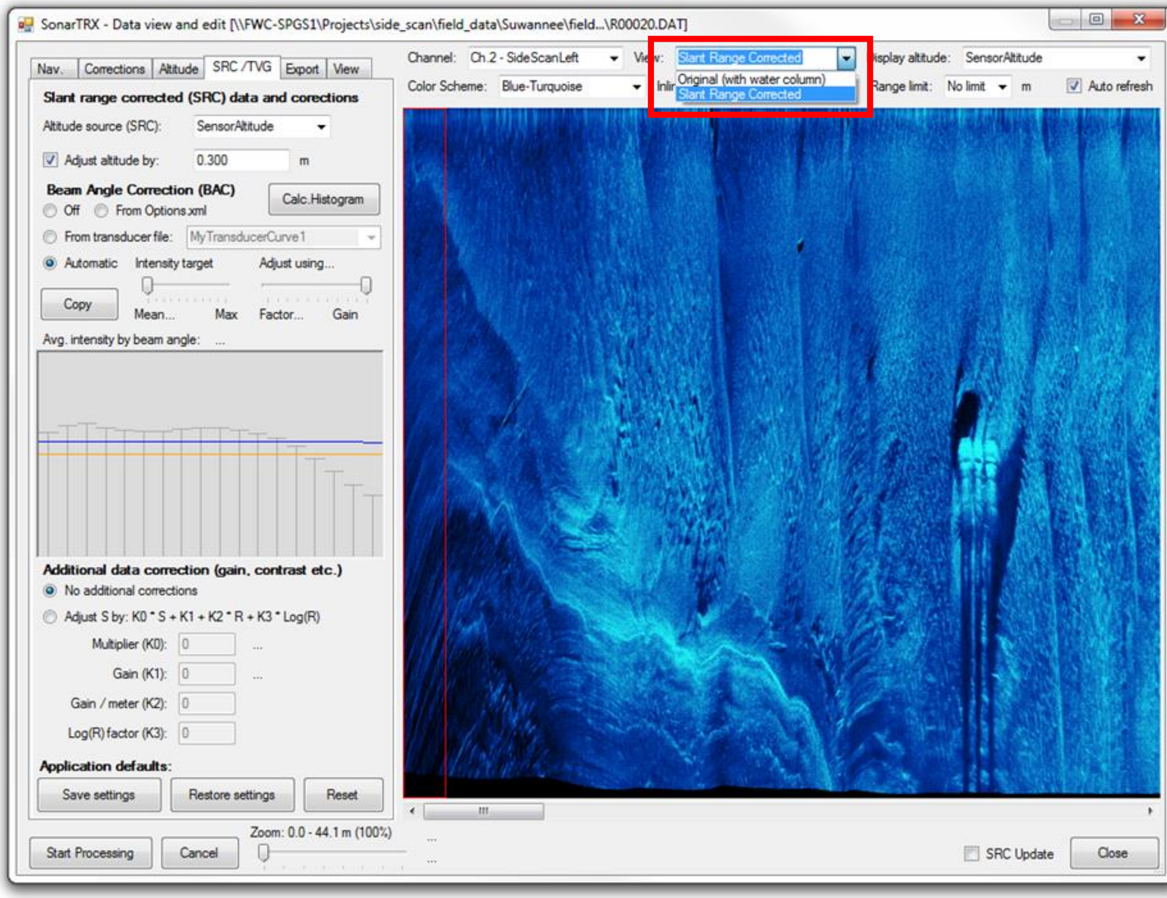
<u>Slant Range Correction (SRC)</u>

- Click the “SRC/TVG” tab in the Data view and edit window



- “Altitude source (SRC):” Sensor Altitude
    - o Check the “Adjust altitude by:” box
- “Beam Angle Correction (BAC)”
    - o Select the “Automatic”
- Accept all other defaults
- Click the “Start Processing” button

- After the process is completed, in order to see the SRC images: In the “View:” dropdown menu (upper right), select “Slant Range Corrected”

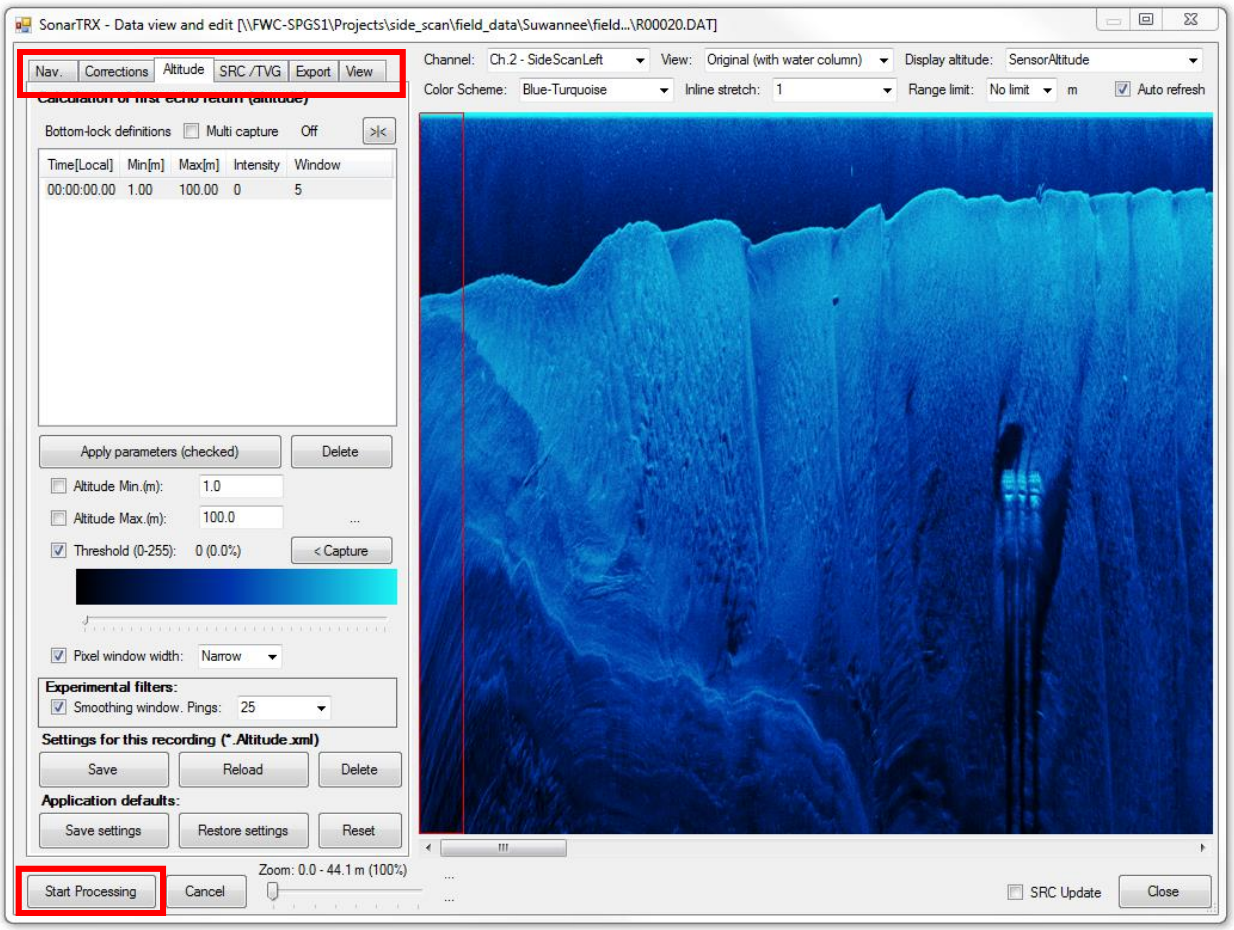


- SonarTRX does some additional processing by using the embedded depth data (Sensor Altitude) to even out pixels values across the entire range of coverage, resulting in bright image tones all the way to the edge.
    - However, this processing uses the average depth collected across the entire recording to adjust the pixel values, causing the shallowest portions of the recording to be very light, and the deepest parts to be quite dark. If depths do not vary dramatically through the recording (a scanned a lake or offshore for instance), then the SRC image will be flat. But, if the recording is taken in a riverine setting, there will likely be dramatic changes in depths as the boat passes over riffles, pools, bars, and protruding woody debris.
        - Even with dramatic changes in depth, the quality of the SRC imagery is acceptable.

First Echo Return processing (imagery with the water column)

The original (with water column) imagery can be difficult to adjust properly, and adjustments are limited to the Auto adjust contrast and slider manipulations in the View tab. By processing the first echo return functions in SonarTRX, the parameter manipulations can be used with the water column preserved in the imagery, and dramatic depth variations do not affect the pixel values as in the SRC corrections.

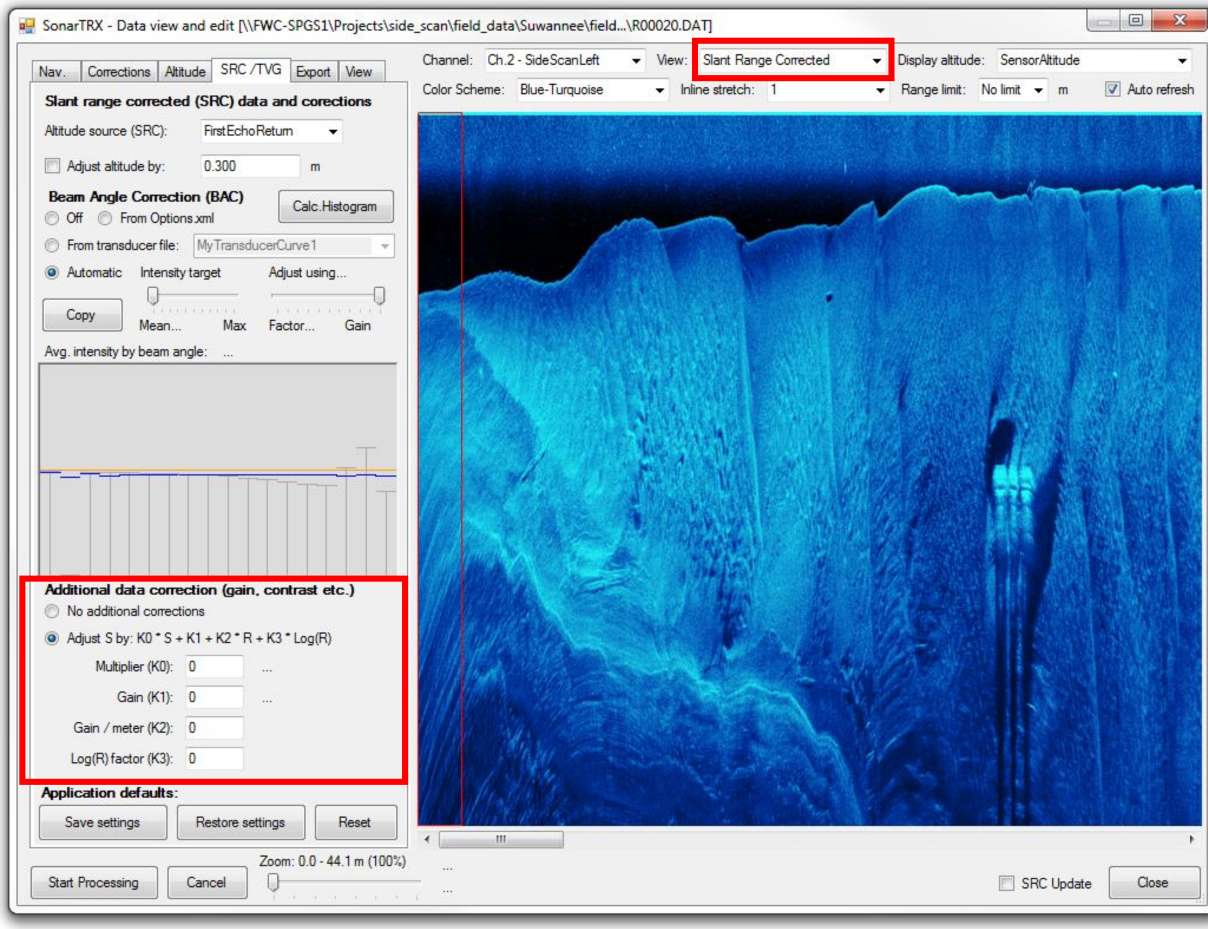
- Go to the Altitude tab.
    - Click the "Start Processing" button



- Go back to the "SRC/TVG" tab
    - Change the "Altitude source (SRC):" dropdown menu to "FirstEchoReturn"
    - UN-check the "Adjust altitude by:" box
    - Click the "Start Processing" button
    - Once processing finishes, change the "View:" dropdown menu to "Slant Range Corrected"

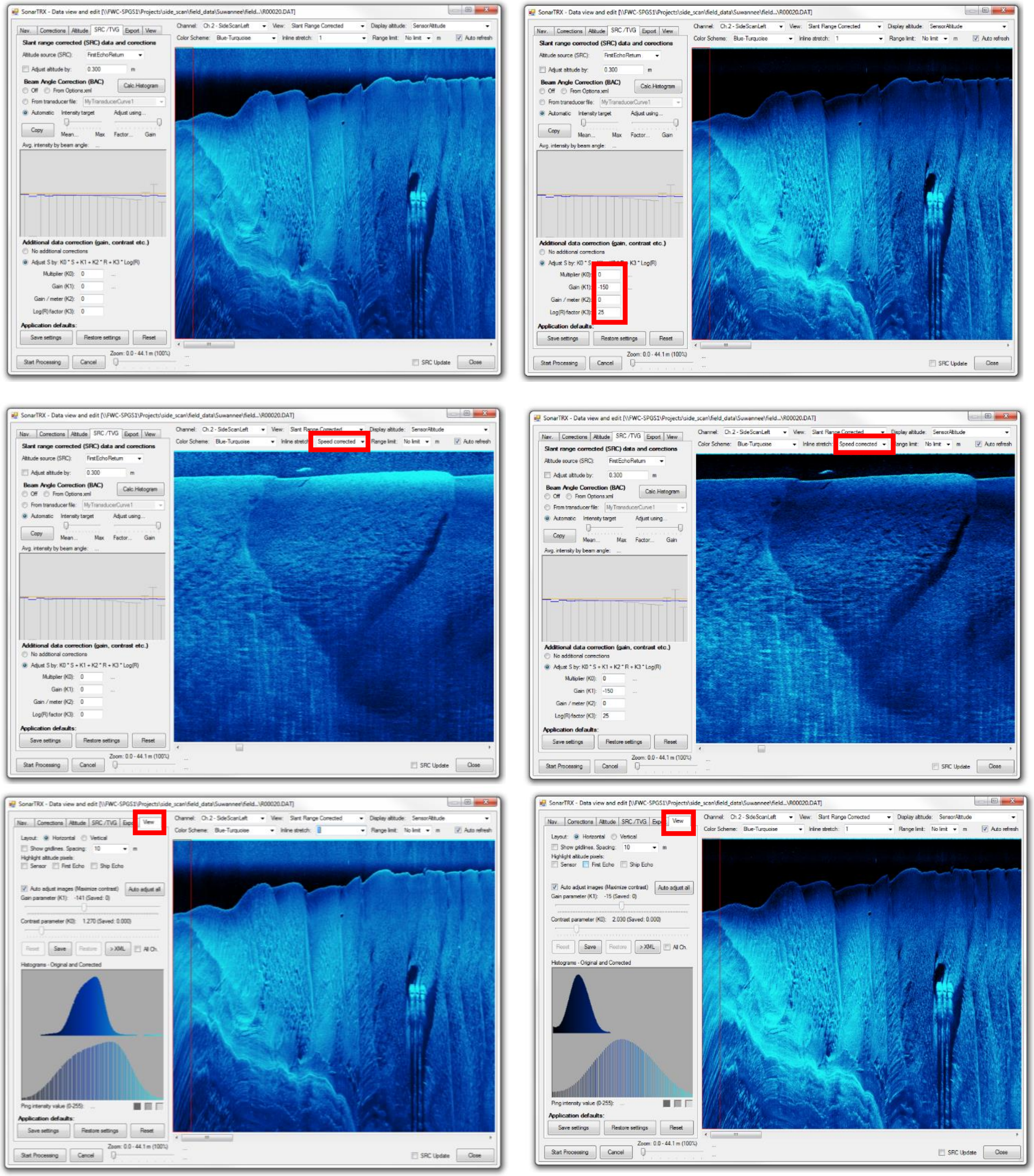
Additional data correction parameters (image adjustments)

- Because the SRC imagery often does not require additional adjustments, the following examples use the FirstEchoReturn imagery, where the parameter adjustments make the most difference.



