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Attoyac Bayou GIS Inventory, Source Survey and Land Use Cover Report

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Attoyac Bayou GIS Inventory, Source Survey and Land Use Land Cover Report

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Investigating Entities:
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List of Acronyms

ANRA	Angelina Neches River Authority
CES	Castilaw Environmental Services, LLC
DETCOG	Deep East Texas Council of Governments
ESRI	Environmental Systems Research Institute
ETCOG	East Texas Council of Governments
FEMA	Federal Emergency Management Agency
GIS	geographic information system
HUC	hydrologic unit code
LULC	land use land cover
NAIP	National Agricultural Imagery Program
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Landcover Dataset
NRCS	U.S. Dept. of Agriculture – Natural Resources Conservation Service
RRC	Railroad Commission of Texas
RUAA	recreational use attainability analysis
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSURGO	Soil Survey Geographic
STATSGO	State Soil Survey Geographic
SFASU	Stephen F. Austin State University
TCEQ	Texas Commission on Environmental Quality
TWDB	Texas Water Development Board
USDOT	U.S. Dept. of Transportation
USGS	U.S. Geological Survey
WWTF	Wastewater Treatment Facility

Introduction

The Attoyac Bayou watershed is part of the larger Neches River Basin and covers 354,629 acres in Nacogdoches, Rusk, San Augustine and Shelby counties. The Attoyac Bayou flows into Sam Rayburn Reservoir south of FM 103. The Attoyac Bayou originates north of US 84 in Rusk County, and flows into Nacogdoches County, south into San Augustine County, and ending in Shelby County.

The Attoyac Bayou watershed is one of many rural watersheds included in the *Texas Water Quality Inventory and 303(d) List* as an impaired water body due to excessive *E. coli* levels. In many cases the assessed data in these waterbodies is limited and information regarding potential sources of pollution or other factors that may influence the presence of pollutant sources is not readily available.

To address this need, a comprehensive geographic information system (GIS) inventory of the watershed will be developed and will integrate numerous existing information resources into a single location. Generally, the GIS will illustrate waterbodies, roadways, permitted point-source dischargers, and other points of concern. Additionally, current land use/land cover (LULC) maps for the watershed will be updated. Existing LULC layers will be utilized as a starting point and will be re-delineated utilizing ground-truthed data points collected for the GIS inventory to verify the accuracy of the LULC map. Through the development of the GIS and update of the LULC maps, a physical source survey will also be conducted across the watershed to document the primary sources of bacteria in the watershed.

GIS Development Approach

In order to increase the availability of spatial information and to aid in an improved understanding of the watershed and its features, Castilaw Environmental Services, LLC (CES) personnel identified, located and aggregated available data into a watershed specific GIS. Initially, the intent was to include the most recent information on land use, elevation, soils, stream networks, reservoirs, roads, municipalities and satellite imagery or aerial photography. Locations of SWQM stations, USGS gages, public access points to the waterbodies, floodwater-retarding structures, wetlands, TPDES permittees (including WWTFs, CAFOs and MS4s), and subdivisions should also be included. Table 1 includes a brief data description, the use of the data as well as the source of the data acquired and aggregated.

Table 1. Data aggregated into the watershed GIS, its uses and sources

Data Description	Use	Source
911 Address Structure Points	Determine location and density of structures within the watershed	ETCOG & DETCOG
Attoyac Water Quality Monitoring Stations	Document locations of water quality monitoring stations	TCEQ & SFASU
Confined Animal Feeding Operations in Texas	Determine location of CAFO's as potential source of pollution (none in watershed).	TCEQ
GPS points from LULC field verification	Determine accuracy of LULC data.	CES Personnel
Locations of fecal samples collected in watershed	Document the amount and distribution of fecal samples	Project Partners
Locations of Steering Committee Member Location	Document the distribution of steering committee members to ensure adequate representation	CES
Municipal solid waste sites in Texas	Determine location of Municipal solid waste sites in watershed	TCEQ
Water control structures within watershed	Assist identifying larger impoundments in the watershed	NRCS
Poultry house locations	Determine the number and density of poultry houses in watershed	Delineated by CES from 2009 aerial imagery
RUAA sampling locations	RUAA sampling locations used to field sample Attoyac Bayou and Tributaries to determine recreational uses	SFASU
State Water Quality Monitoring Stations	Document TCEQ's existing monitoring stations	TCEQ
Superfund sites for state of Texas	Determine location of superfund sites as potential source of pollution (none in watershed).	TCEQ
Permitted Industrial & Hazardous Waste Sites	Determine location of industrial and hazardous waste sites as potential source of pollution (none in watershed).	TCEQ
Waste Water Treatment Plants	Determine locations of waste water treatment plants as potential source of pollution	TCEQ

Data Description	Use	Source
Oil & Natural Gas Wells	Document location and density of oil and natural gas wells as potential source of pollution	RRC of Texas
Bridge locations from National Bridge Inventory	Document potential source of pollution. Bridges can be home to high concentrations of birds and bats	USDOT
Water Wells	Characterize Watershed	TWDB
Detailed streets and highways	General map layer	ESRI
Named Streams	General may layer	ESRI
National Hydrography Dataset	Used for specific attributes of streams	USGS
Attoyac Watershed Boundary	Area of interest for entire project	Multiple Sources
Aquifers (Major & Minor)	Characterize watershed	TWDB
Landuse/Landcover	Characterize watershed and identification of potential problem areas	CES digitized from 2008 leaf-off imagery
2010 Census data	Determine population characteristics	US Census Bureau
City Boundaries	General map layer	ESRI
County Boundaries	General map layer	ESRI
100-Year Floodzones	Used in delineating LULC classes as well as characterizing watershed	FEMA
Geologic Data	Characterize watershed	Texas Bureau of Economic Geology

Data Description	Use	Source
Texas Precipitation Data	Characterize watershed	TWDB
Soils by county (SSURGO)	Characterize watershed (large scale) and identified potential problem areas	NRCS
General soils (STATSGO)	Characterize watershed (small scale)	NRCS
10-Meter National Elevation Dataset (NED) mosaic of watershed	Characterize watershed, base for deriving other land features such as slope, identification of potential problem areas	USGS
2004 CIR aerial imagery	Secondary imagery source during LULC delineation	NAIP
2008 leaf-off aerial imagery	Primary imagery source during LULC delineation	NAIP
US Hillshade	General map layer	ESRI
National landcover dataset	Verification of delineated LULC dataset	USGS
Topographic maps (24K)	General map layer and characterizing watershed.	USGS

GIS data were used to make maps illustrating the extent and distribution of representative data within the watershed. These served as informative tools for watershed stakeholders. GIS data was also utilized in several other aspects of the project. GIS data utilized in the Spatially Explicit Load enrichment Calculation Tool or the SELECT model (Borel et al. 2012) included soils, topography, LULC, hydrology, and the watershed boundary. The recreational use attainability analysis (RUAA) also utilized GIS information gathered to aid in determining survey locations and to assess LULC around survey sites (Fuller et al. 2012). Ultimately, GIS information and maps produced aided in prioritizing recommended management measures included in the Attoyac Bayou WPP. With the exception of several maps larger than the watershed area, all maps included in the Attoyac Bayou WPP were developed from this GIS.

Watershed Source Survey

A watershed source survey was by the project team to identify potential sources of bacteria contributions in the watershed. The CES team as well as Angelina & Neches River Authority staff and Stephen F. Austin State University students and faculty involved in the project contributed heavily to this effort. Observations made during trips to the watershed were noted and included as potential sources of bacteria in the watershed and are listed in Table 2.

Table 2. Source category, cause and deposition method for potential bacteria sources

Category	Cause	Deposition Method
Residential OSSFs	Improperly functioning or non-existent OSSFs releasing improperly treated wastewater to watershed	Direct and Indirect
Pets	Pets deposit fecal matter to the land surface which is washed into water bodies during runoff events.	Indirect
Livestock	Livestock manure directly deposited into water body and/or washed into water body during runoff events.	Direct and Indirect
Poultry	Poultry litter deposited on land application fields and washed into water body during runoff events.	Indirect
WWTFs	Potential maintenance issues and flow exceedances during runoff events causing improperly treated wastewater to be discharged into water body.	Direct
Oil & Gas OSSFs	Improperly functioning or non-existent OSSFs releasing improperly treated wastewater into water bodies. Potential for issues is generally most common during construction and drilling activities only.	Direct and Indirect
Wildlife and Feral Animals	Both wildlife and feral animals depositing fecal matter directly into water-bodies or washed into water body during runoff events.	Direct and Indirect
Illegal Dumping	Illegal dumping of household waste as well as animal carcasses releasing *E. coli* directly into water bodies, and washed into a water body during runoff events.	Direct and Indirect

Land Use and Land Cover Map Update

The LULC assessment for the Attoyac Bayou watershed was created and analyzed by CES using Environmental Systems Research Institute's (ESRI) ArcGIS 9.3 & 10.0 with Spatial Analyst Extension. Watershed LULC was classified using heads-up digitization methods that required an operator to manually delineate significantly different cover types. Cover types were adapted from the National Land Cover Dataset (NLCD) to provide standard definitions that were modified to provide more project specific definitions. Project specific cover type definitions are:

Open Water (11) – All areas of open water, generally with less than 25% cover of vegetation or soil.