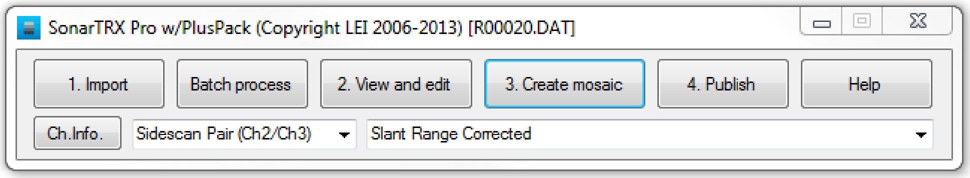
- Each recording is different and will need different levels of adjustment
- The only parameters adjusted during this project are the “Gain (K1)” and the “Log(R) factor (K3)”
    - Gain (K1) = increases contrast
        - Lower values increase contrast
        - Upper values decrease contrast
        - Start with negative values and increase or decrease depending on how the imagery is affected
    - Log(R) factor (K3)
        - This is a fine tune parameter, which appears to reduce shallow water washout. Generally ranges from 0-50, too high or low and the imagery will go all white or black, respectively.
- Click the “Start Processing” button after each change in parameter values to apply the changes

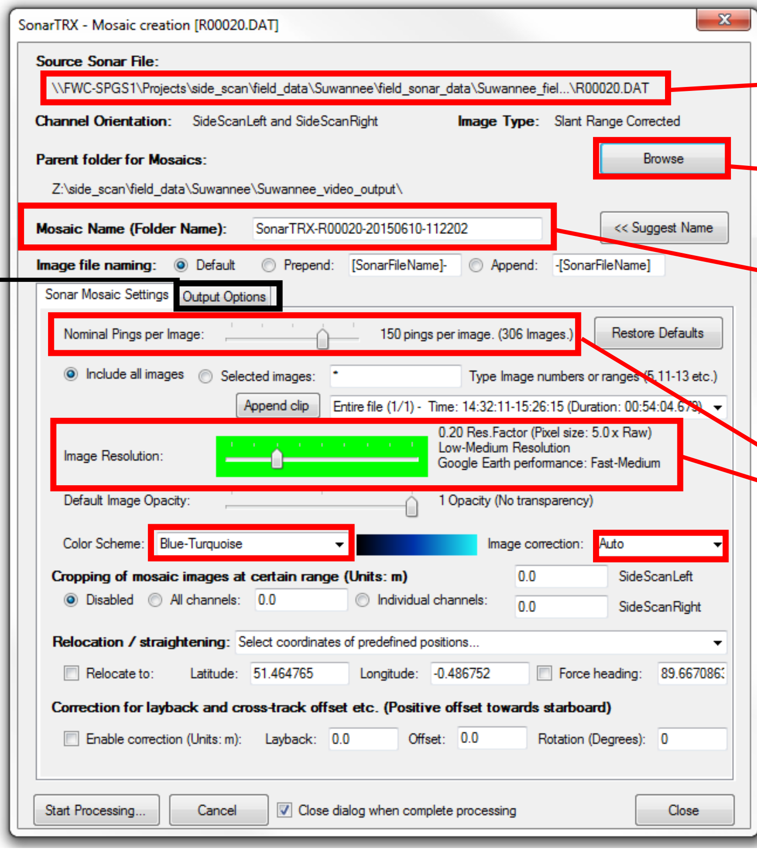
Example image corrections



- In our experience, Gain (K1) = -150 and log(R) = 25 are good starting places

Exporting Imagery



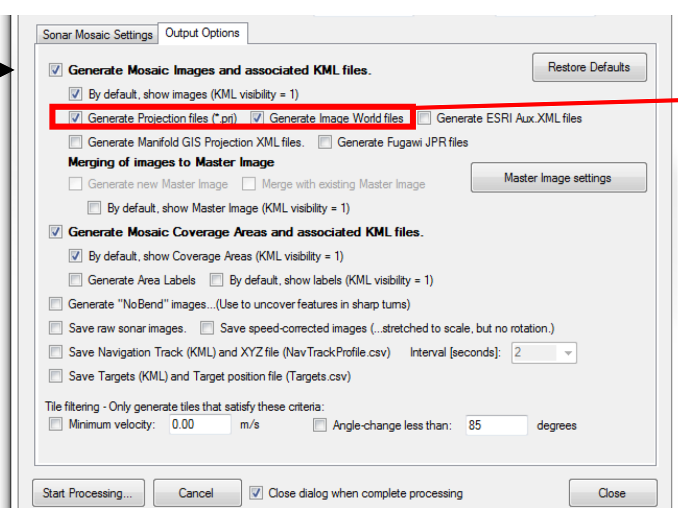


Location of current recording file

Choose location to save the output imagery folder

Change the name of the output folder to something more descriptive of the imagery

These defaults are ok. There will be a balance of resolution and file size that works for you and the size of the features you hope to see in the imagery, i.e. large boulders vs. fish beds



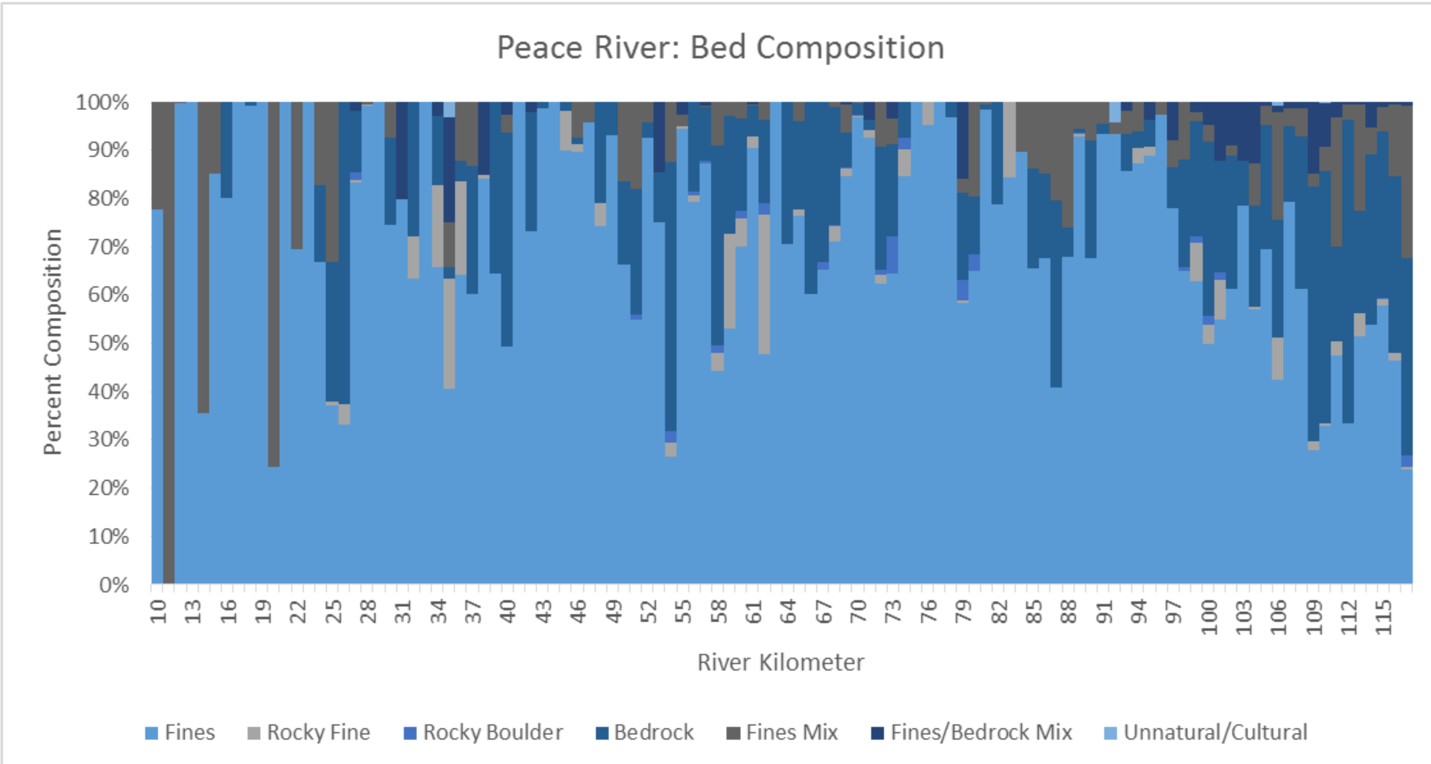
Checking these boxes enables you to load the imagery into ArcGIS later

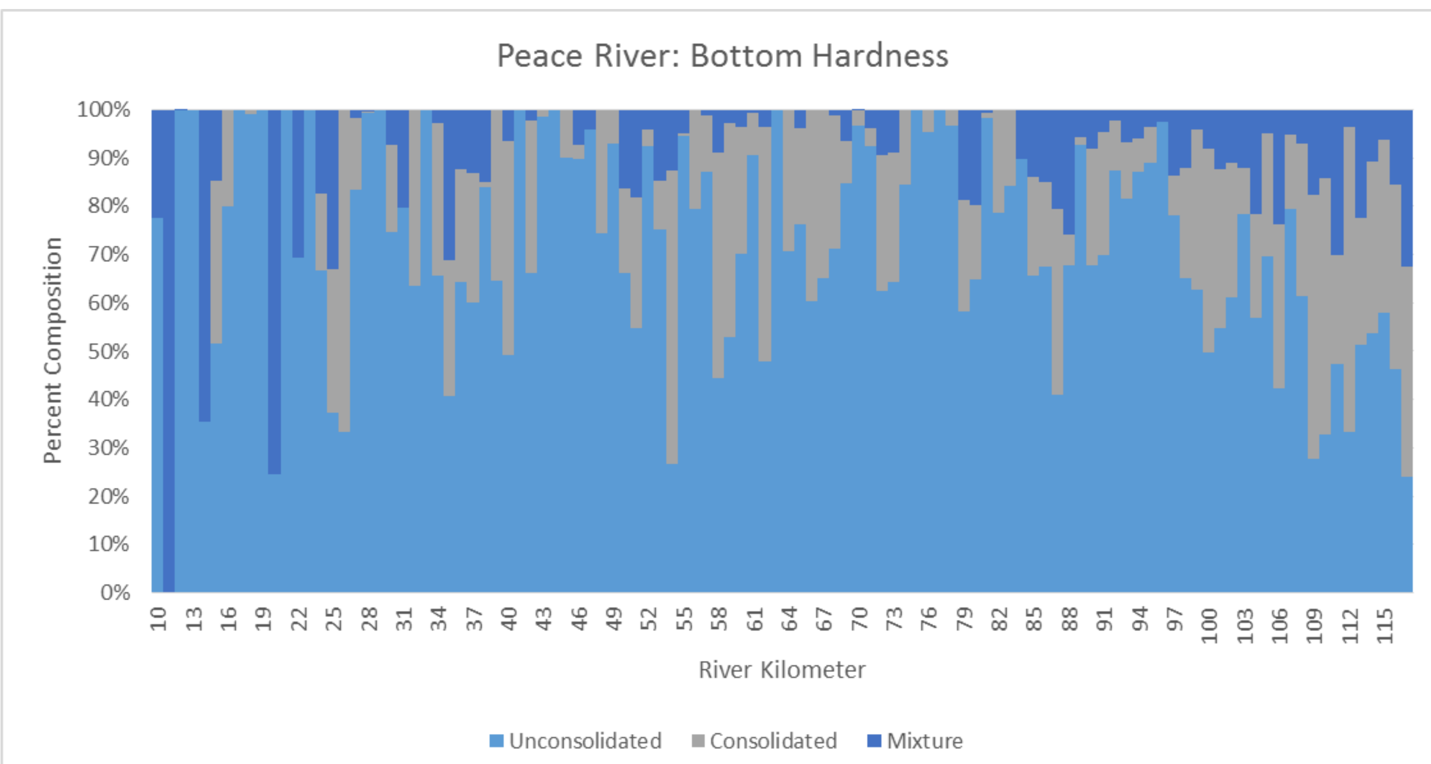
- Click "Start Processing"

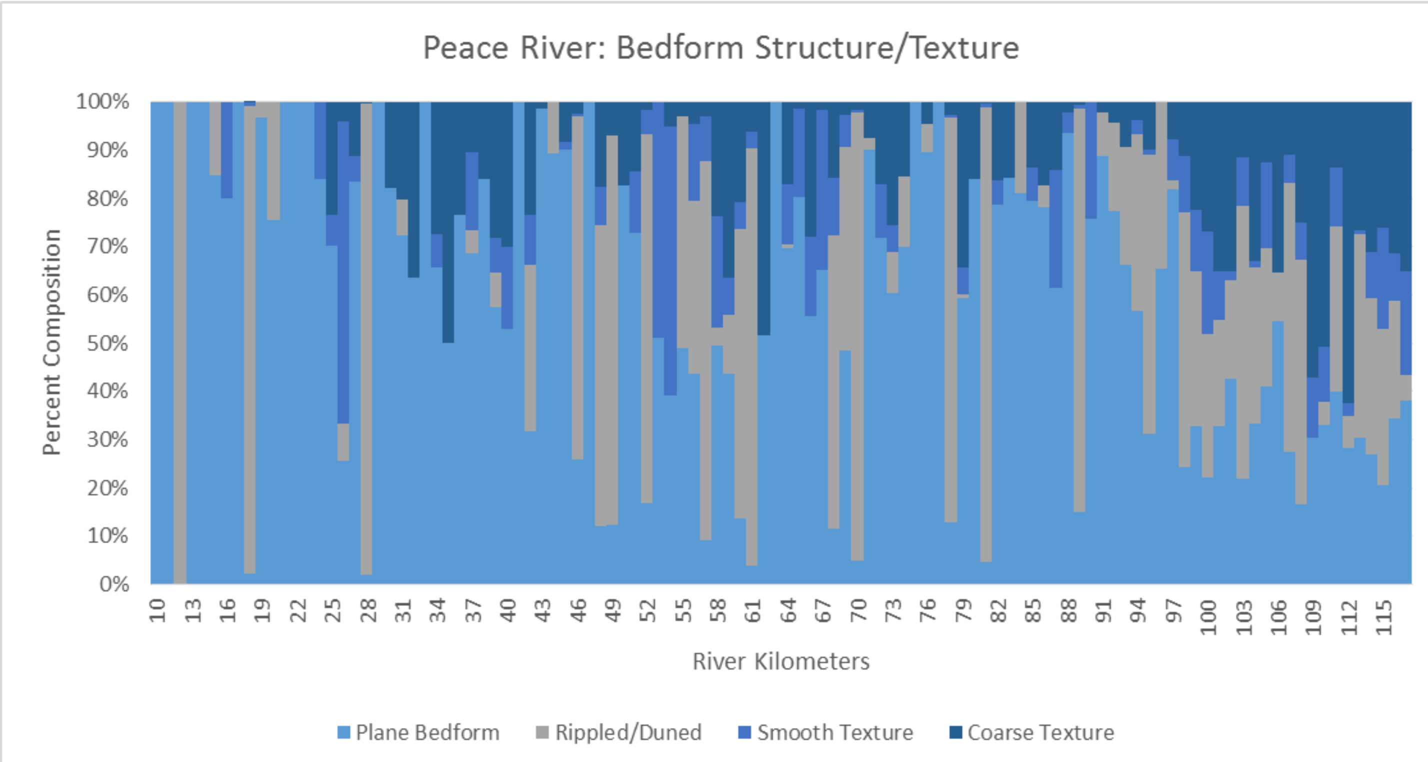
- The folder created will contain the “image tiles” (in the folder named “files”), and a .kml file that can be opened in Google Earth.

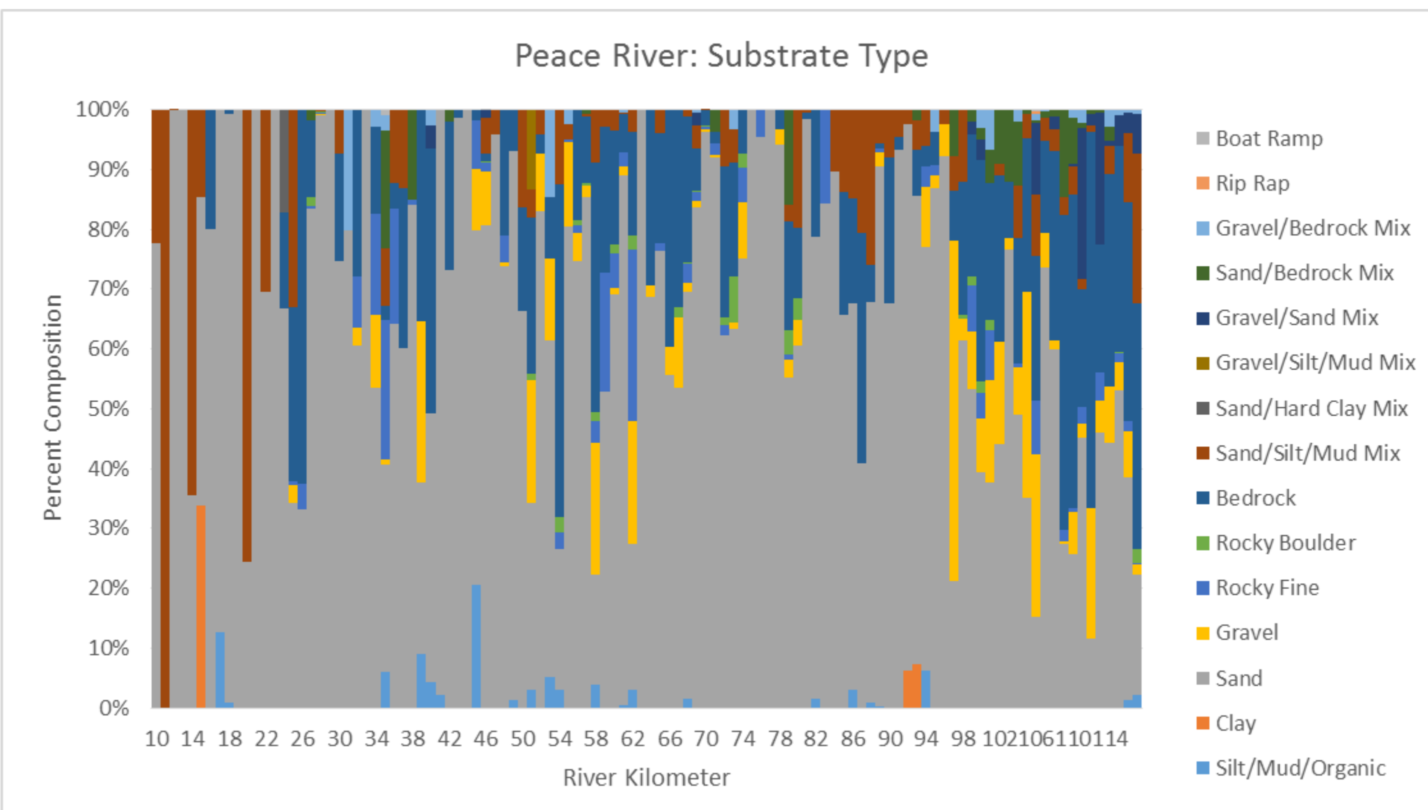
- Navigate to the folder you just exported the imagery to, open the “files” folder, and DELETE the “Logo” image file.