Developed (Open Space) (21) – Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed (Low Intensity) (22) – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of the total cover. These areas most commonly include single-family housing units.

Developed (Medium Intensity) (23) – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.

Developed (High Intensity) (24) – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80-100% of the total cover.

Barren Land (31) – (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover and includes transitional areas.

Forested Land (41) – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover.

Pine Plantation (42) – Areas of land dominated by pine trees that have been planted to artificially reforest an area for the purpose of timber production; trees are generally planted in an evenly spaced, systematic manner that is easily distinguishable from native tree stands.

Mixed Forest (43) – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% but less than 50% of total vegetation cover.

Near Riparian Forested (44) – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover. These areas are found following in near proximity (within 30-60 m) to streams, creeks, and/or rivers.

Rangeland (71) – Areas of unmanaged shrubs, grasses, or shrub-grass mixtures.

Pasture/Hay (81) – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

Cultivated Crops (82) – Areas used for the production of annual crops, such as corn, soybeans, vegetables, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

Data and Materials

National Agriculture Imagery Program (NAIP) Digital Ortho Imagery: NAIP Ortho photos are collected and compiled every year by the United States Department of Agriculture – Farm Service Agency. The imagery can be collected during the growing season (leaf-on) and during the dormant season (leaf-off) at a resolution of one to two meters in natural color or color infrared. The imagery used for the LULC was flown during the dormant season in late 2008 or early 2009 at a resolution of one meter in natural color. The imagery was projected to the Universal Transverse Mercator Zone 15, North American Datum 1983.

National Hydrography Dataset (NHD) High and Medium Resolution Data: The NHD is a combination of United States Geological Survey (USGS) Digital Line Graph files and the Environmental Protection Agency (EPA) flow direction, reach codes, and other attribute files. The powerful, nationwide hydrologic dataset was clipped to the watershed boundary for use during analysis.

Watershed Boundary Datasets Hydrologic Unit Code (HUC): The HUC is a standardized hydrologic unit system delineated to nest in a multi-level drainage hierarchy. From largest to smallest is Region (2-digit), Sub-region (4-digit), Basin (6-digit), Sub-basin (8-digit), Watershed (10-digit), and Subwatershed (12-digit). The HUC dataset was used to determine the watershed boundary.

National Elevation Dataset (NED): The NED is the current elevation data offered by USGS. The NED is a seamless, raster, elevation dataset of the conterminous United

States, Alaska, Hawaii, and territorial islands. The NED is derived from a variety of sources and is updated on a two month cycle with any new or improved elevation data. NED datasets used for this project were at a resolution of 1/3rd arc-second (approximately 10-meters). For watershed sized applications, a mosaic of 30 individual NED quadrangles was utilized.

National Land Cover Dataset (NLCD): The NLCD was developed using a decision-tree classification approach for multi-temporal, 30-meter Landsat imagery and several ancillary datasets. The classification was clipped to the watershed boundary for use during analysis.

Ground Truth Data: Sample points were taken within the watershed for all of the LULC types and recorded using a DeLorme Earthmate PN-40 GPS unit. The sample points were established within ESRI's ArcView and the cover type verified in the field.

U.S. and Canada Detailed Streets: The U.S. and Canada Detailed Streets are part of ESRI's Data & Maps data bundle that is delivered with each copy of ESRI's mapping software. The data represents detailed streets, interstate highways, and major roads within the U.S. and Canada. The data used for the LULC is from the 2003 Tele Atlas Dynamap Transportation version 5.2 products.

Methods

Background Information

The Attoyac Bayou watershed was delineated in order to determine the extent of land area to be classified. This was done using USGS 12-digit HUC shapefiles and Texas Commission on Environmental Quality's (TCEQ) segment boundary for Segment 612. The 12-digit HUC units within the Attoyac Bayou Watershed were merged into one shapefile in order to provide detailed extent of the watershed. When merged, the southern extent of the watershed was not the same as TCEQ's southern extent of Segment 612, so the watershed had to be clipped according to TCEQ's segment boundary. This was achieved by utilizing the suite of hydrology tools offered in the spatial analyst extension. The watershed was delineated using a mosaic of 10-meter NED images to cover the entire watershed, and TCEQ's southern boundary for Segment 612 as the outfall point of the watershed. Using the watershed boundary delineated by spatial analyst, the southern extent of the merged 12-digit HUC shapefile was clipped. There were no significant discrepancies within the remainder of the watershed boundary.

Delineation of LULC Classes

CES personnel conducted field surveys to characterize dominant LULC types within the watershed and to relate on-the-ground observations with aerial photographic signatures associated with different LULC classes. The watershed was then delineated into predetermined LULC classifications using leaf-off, 1-meter, 2008 - 2009 NAIP aerial imagery. Imagery was manually screened to differentiate between and delineate LULC classes. LULC boundaries were manually set to reduce the chance of slivers and gaps produced when digitizing separate polygons. This classification process was performed by two individuals working closely together to minimize any differences in judgment while still being able to keep work on the project moving forward in a timely manner. The minimal size for any single area of LULC class for this project was two (2) acres for all LULC classes other than open-water. Due to the small size, but large number of man-made ponds and tanks located in the watershed, the minimum size for the open-water LULC class was ½ acre. This minimum size was used as a general guideline and not a strict rule during the delineation process. Any LULC features that were smaller than the minimum size was addressed upon completion of the delineation phase of this process, and is discussed further in the section titled "*Data Processing*".

Data Processing

Upon completion of the delineation phase in this process some inevitable, discrete errors were present within the dataset. These errors generally consisted of gaps (areas containing no data in between areas of data), slivers (unintended, small features within the dataset), and delineated LULC features that were below the minimum size threshold.

To fill gaps present within the dataset, a union was performed between the LULC dataset, and an empty watershed boundary dataset. This union filled any gaps present; however these areas were not classified. Filled gaps that were larger than the minimum size threshold were classified according to the methods previously presented. Any filled gaps that were smaller than the minimum size threshold were not classified and were removed by using the eliminate tool. The eliminate tool removed selected polygon features by merging the selected features with the adjacent feature having the longest shared boundary. Attributes other than size of the original feature remains the same.

Stakeholder Driven Changes to the LULC Data

Through stakeholder input, the near riparian forested class was modified to only include those forested areas within 60 ft on either side of a stream channel depicted on the high resolution NHD dataset, as well as those forested areas occurring within a 100-year floodplain as depicted by the Federal Emergency Management Agency (FEMA) digital flood insurance rate maps compiled for each county in the watershed. The resulting acreage and percentage of the Near Riparian Forested class was 43,193 acres, and

12.18% respectively. Acreage removed from the Near Riparian Forested class was added to the forested land LULC class.

Accuracy Assessment

Subsequent to delineating LULC classes in the watershed and processing the dataset, the accuracy of the data was assessed and quantified. This accuracy assessment was conducted in two phases: ground truthing delineated LULC classes and a desktop assessment quantifying the amount of impervious cover within developed classes.

Ground Truthing

Individual LULCs delineated areas were verified by ground truth locations with a target of 10 locations for each of the 13 LULC classes. Due to limited access and limited availability of certain LULC classes, the number of ground checked locations varied by LULC class. Two attributes in ground truthed locations were needed to ensure data validity: locations needed to be randomly positioned throughout the watershed, and the locations needed to be accessible. To ensure randomness and accessibility, a database was compiled of all locations near public streets. The ESRI street database was buffered according to approximate street size with an objective of creating a shapefile of the potential sampling area. Potential sampling areas included the approximate road corridor width, with an additional 50-foot adjacent to the road corridor. The 50-foot of additional area adjacent to the road corridor was an estimation of the distance one could adequately determine the LULC class from a public road corridor. Major roads had a buffer of 200 feet (ft), secondary roads had a buffer of 100 ft, and rural roads had a buffer of 50 ft. The buffer was on either side of the road centerline shapefile.