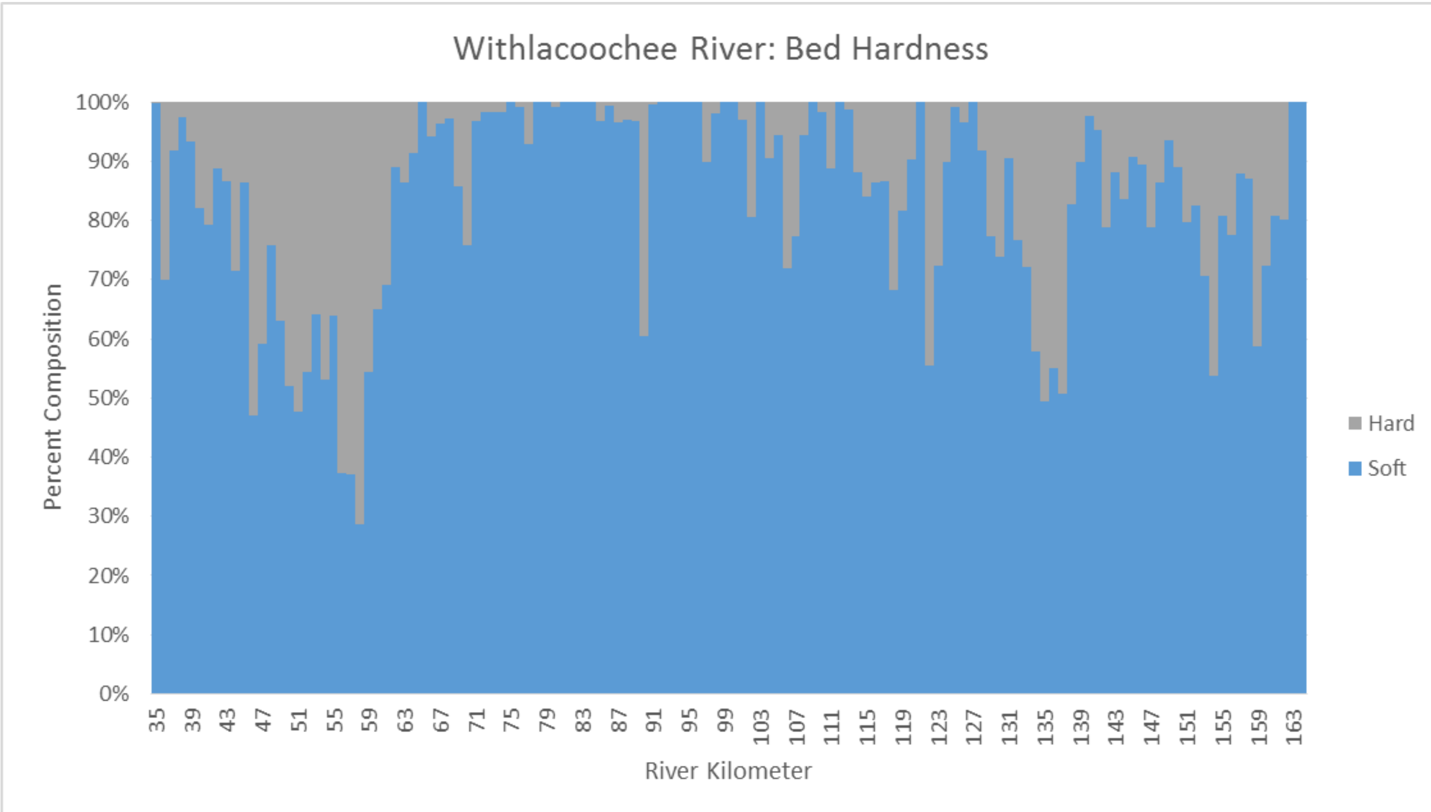
F) Classification Summary

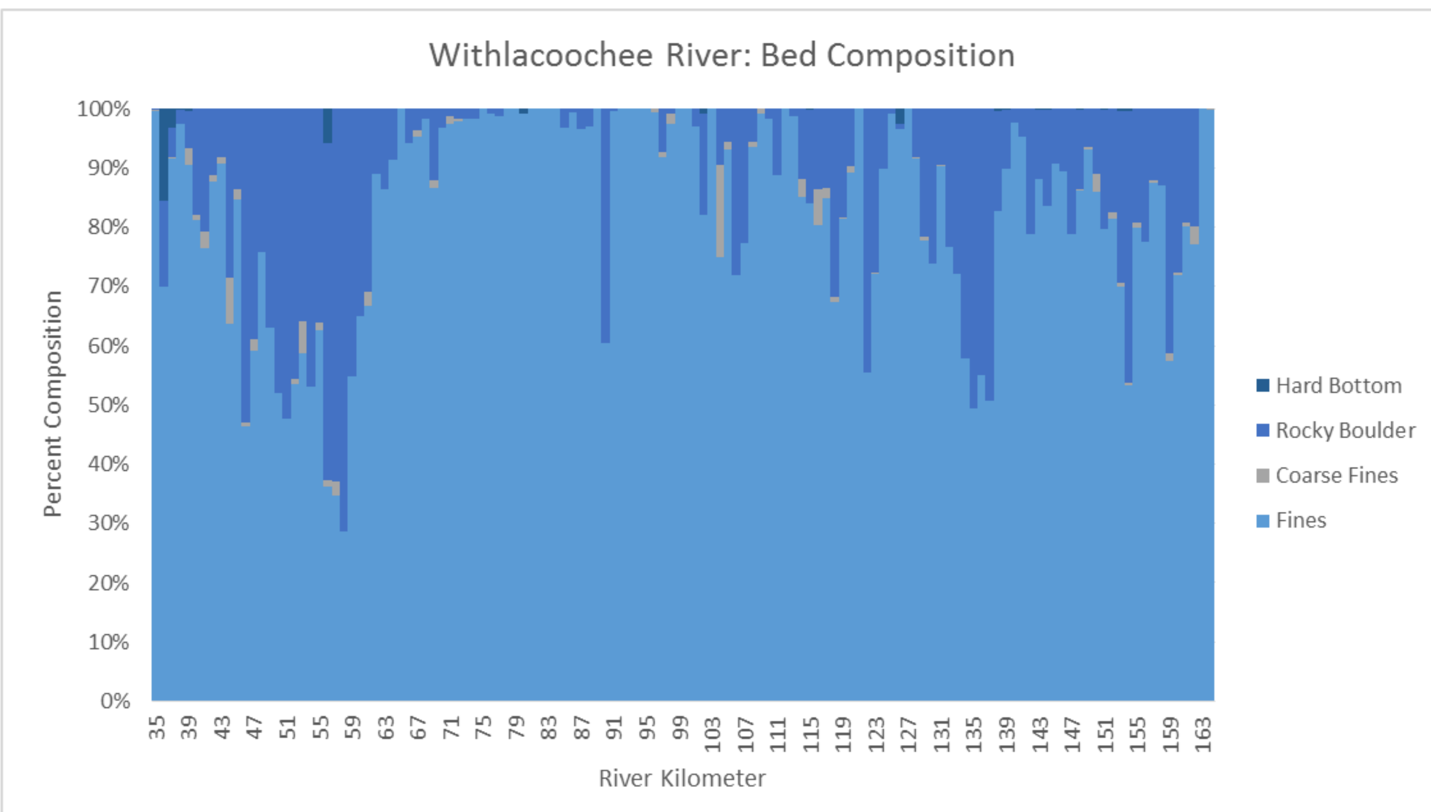


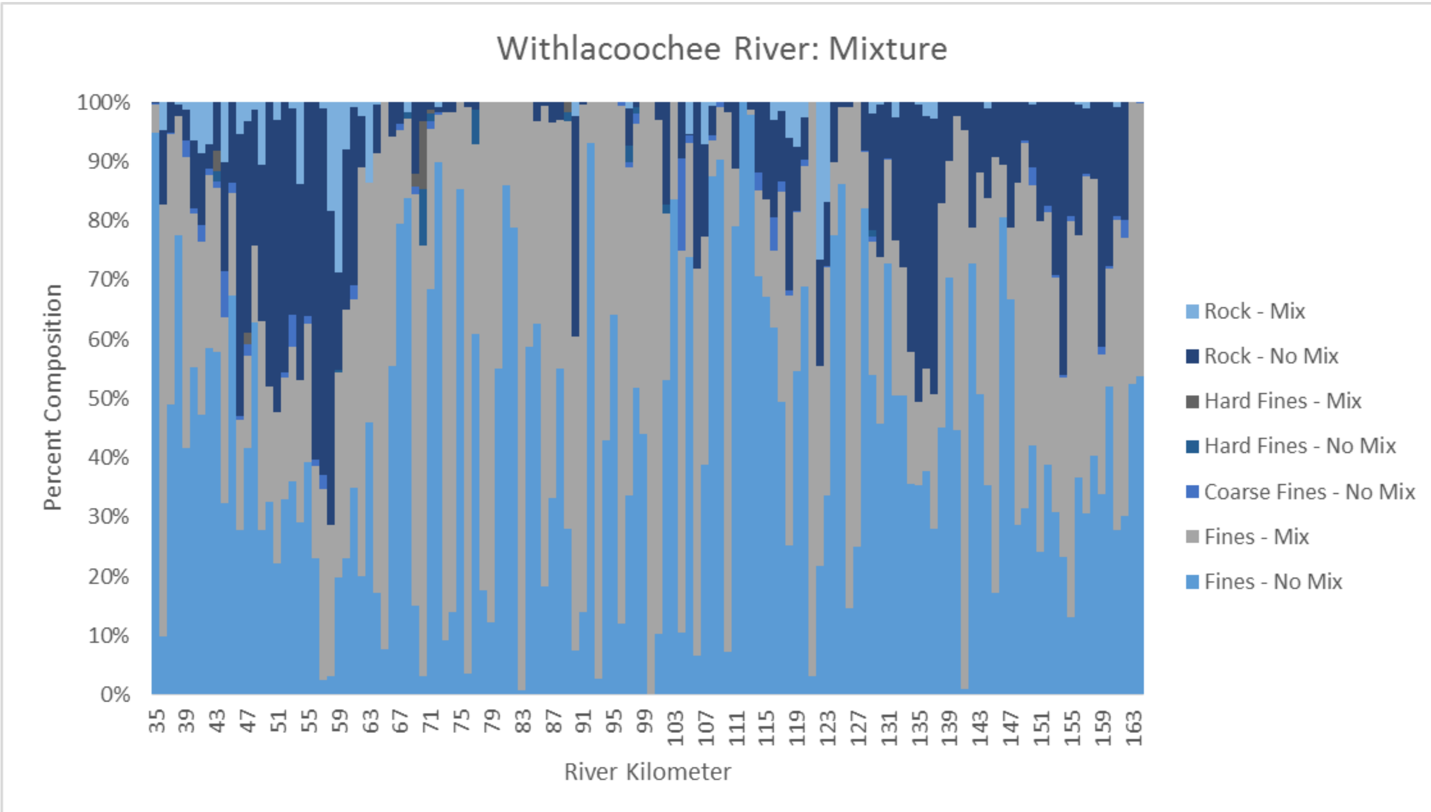


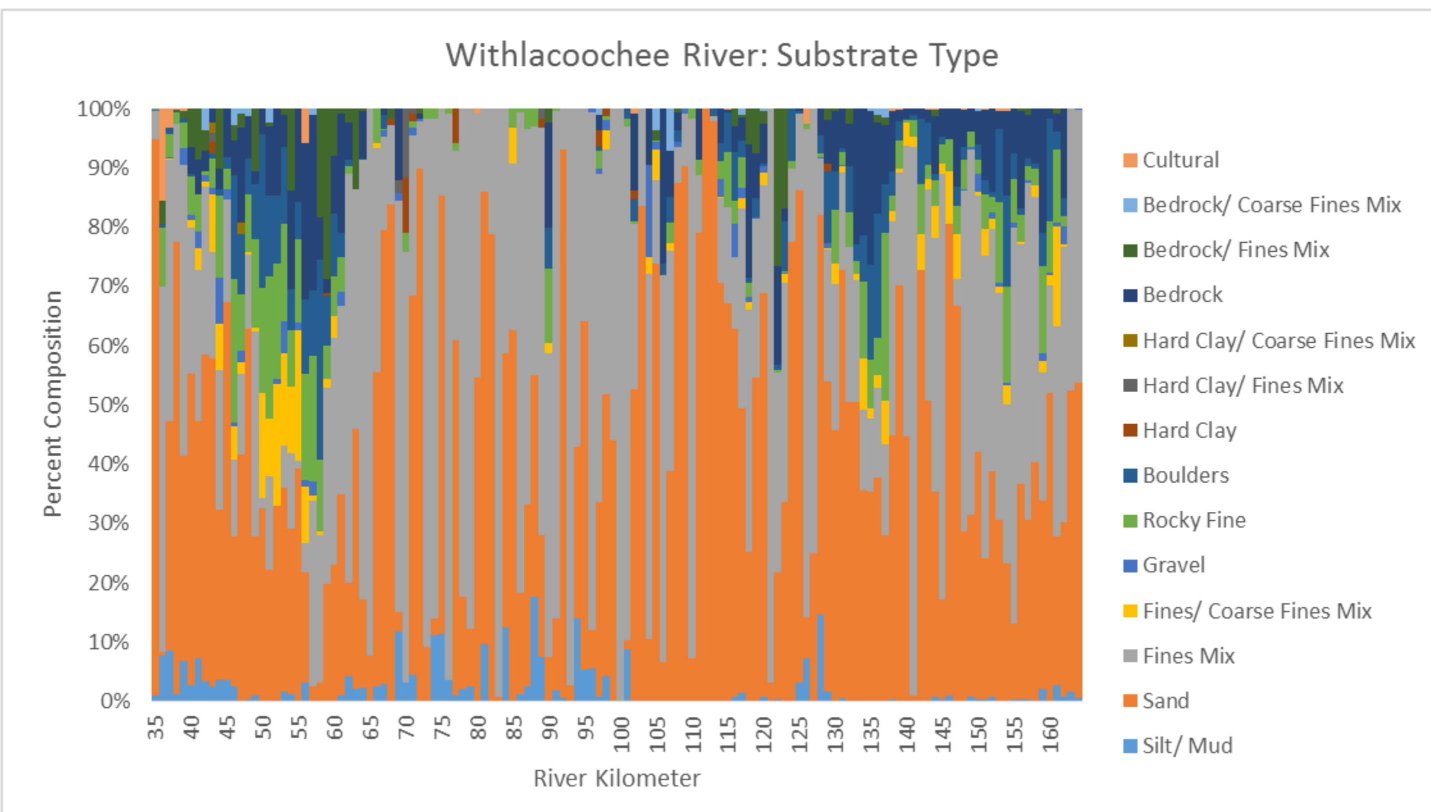

Peace River: Bedform Structure/Texture
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94 97 100 103 106 109 112 115
River Kilometers
Plane Bedform
Rippled/Duned
Smooth Texture
Coarse Texture

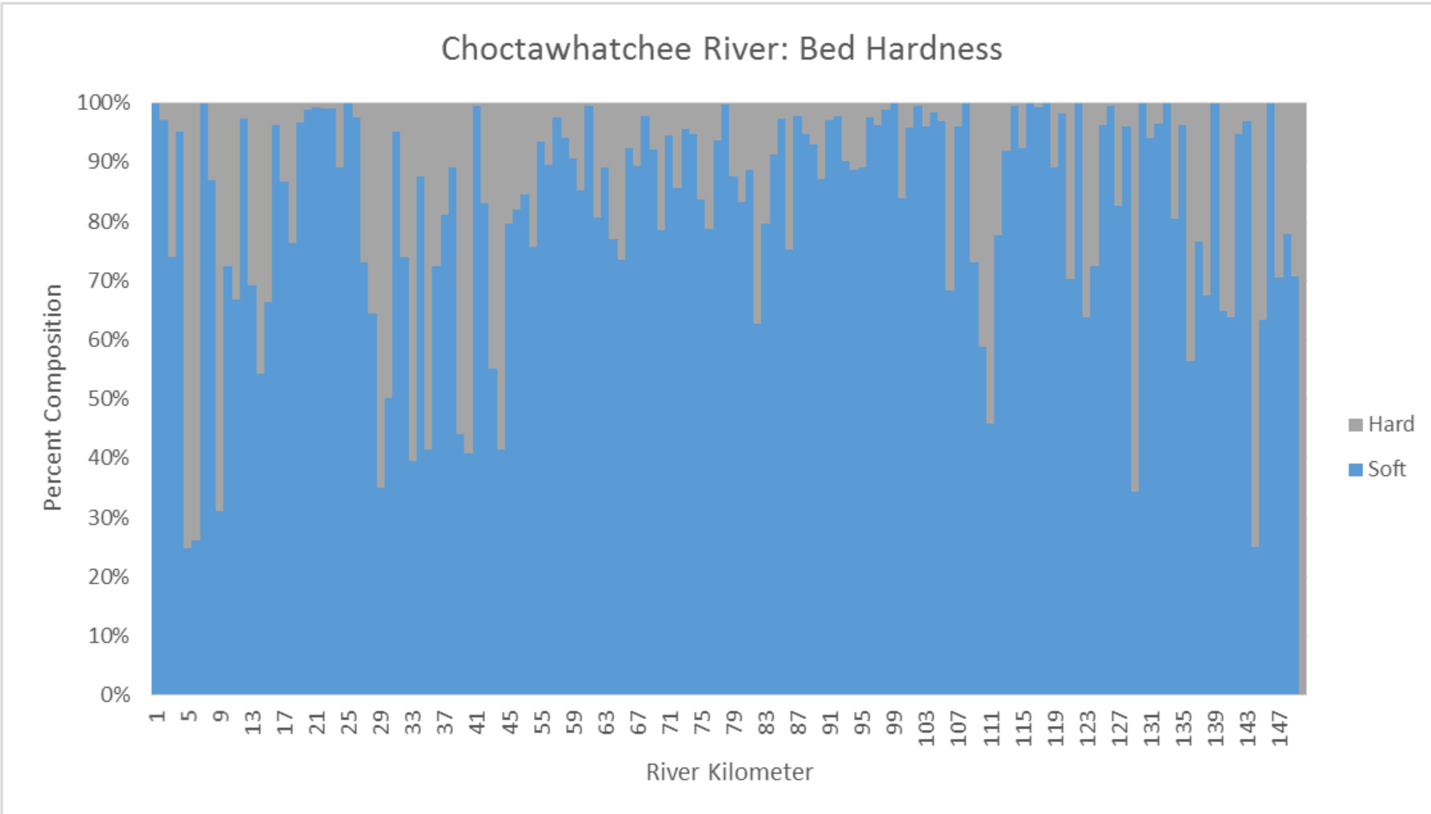

Peace River: Substrate Type
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82 86 90 94 98 102106110114
River Kilometer
Boat Ramp
Rip Rap
Gravel/Bedrock Mix
Sand/Bedrock Mix
Gravel/Sand Mix
Gravel/Silt/Mud Mix
Sand/Hard Clay Mix
Sand/Silt/Mud Mix
Bedrock
Rocky Boulder
Rocky Fine
Gravel
Sand
Clay
Silt/Mud/Organic

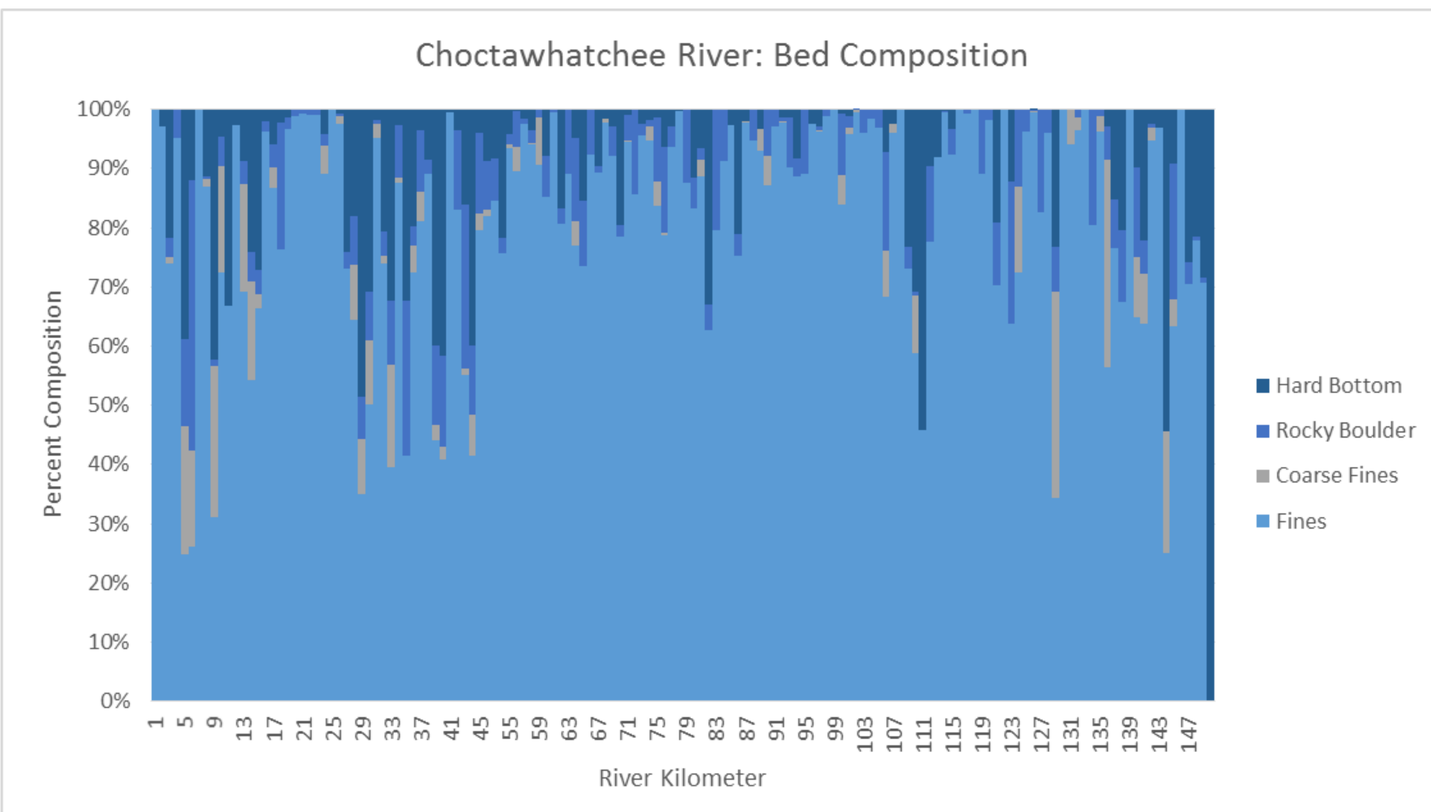

Withlacoochee River: Bed Hardness
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
35 39 43 47 51 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147 151 155 159 163
River Kilometer
Hard
Soft

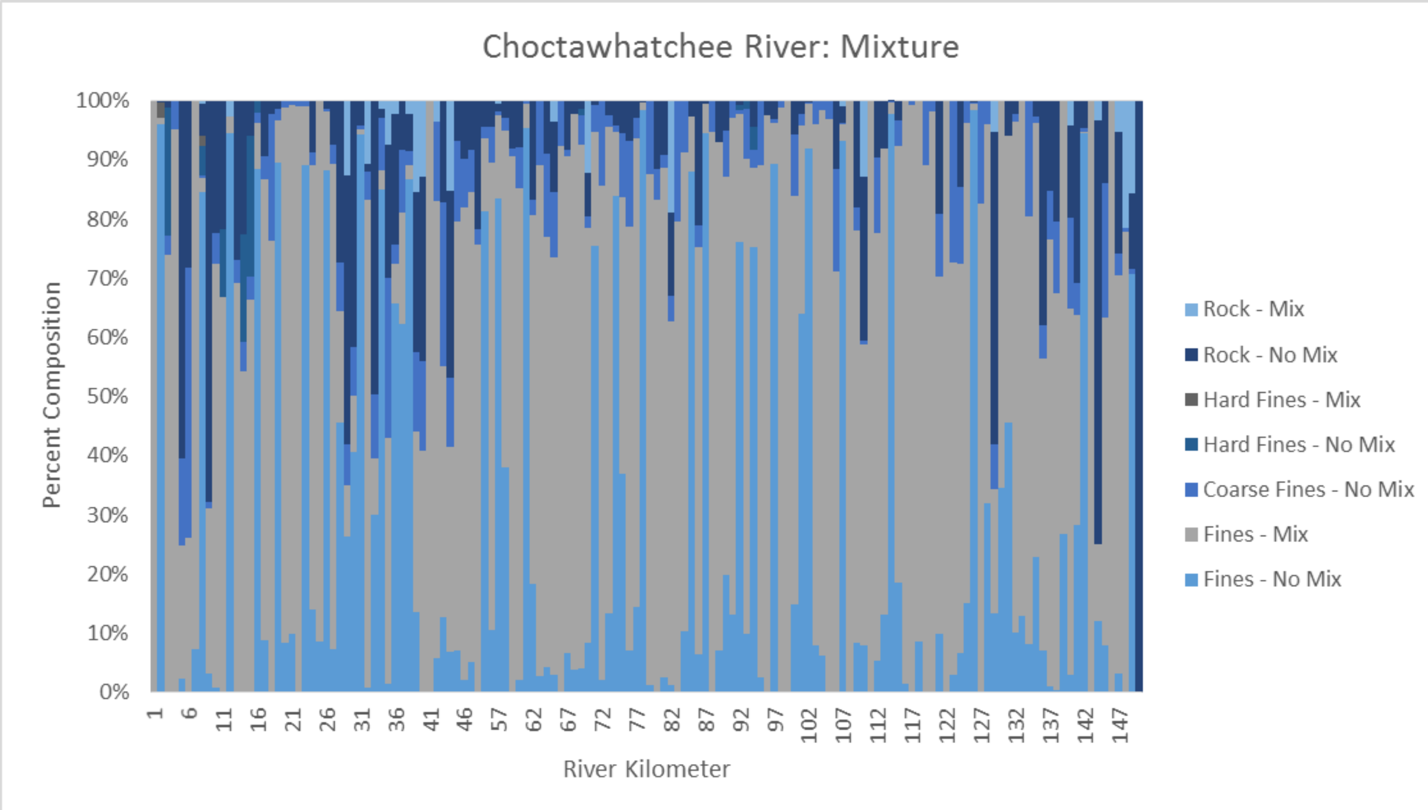

Withlacoochee River: Bed Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
35 39 43 47 51 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147 151 155 159 163
River Kilometer
Hard Bottom
Rocky Boulder
Coarse Fines
Fines


Withlacoochee River: Mixture
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
35 39 43 47 51 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147 151 155 159 163
River Kilometer
Rock - Mix
Rock - No Mix
Hard Fines - Mix
Hard Fines - No Mix
Coarse Fines - No Mix
Fines - Mix
Fines - No Mix

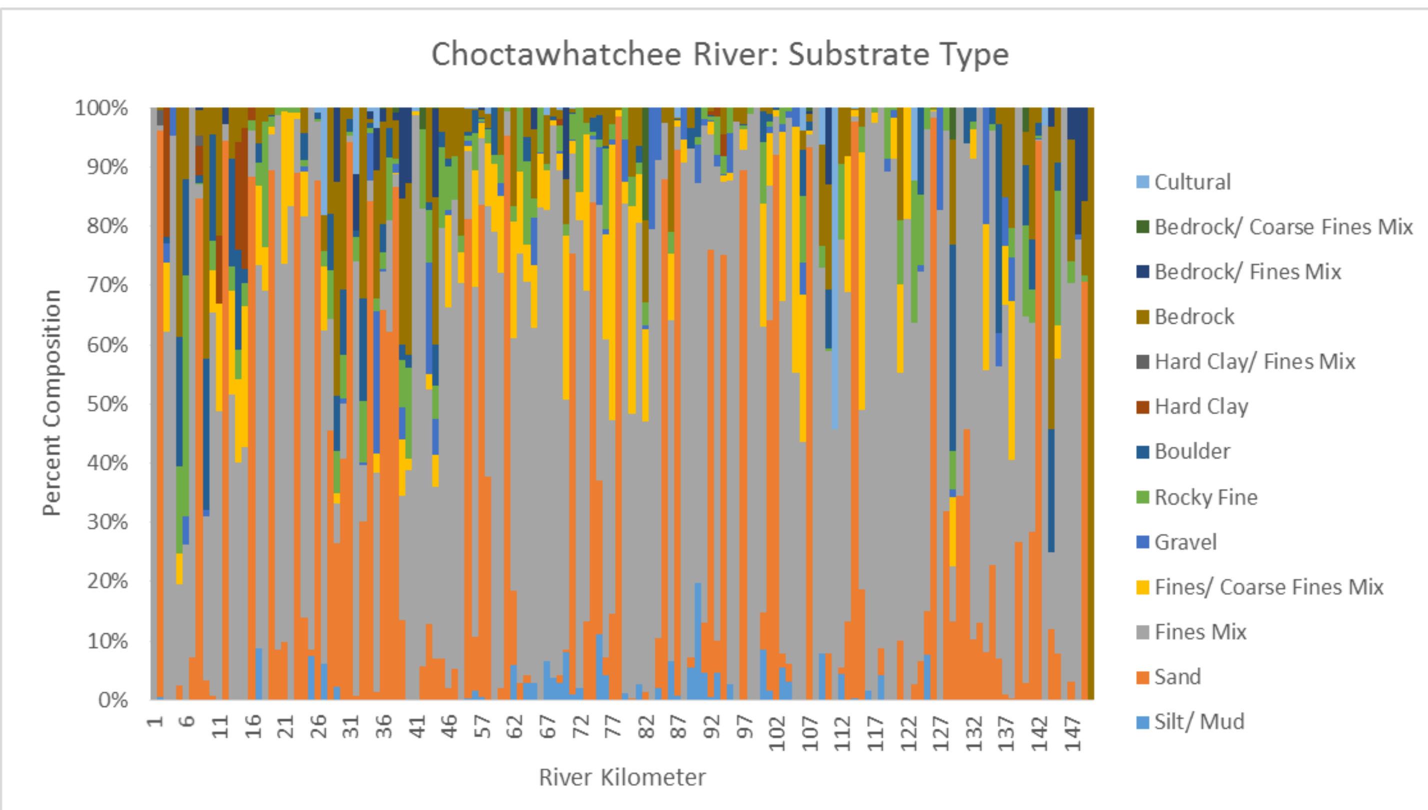

Withlacoochee River: Substrate Type
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160
River Kilometer
Cultural
Bedrock/ Coarse Fines Mix
Bedrock/ Fines Mix
Bedrock
Hard Clay/ Coarse Fines Mix
Hard Clay/ Fines Mix
Hard Clay
Boulders
Rocky Fine
Gravel
Fines/ Coarse Fines Mix
Fines Mix
Sand
Silt/ Mud


Choctawhatchee River: Bed Hardness
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 5 9 13 17 21 25 29 33 37 41 45 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147
River Kilometer
Hard
Soft

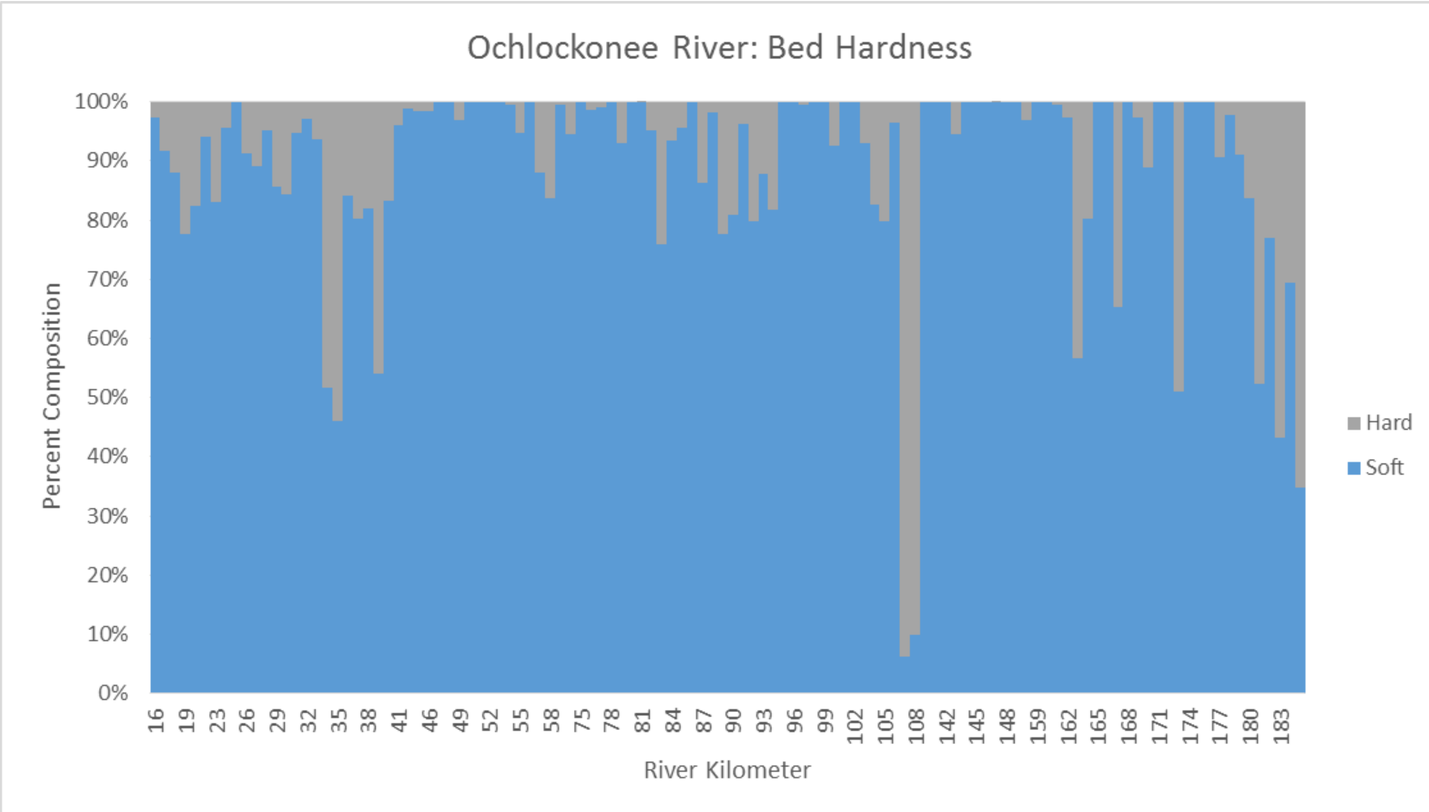

Choctawhatchee River: Bed Composition
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 5 9 13 17 21 25 29 33 37 41 45 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147
River Kilometer
Hard Bottom
Rocky Boulder
Coarse Fines
Fines

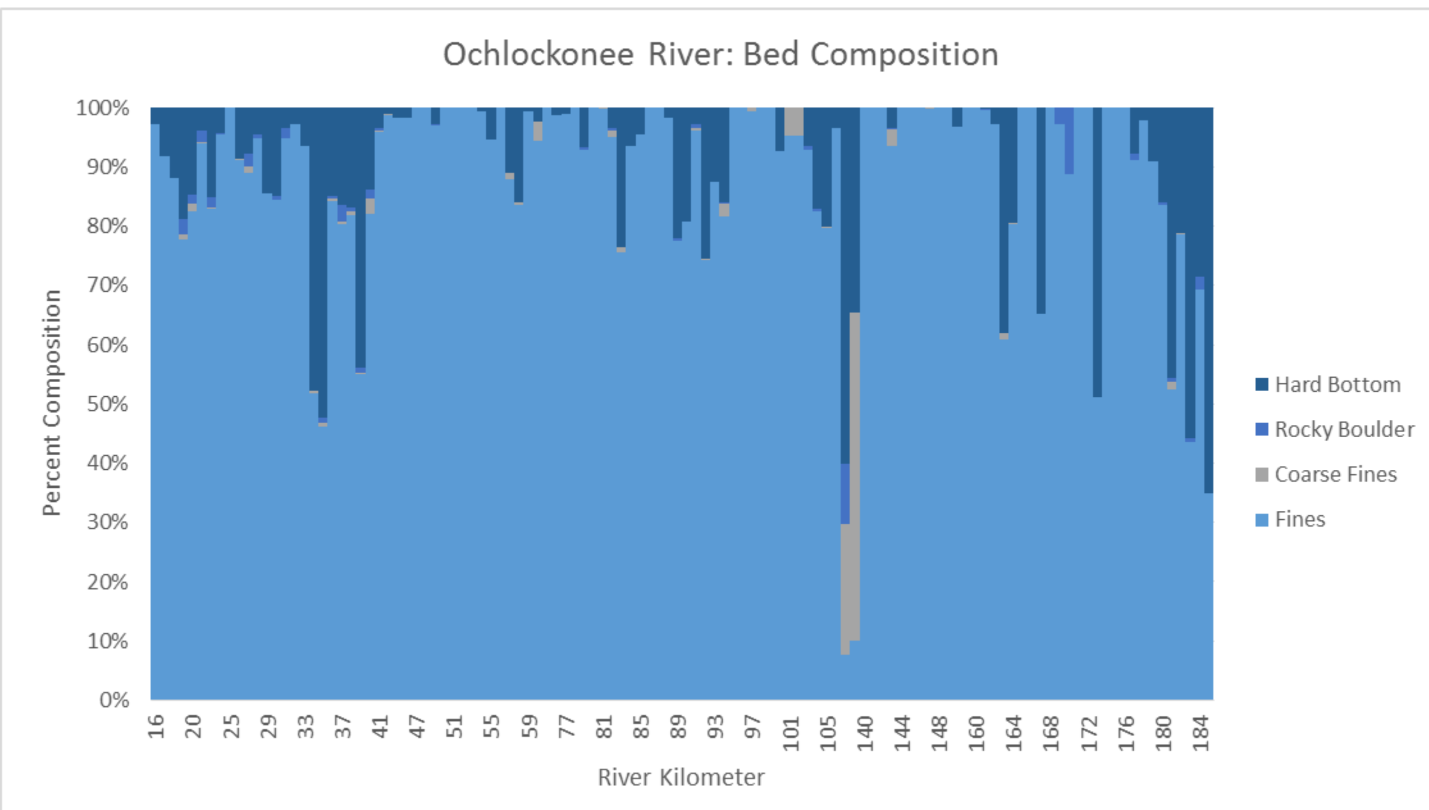


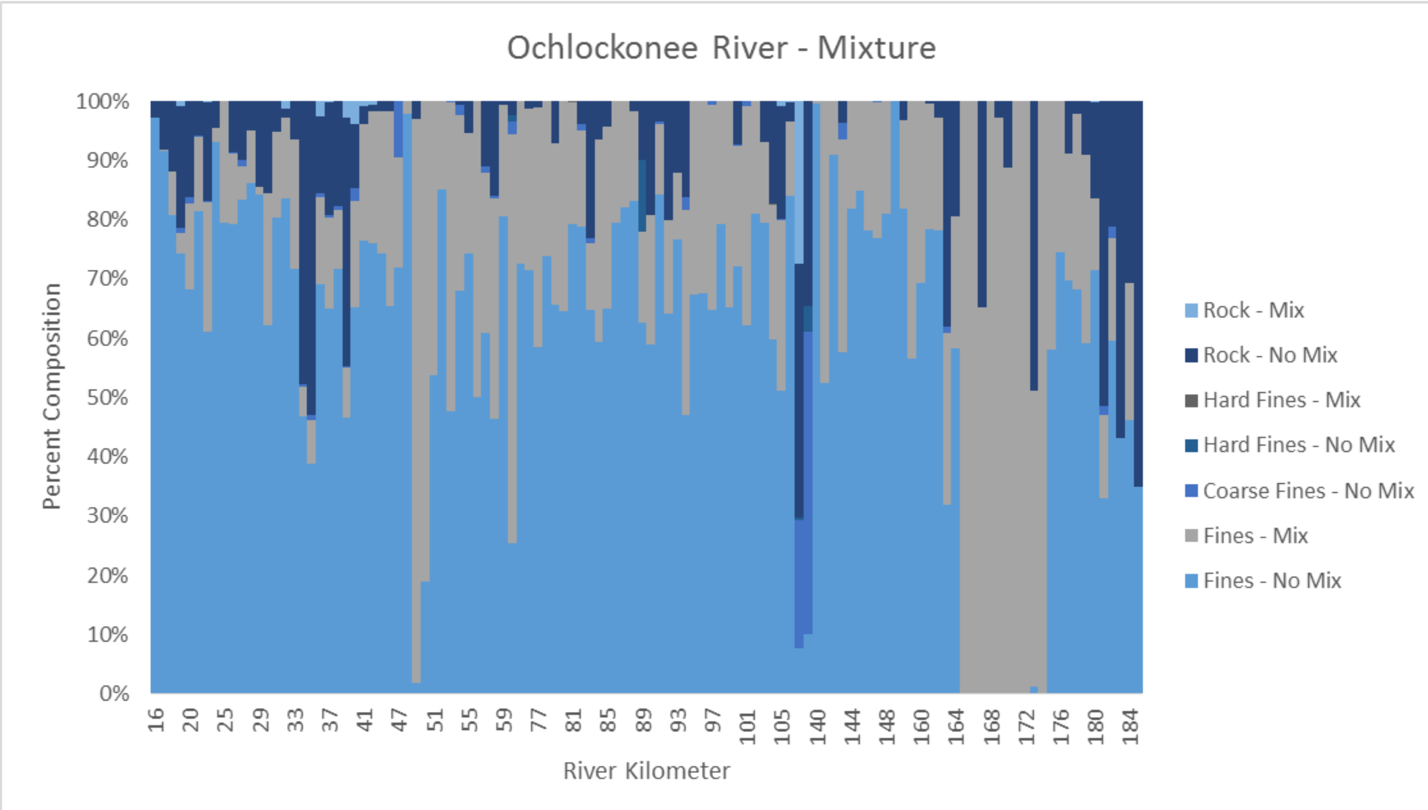
Choctawhatchee River: Mixture
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
6
11
16
21
26
31
36
41
46
57
62
67
72
77
82
87
92
97
102
107
112
117
122
127
132
137
142
147
River Kilometer
Rock - Mix
Rock - No Mix
Hard Fines - Mix
Hard Fines - No Mix
Coarse Fines - No Mix
Fines - Mix
Fines - No Mix

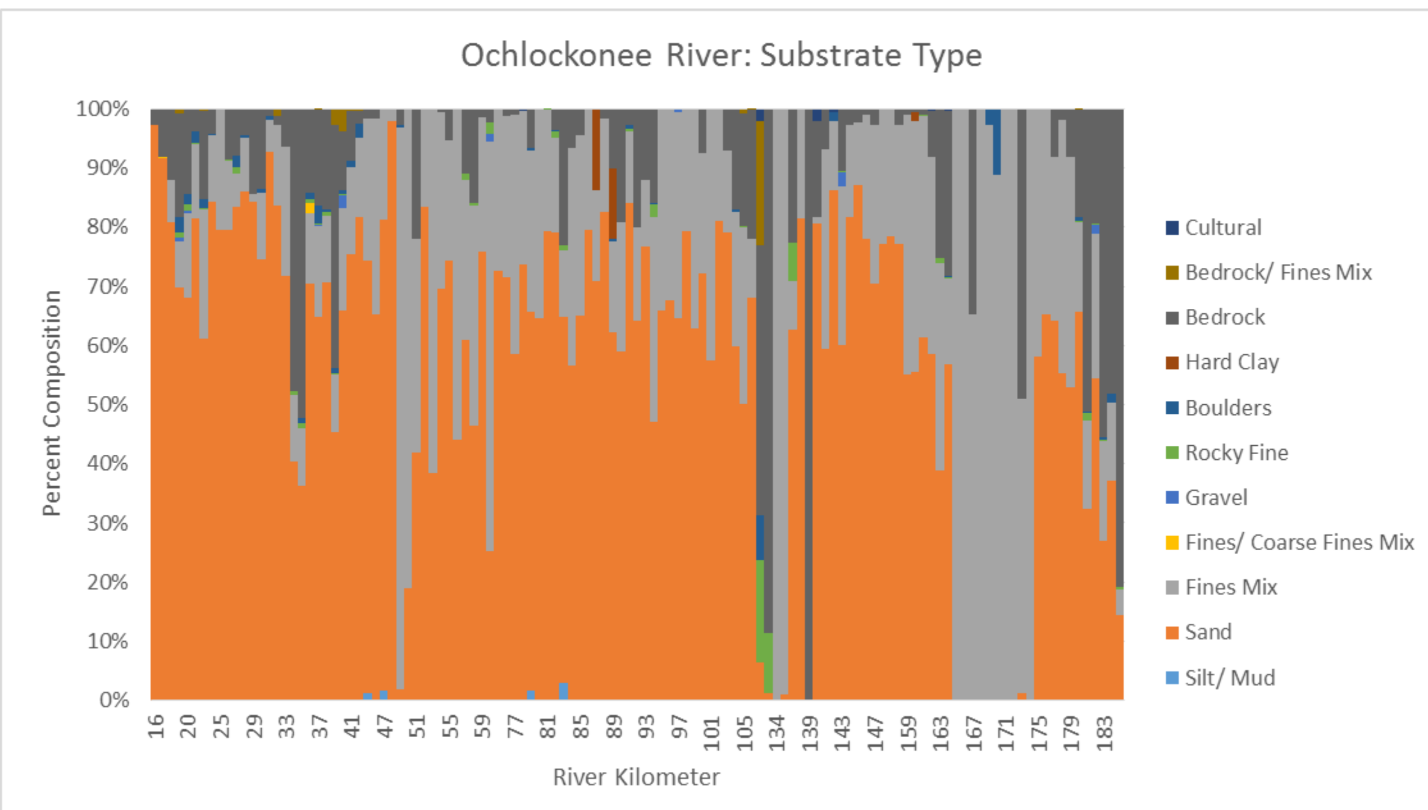


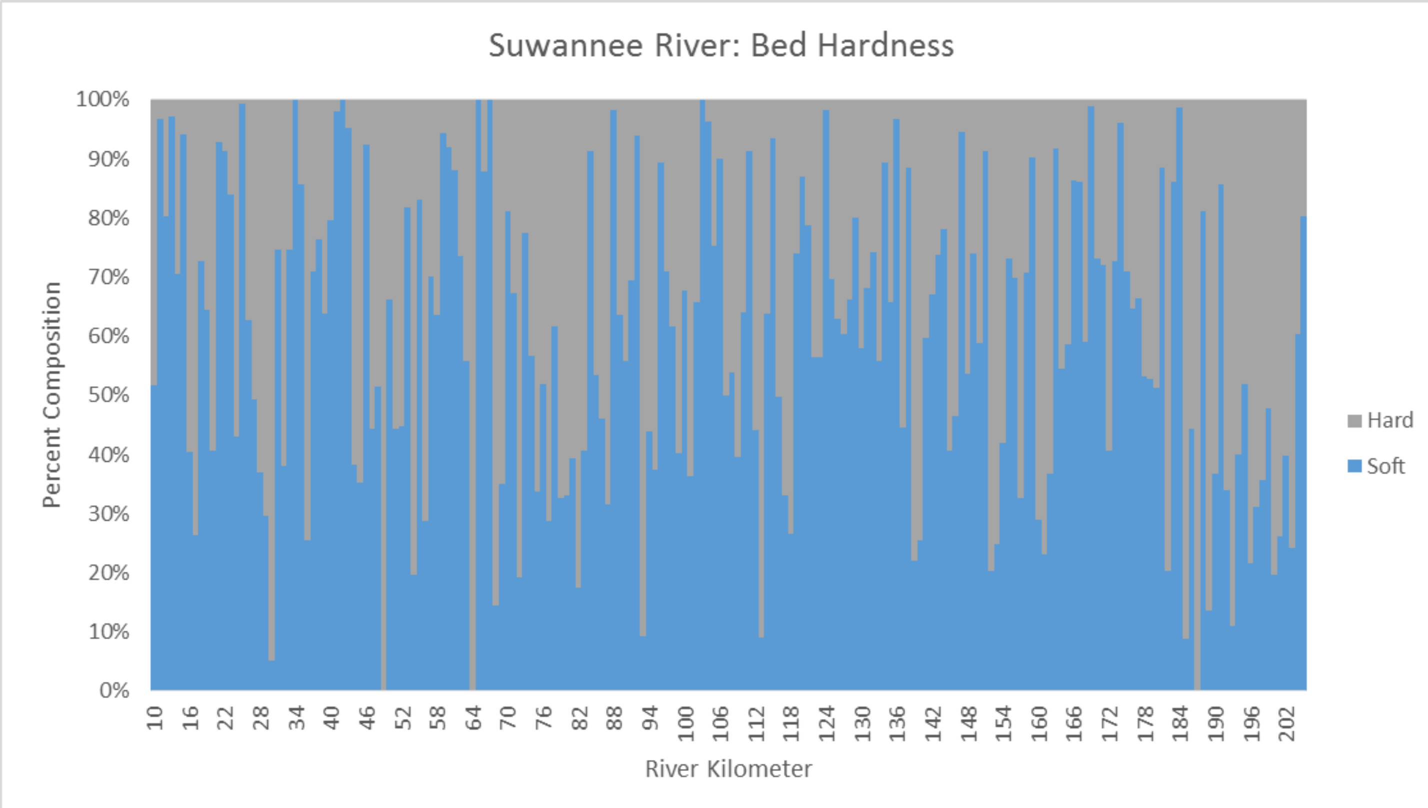
Choctawhatchee River: Substrate Type
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
6
11
16
21
26
31
36
41
46
57
62
67
72
77
82
87
92
97
102
107
112
117
122
127
132
137
142
147
River Kilometer
Cultural
Bedrock/ Coarse Fines Mix
Bedrock/ Fines Mix
Bedrock
Hard Clay/ Fines Mix
Hard Clay
Boulder
Rocky Fine
Gravel
Fines/ Coarse Fines Mix
Fines Mix
Sand
Silt/ Mud

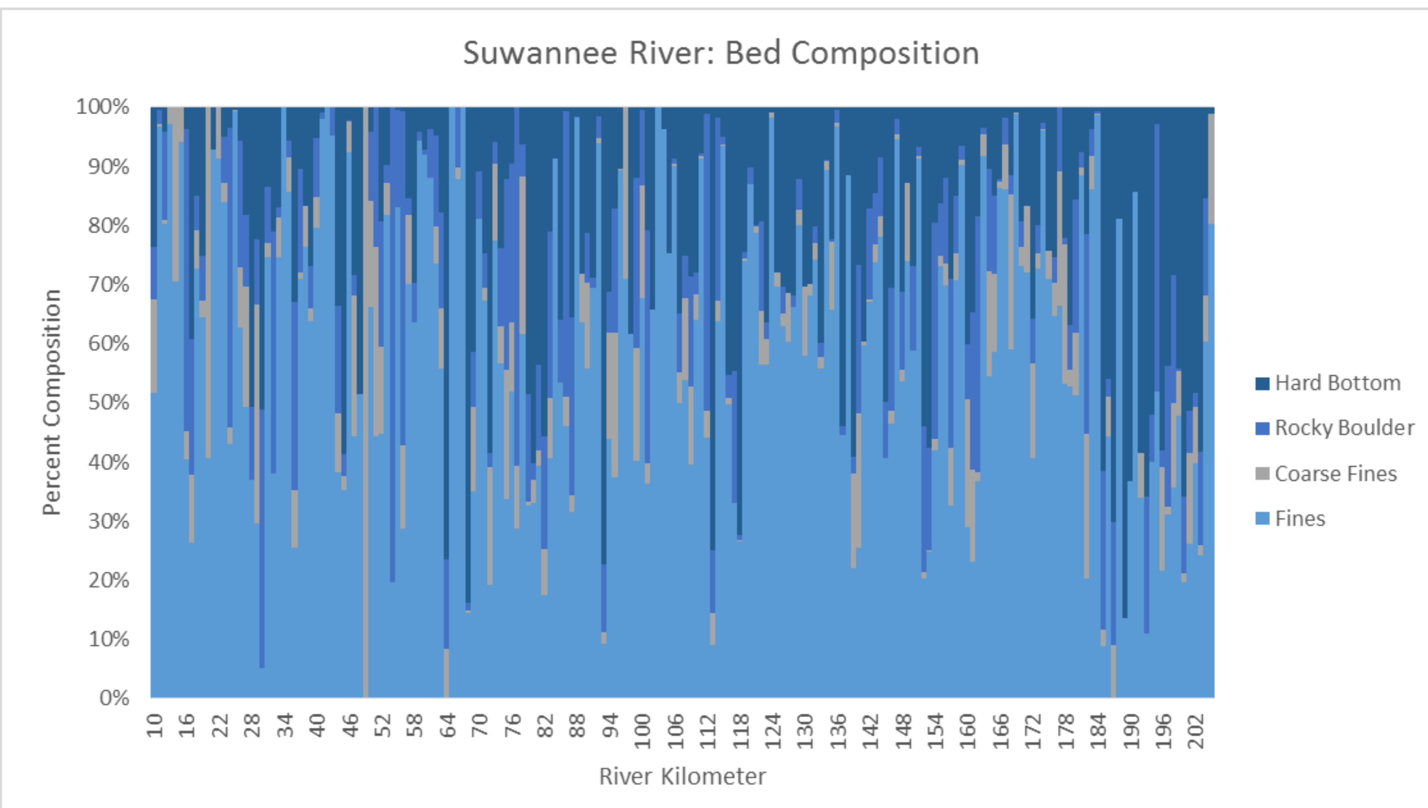

Ochlockonee River: Bed Hardness
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16 19 23 26 29 32 35 38 41 46 49 52 55 58 75 78 81 84 87 90 93 96 99 102 105 108 142 145 148 159 162 165 168 171 174 177 180 183
River Kilometer
Hard
Soft

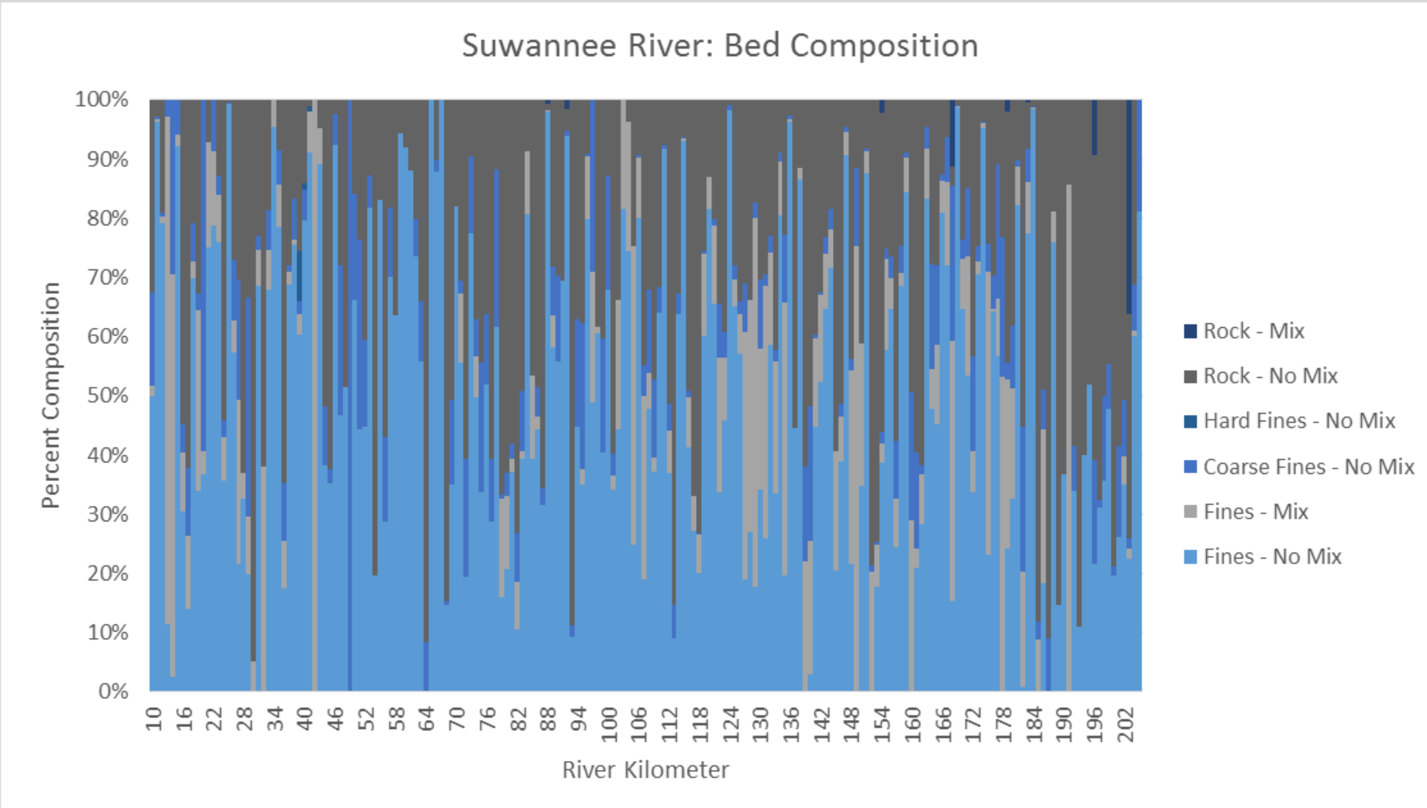

Ochlockonee River: Bed Composition
Percent Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16 20 25 29 33 37 41 47 51 55 59 77 81 85 89 93 97 101 105 140 144 148 160 164 168 172 176 180 184
River Kilometer
Hard Bottom
Rocky Boulder
Coarse Fines
Fines

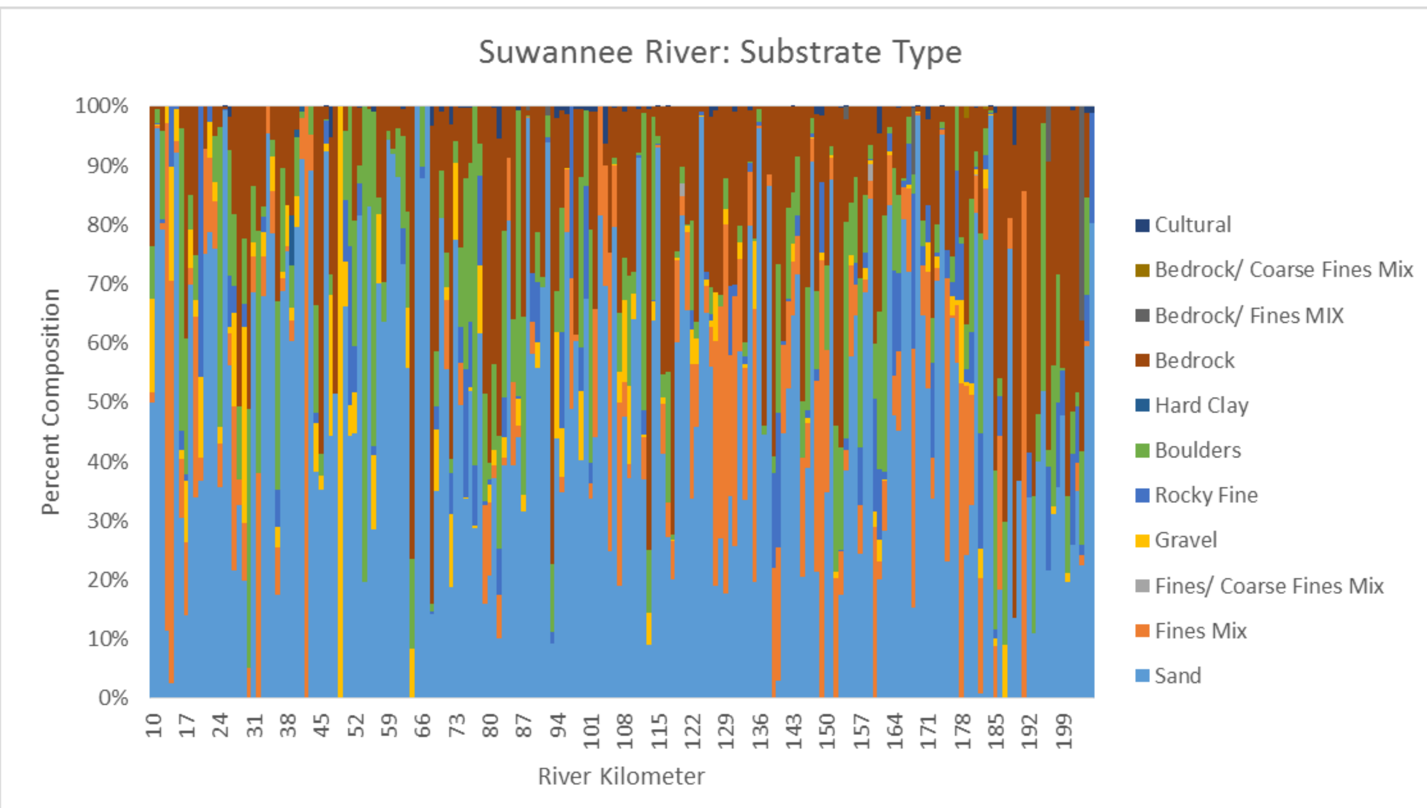

Ochlockonee River - Mixture
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
16
20
25
29
33
37
41
47
51
55
59
77
81
85
89
93
97
101
105
140
144
148
160
164
168
172
176
180
184
River Kilometer
Rock - Mix
Rock - No Mix
Hard Fines - Mix
Hard Fines - No Mix
Coarse Fines - No Mix
Fines - Mix
Fines - No Mix


Ochlockonee River: Substrate Type
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
16
20
25
29
33
37
41
47
51
55
59
77
81
85
89
93
97
101
105
134
139
143
147
159
163
167
171
175
179
183
River Kilometer
Cultural
Bedrock/ Fines Mix
Bedrock
Hard Clay
Boulders
Rocky Fine
Gravel
Fines/ Coarse Fines Mix
Fines Mix
Sand
Silt/ Mud


Suwannee River: Bed Hardness
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10
16
22
28
34
40
46
52
58
64
70
76
82
88
94
100
106
112
118
124
130
136
142
148
154
160
166
172
178
184
190
196
202
River Kilometer
Hard
Soft

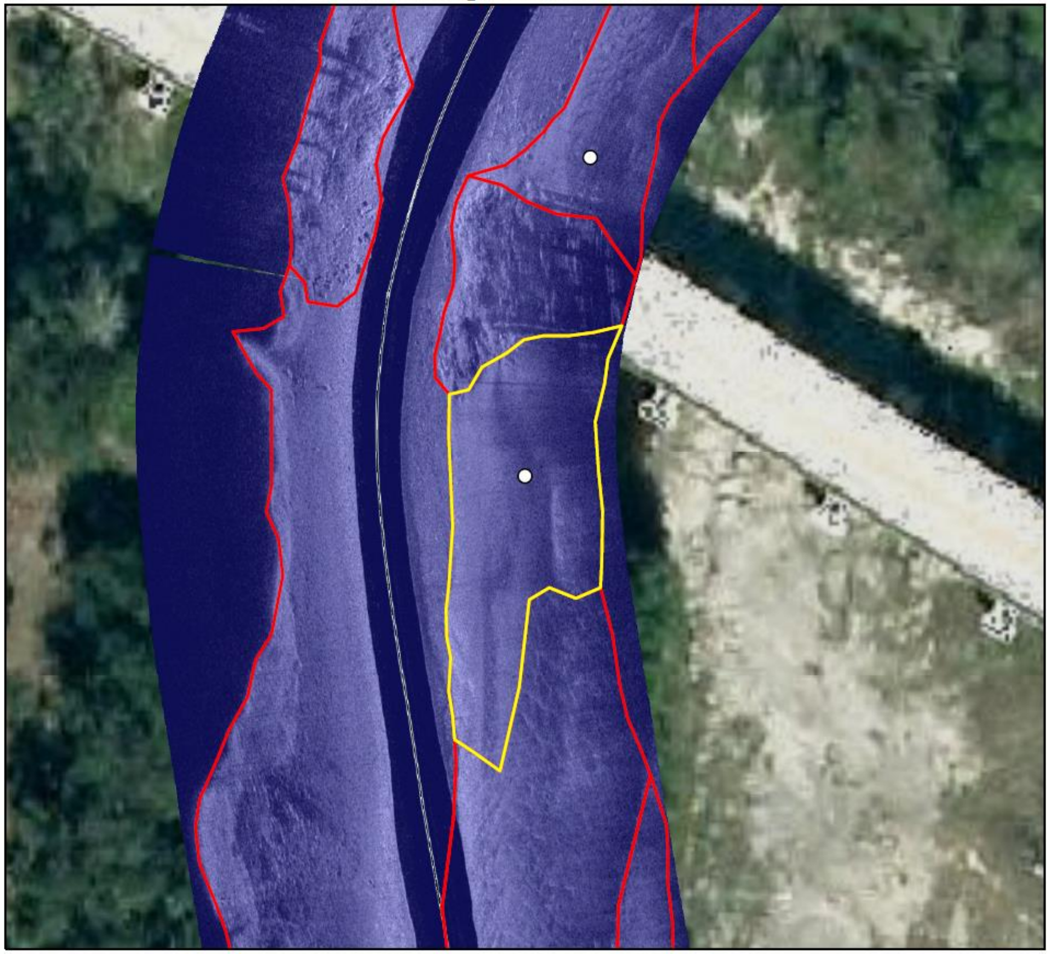

Suwannee River: Bed Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10
16
22
28
34
40
46
52
58
64
70
76
82
88
94
100
106
112
118
124
130
136
142
148
154
160
166
172
178
184
190
196
202
River Kilometer
Hard Bottom
Rocky Boulder
Coarse Fines
Fines


Suwannee River: Bed Composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10
16
22
28
34
40
46
52
58
64
70
76
82
88
94
100
106
112
118
124
130
136
142
148
154
160
166
172
178
184
190
196
202
River Kilometer
Rock - Mix
Rock - No Mix
Hard Fines - No Mix
Coarse Fines - No Mix
Fines - Mix
Fines - No Mix


Suwannee River: Substrate Type
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Composition
10
17
24
31
38
45
52
59
66
73
80
87
94
101
108
115
122
129
136
143
150
157
164
171
178
185
192
199
River Kilometer
Cultural
Bedrock/ Coarse Fines Mix
Bedrock/ Fines MIX
Bedrock
Hard Clay
Boulders
Rocky Fine
Gravel
Fines/ Coarse Fines Mix
Fines Mix
Sand

G) Peace River Accuracy Assessment Summary

Sample OID: 391



Field Notes

Mapped Classification

LVL I: 01 - Fines

LVL IV: 03 - Sand

Field Classification

LVL I: 01 - Fines

LVL IV: 03 - Sand

RKM: 61

Polygon Area: 278.881407 m2

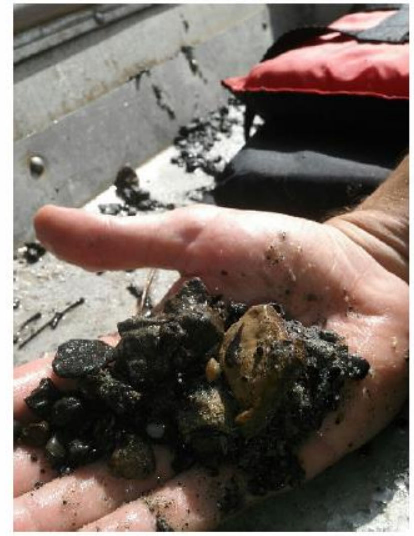
Lat: 27.302488

Lon: -81.846142

Sampled At:

2015-07-16 08:50:37 EDT

Sample OID: 770



Mapped Classification

LVL I: 01 - Fines

LVL IV: 04 - Gravel

Field Classification

LVL I: 01 - Fines

LVL IV: 04 - Gravel

RKM: 100

Polygon Area: 414.08778 m2

Lat: 27.509088

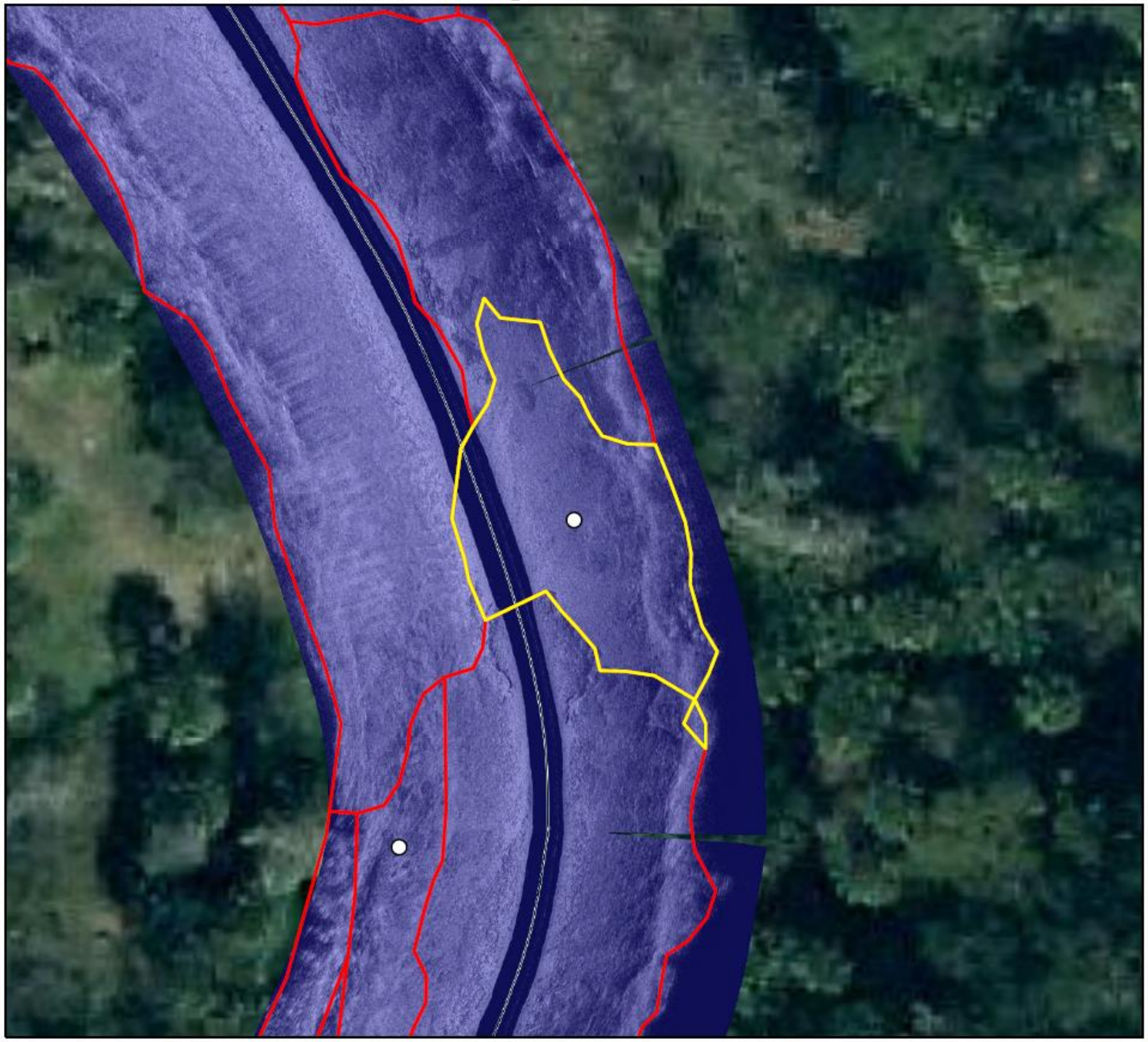
Lon: -81.796373

Sampled At:

2015-07-15 10:26:26 EDT

Field Notes

Sample OID: 752



Mapped Classification

LVL I: 02 - Rocky Fine

LVL IV: 22 - Rocky Fine

Field Classification

LVL I: 02 - Rocky Fine

LVL IV: 22 - Rocky Fine

RKM: 100

Polygon Area: 272.983087 m2

Lat: 27.506816

Lon: -81.796533

Sampled At:

2015-07-15 10:07:23 EDT

Field Notes

Gravel and rocky fine mix

Sample OID: 795

Mapped Classification

LVL I: 02 - Rocky Fine

LVL IV: 22 - Rocky Fine

Field Classification

LVL I: 02 - Rocky Fine

LVL IV: 22 - Rocky Fine

RKM: 101

Polygon Area: 1640.596417 m2

Lat: 27.512391

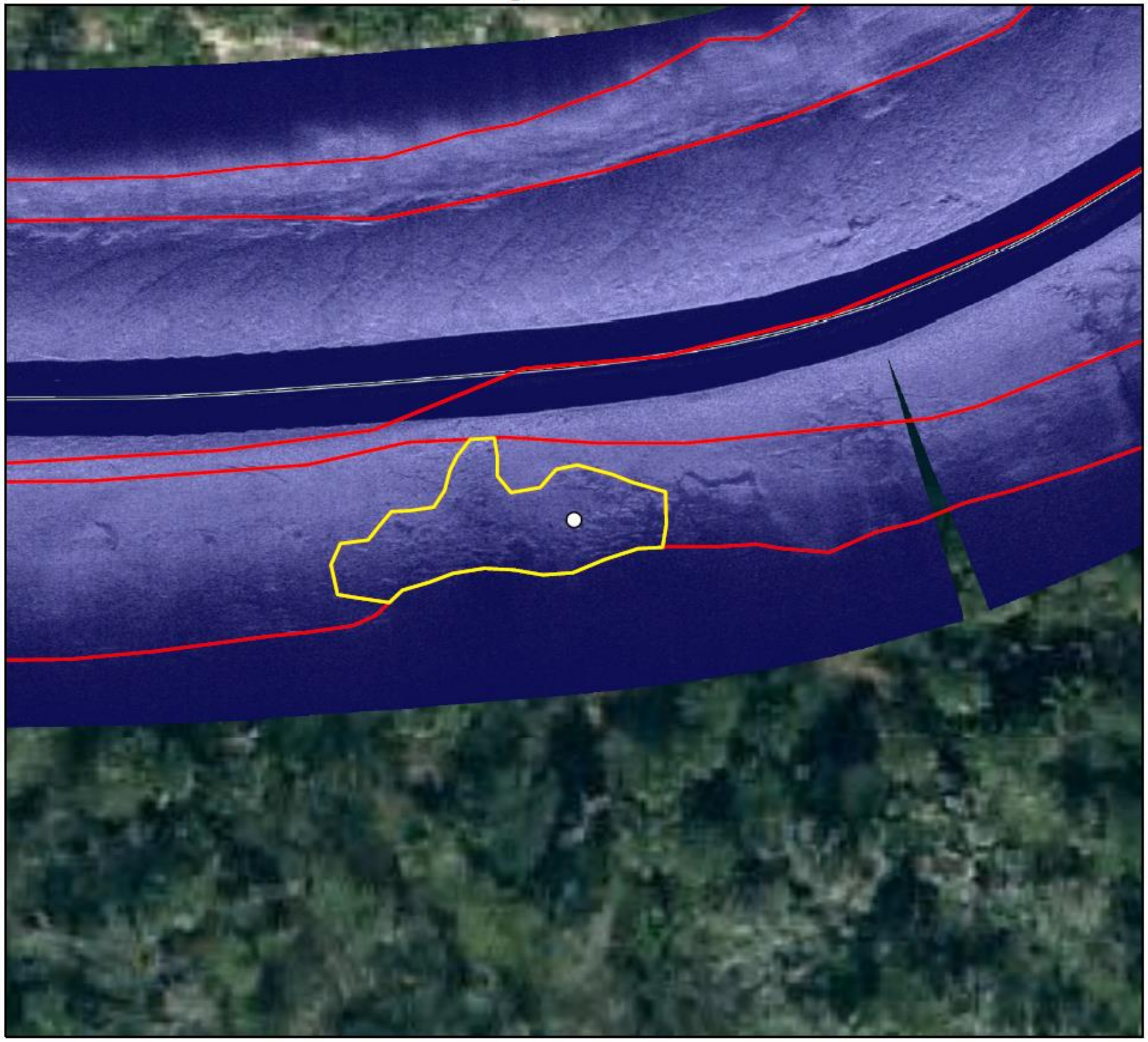
Lon: -81.793145

Sampled At:

2015-07-15 10:51:44 EDT

Field Notes

Sample OID: 2264



Mapped Classification

LVL I: 02 - Rocky Fine

LVL IV: 22 - Rocky Fine

Field Classification

LVL I: 03 - Rocky Boulder

LVL IV: 23 - Rocky Boulder

RKM: 38

Polygon Area: 137.375984 m2

Lat: 27.176064

Lon: -81.887005

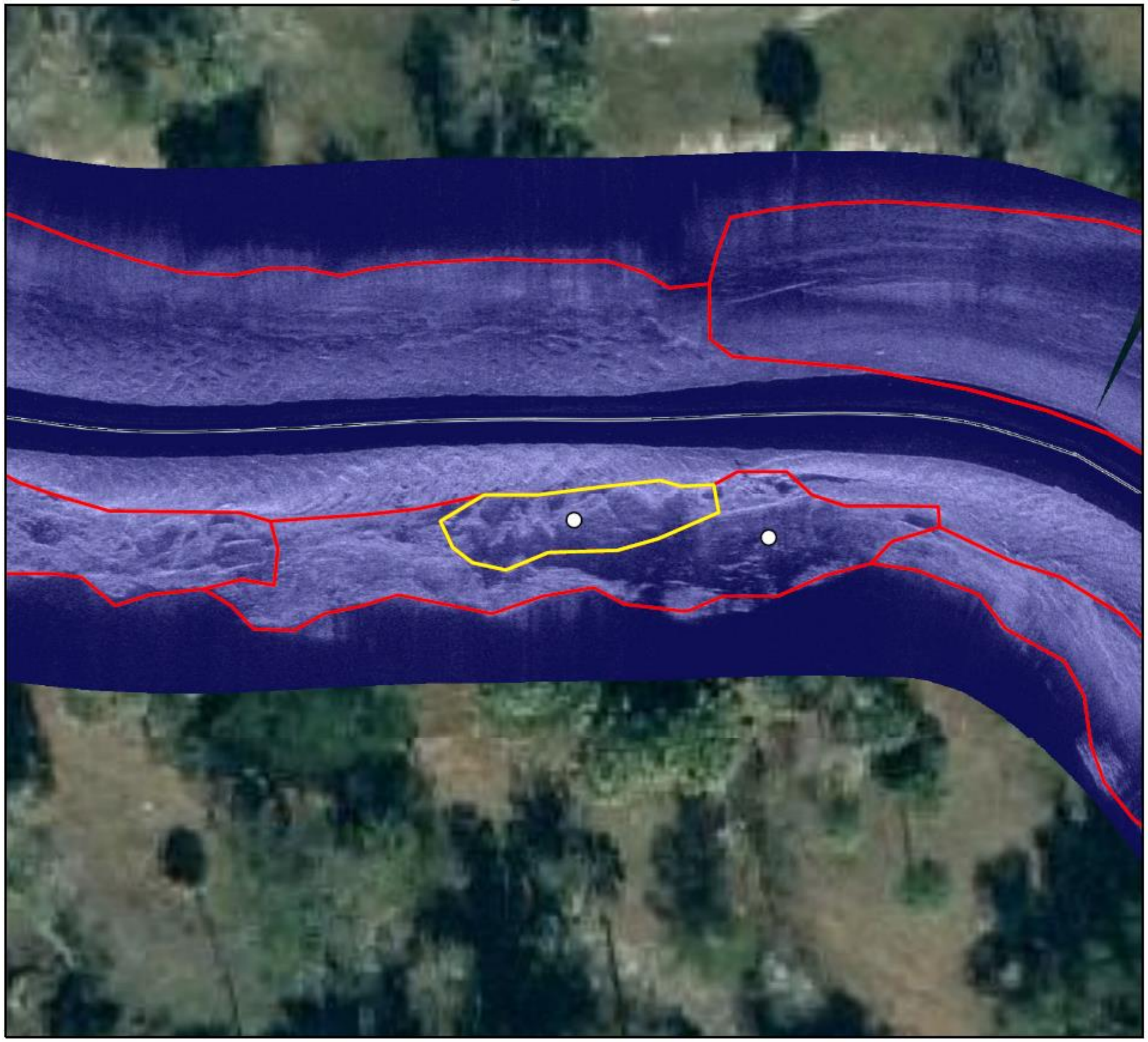
Sampled At:

2016-01-07 14:32:58 EST

Field Notes

Largely rocky fine, but has boulders. Boulders composed of very hard sand.

Sample OID: 1556



Mapped Classification

LVL I: 03 - Rocky Boulder

LVL IV: 23 - Rocky Boulder

Field Classification

LVL I: 03 - Rocky Boulder

LVL IV: 23 - Rocky Boulder

RKM: 73

Polygon Area: 75.264745 m2

Lat: 27.382727

Lon: -81.843274

Sampled At:

2015-07-16 11:51:11 EDT

Field Notes

H) Withlacoochee River Accuracy Assessment Summary

Sample OID: 711

Mapped Classification

LVL I: 01 - Fines

LVL IV: 01 - Silt/Mud

Field Classification

LVL I: 01 - Fines

LVL IV: 01 - Silt/Mud

RKM: 45

Polygon Area: 399.529107348 m2

Lat: 29.0155

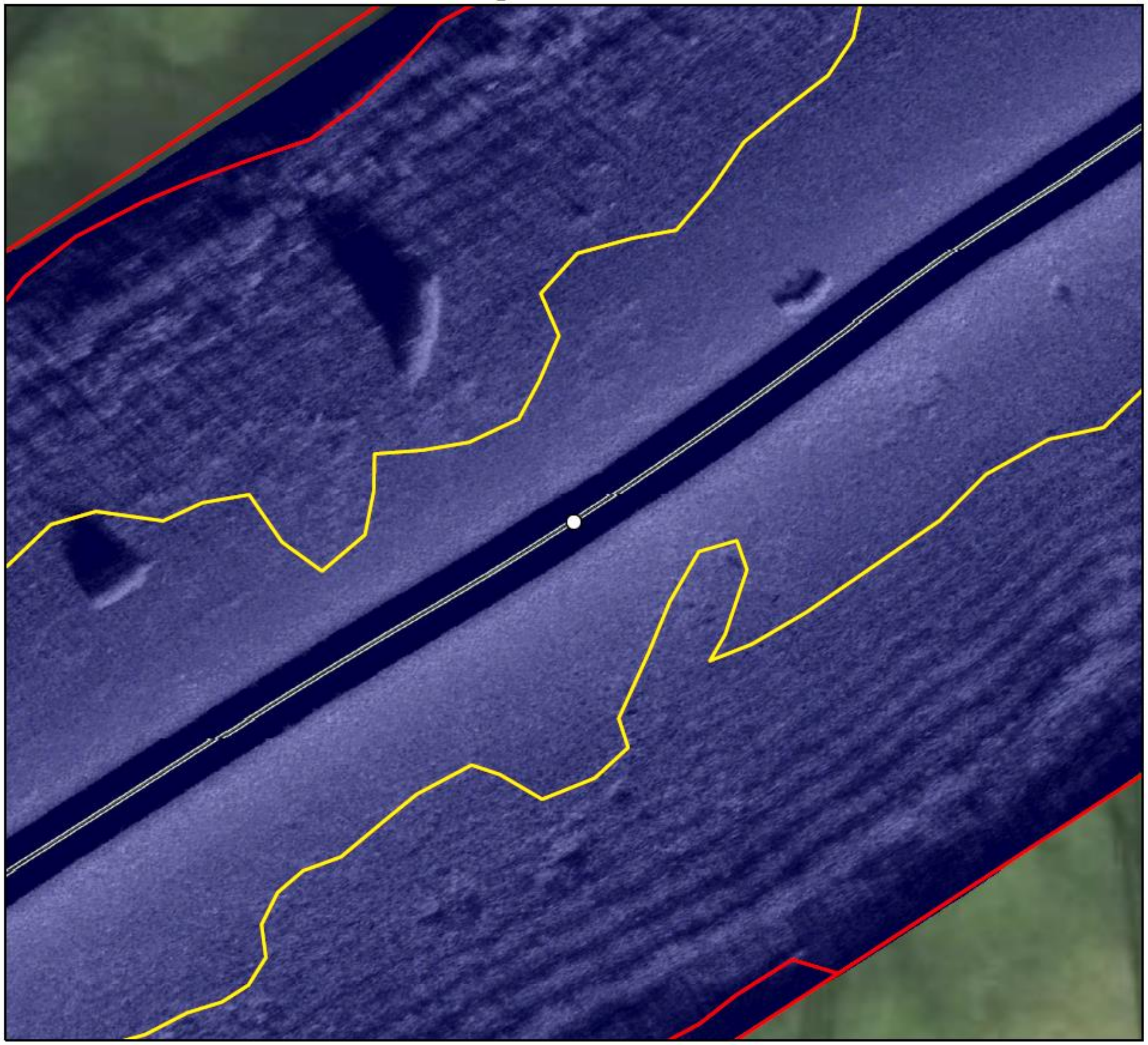
Lon: -82.420252

Sampled At:

2016-04-12 13:54:26 EDT

Notes

Sample OID: 1024



Notes

Muck extremely soft

Mapped Classification

LVL I: 01 - Fines

LVL IV: 02 - Sand

Field Classification

LVL I: 01 - Fines

LVL IV: 01 - Silt/Mud

RKM: 101

Polygon Area: 75345.717974 m2

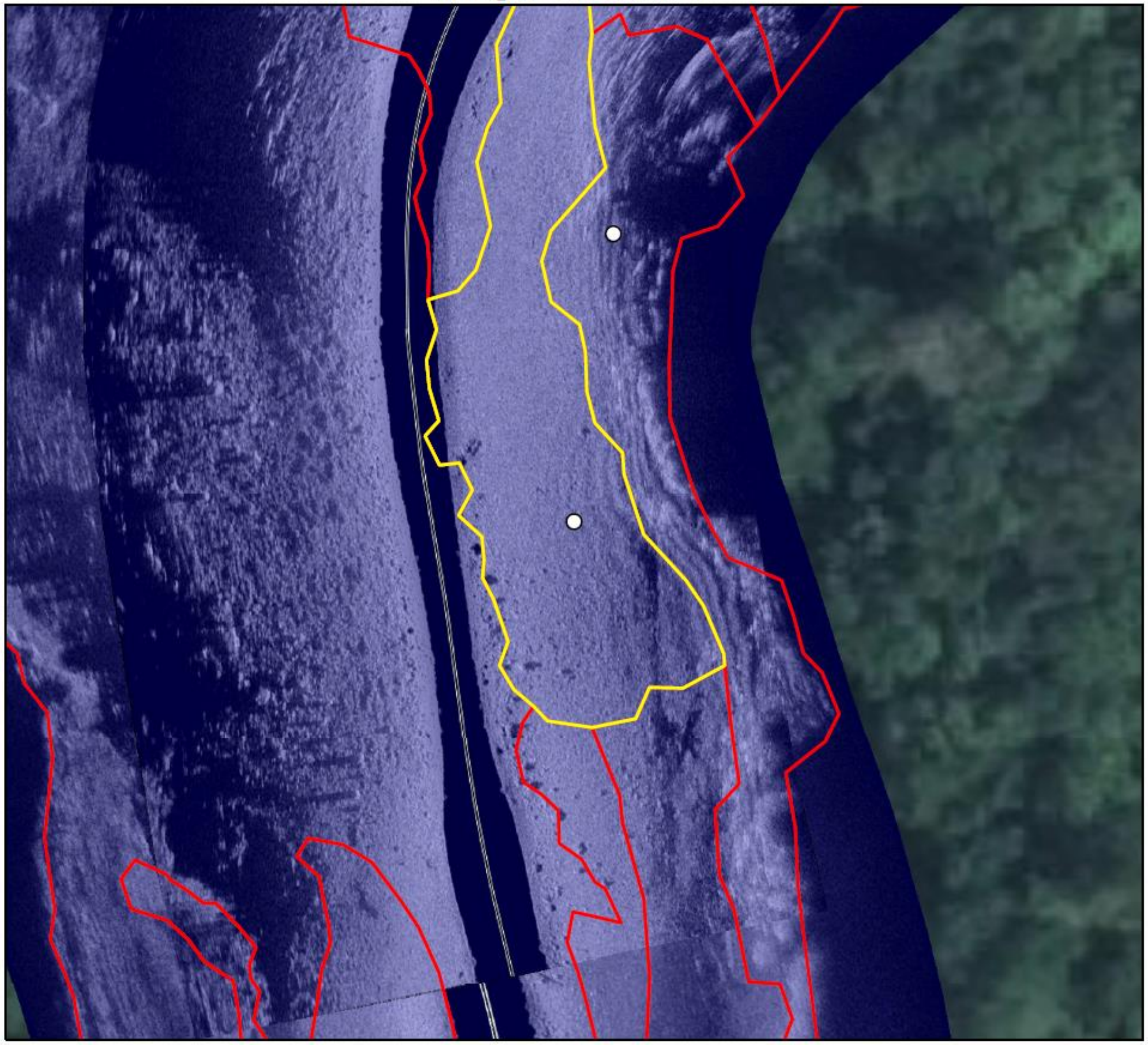
Lat: 28.733714

Lon: -82.233769

Sampled At:

2016-04-04 10:30:31 EDT

Sample OID: 1195



Notes

Lots of leaves over sand

Mapped Classification

LVL I: 01 - Fines

LVL IV: 02 - Sand

Field Classification

LVL I: 02 - Coarse Fines

LVL IV: 09 - Rocky Fine

RKM: 46

Polygon Area: 428.14575884 m2

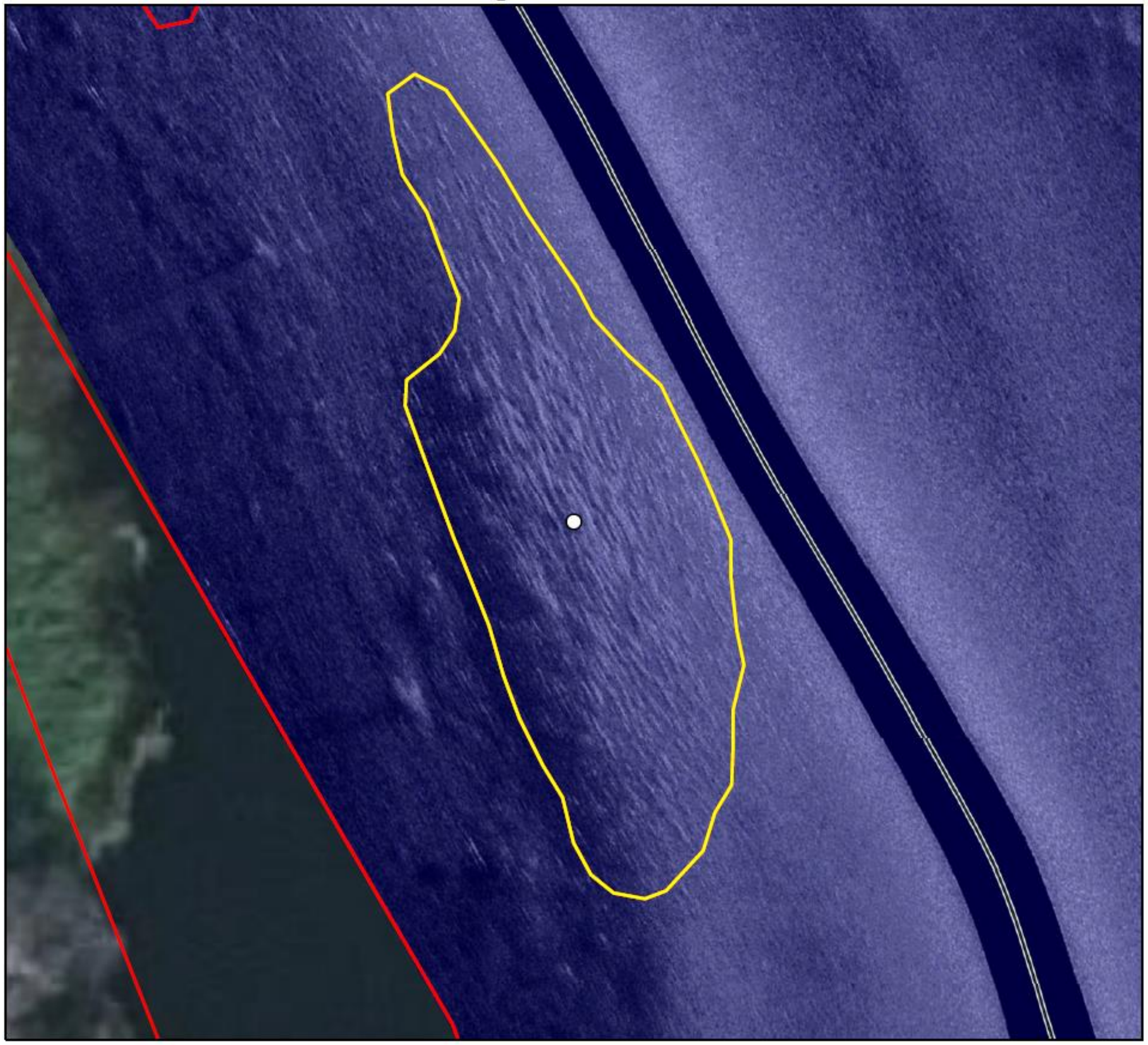
Lat: 29.016199

Lon: -82.409287

Sampled At:

2016-04-12 12:34:25 EDT

Sample OID: 1278



Notes

Mapped Classification

LVL I: 01 - Fines

LVL IV: 02 - Sand

Field Classification

LVL I: 01 - Fines

LVL IV: 02 - Sand

RKM: 67

Polygon Area: 632.773649426 m2

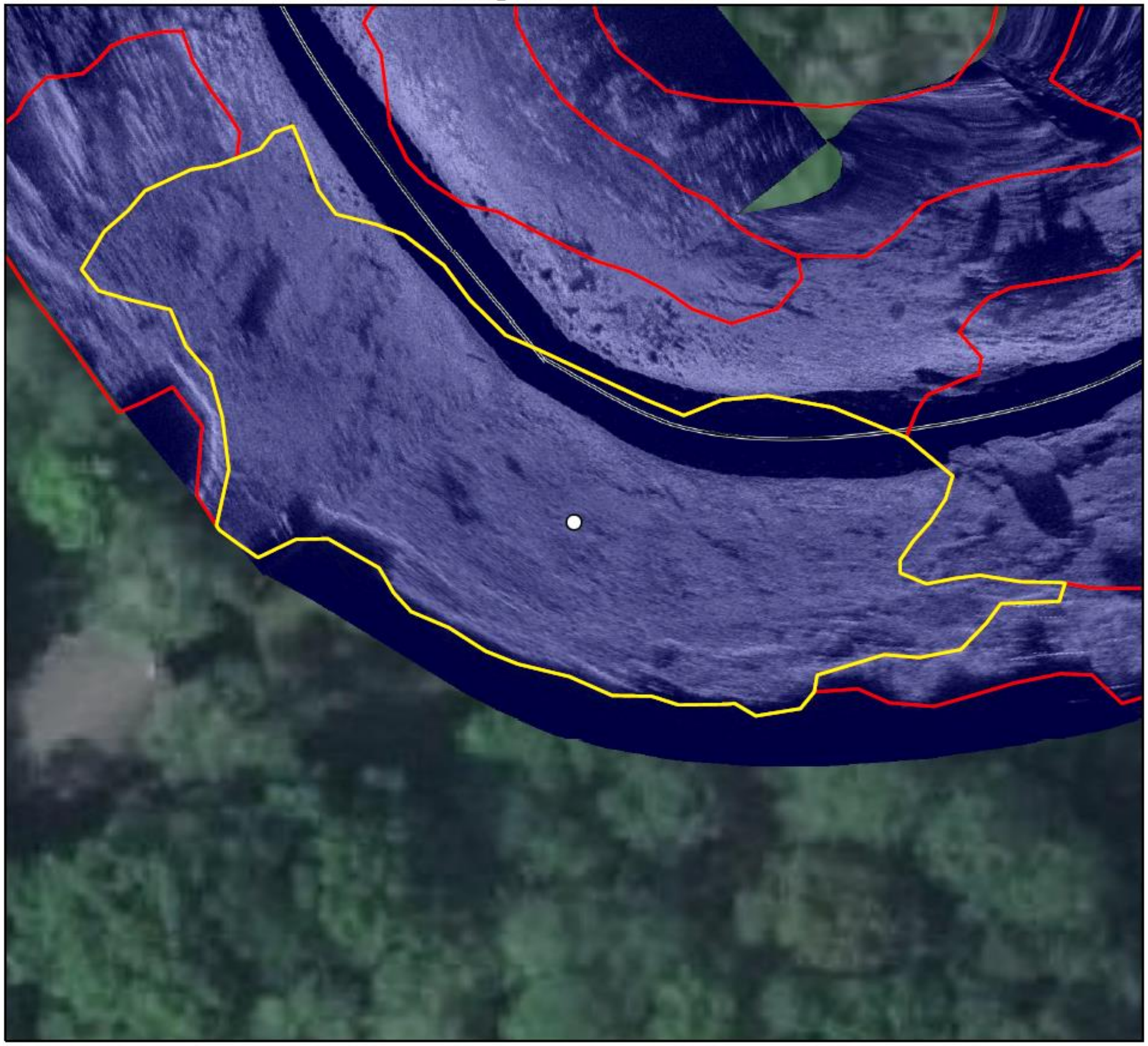
Lat: 28.931868

Lon: -82.288558

Sampled At:

2016-04-13 10:51:47 EDT

Sample OID: 5188



Mapped Classification

LVL I: 04 - Hard Bottom

LVL IV: 12 - Bedrock/ Fines Mix

Field Classification

LVL I: 04 - Hard Bottom

LVL IV: 11 - Bedrock

RKM: 58

Polygon Area: 1049.68644082 m2

Lat: 28.981372

Lon: -82.334022

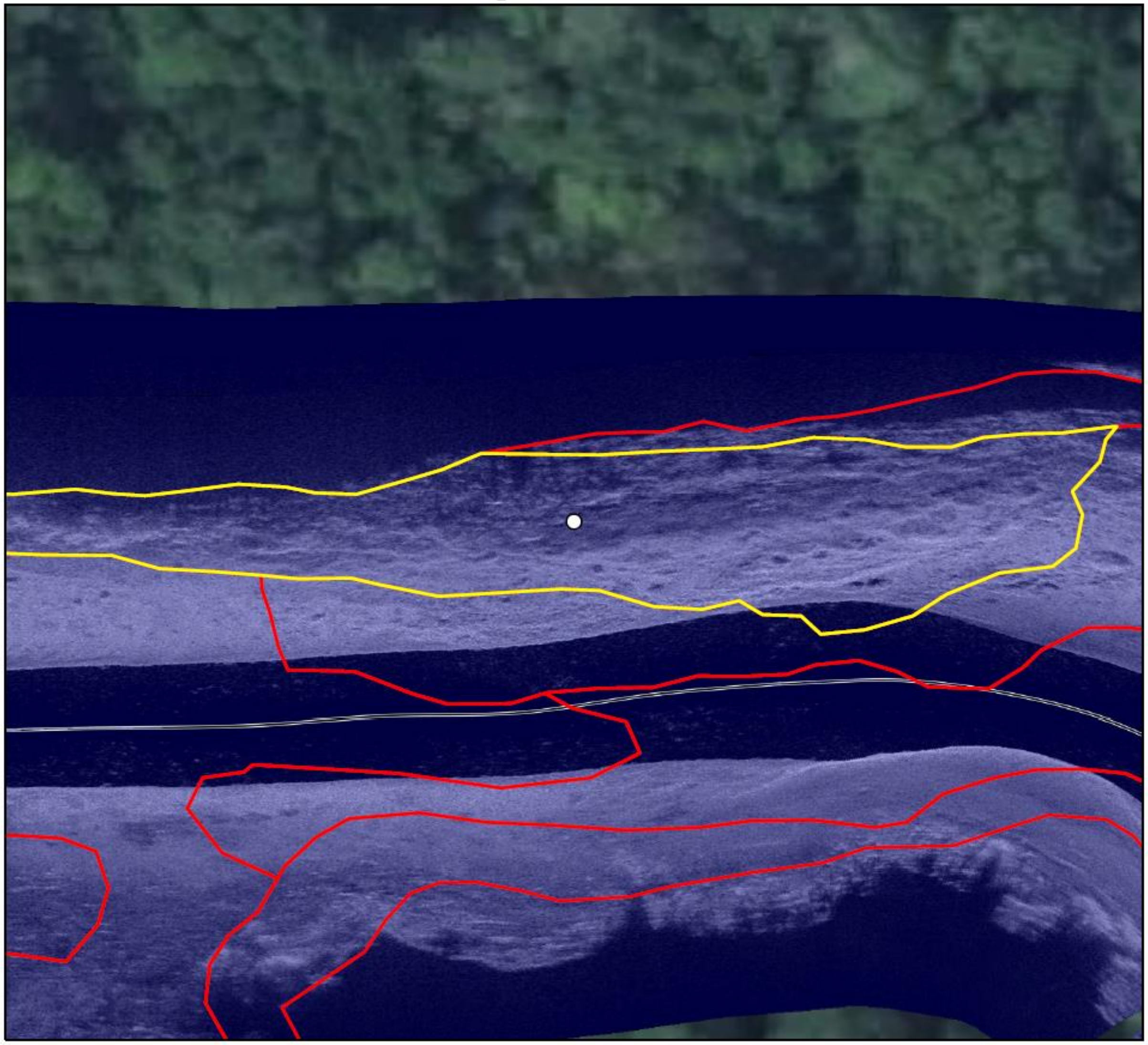
Sampled At:

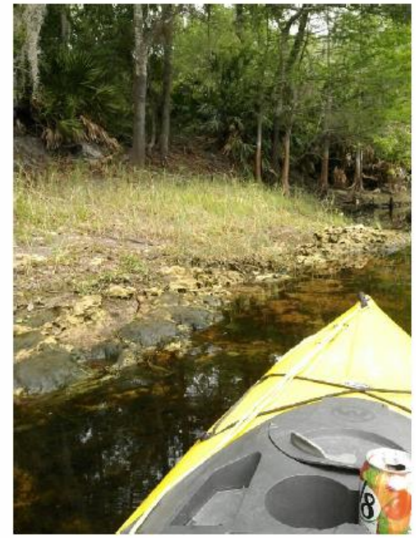
2016-04-13 14:32:37 EDT

Notes

Two distinct boulder patches on bank, scattered rf

Sample OID: 5099





Mapped Classification

LVL I: 04 - Hard Bottom

LVL IV: 11 - Bedrock

Field Classification

LVL I: 04 - Hard Bottom

LVL IV: 11 - Bedrock

RKM: 56

Polygon Area: 886.093385939 m2

Lat: 28.991466

Lon: -82.352827

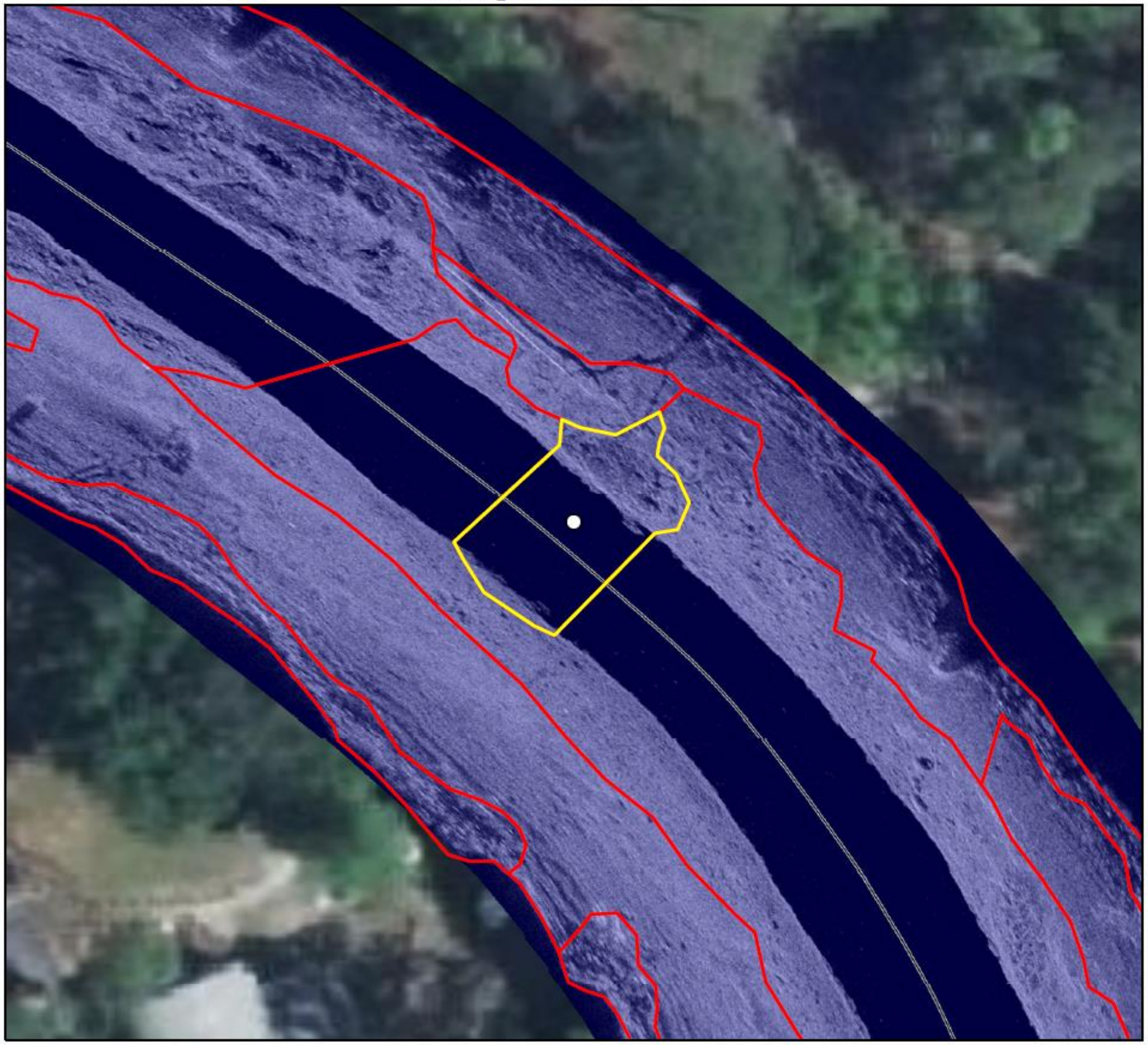
Sampled At:

2016-04-13 15:15:37 EDT

Notes

Shelf. Bumpy.

Sample OID: 5038



Notes

Br surrounded, small amount of fines

Mapped Classification

LVL I: 04 - Hard Bottom

LVL IV: 11 - Bedrock

Field Classification

LVL I: 03 - Rocky Boulder

LVL IV: 10 - Boulders

RKM: 52

Polygon Area: 120.508140402 m2

Lat: 29.004926

Lon: -82.378156

Sampled At:

2016-04-12 09:34:30 EDT