Buffered roads were merged into a shapefile creating the potential sampling area. The “intersect” tool was applied to this area (road buffer) and the LULC classification, producing a LULC classified road buffer. The LULC classified road buffer attribute table was exported into a database that was sorted by the 12-digit HUC then LULC class. One LULC class was randomly selected in each of the 12-digit HUCs to ensure that thorough coverage was obtained. Randomly selected records were then used to select the corresponding LULC classified road buffer polygon. Selected polygons were exported to a new shapefile, converted to centroids (center of polygon exported as point shapefile), and the corresponding point shapefile exported to a DeLorme Earthmate PN-40 GPS (Figure 1). CES personnel then spent two field days traversing the watershed and conducting ground truthing exercises.

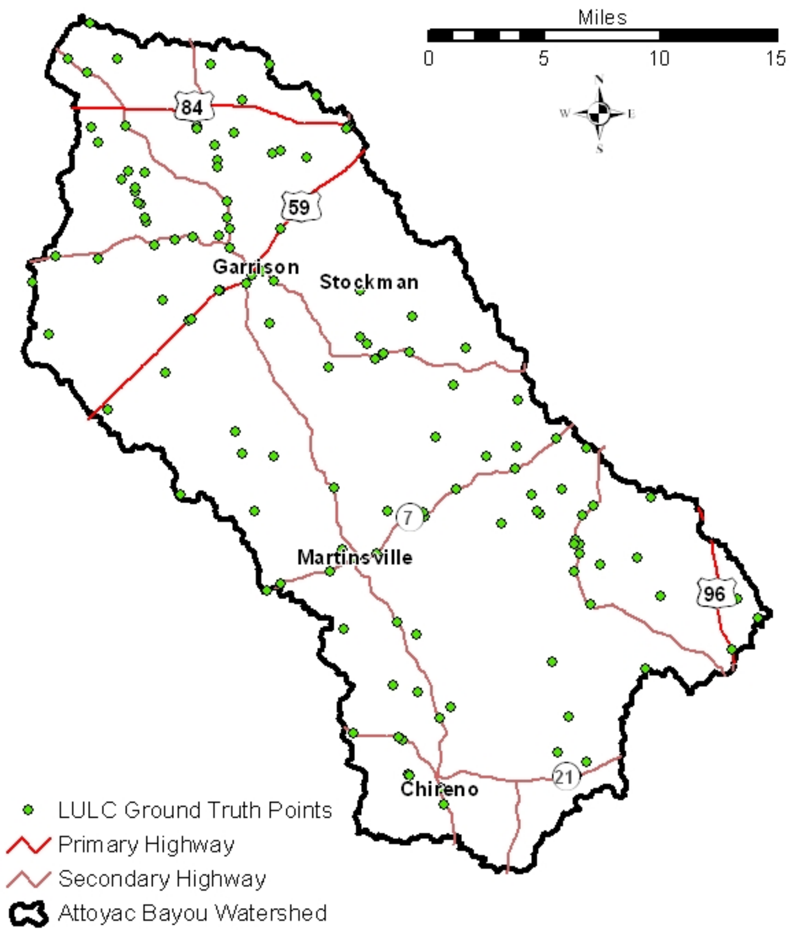


Figure 1 – Distribution of LULC ground truth points

Desktop Accuracy Assessment

While conducting ground truthing activities, it became apparent that determining the percentage of impervious cover in the field was inaccurate and inconsistent. This was due to the difficulty of quantifying the amount of impervious cover across an entire area as it was only possible to view small portions of the area that was mapped from a public roadway. In order to better quantify impervious cover, and in turn determine the accuracy of the different developed classes, a desktop review process was developed.

Developed classes verified through this desktop review process were chosen randomly. Most areas were viewed during the ground truthing exercises; however, the accuracy of mapped areas could not be conclusively assessed from the field. To accurately quantify the percentage of impervious cover within an area mapped as a developed class, the area in question was zoomed to in ArcGIS desktop. A grid was placed over the data frame of various spacing depending on the size of the feature to be assessed with 20 to 100 grid intersections within the feature. Each grid intersection was treated as an assessment point, similar to using a dot-grid matrix. Each point was counted as being over impervious surfaces, such as a roof, parking lot, etc., or over non-impervious surfaces such as vegetation. Grid intersections occurring over shadows, or other imperfections in the imagery were not counted as the corresponding land cover could not be determined. The ratio of grid intersections occurring over impervious surfaces to the total of grid intersections within the feature gave an approximate percentage of the impervious surface within that feature. In the example presented in Figure 2, there were a total of 51 grid intersections within the feature, and 20 were over impervious surface, resulting in an approximate impervious surface cover of 39%. The area in question was mapped correctly as developed (low intensity).

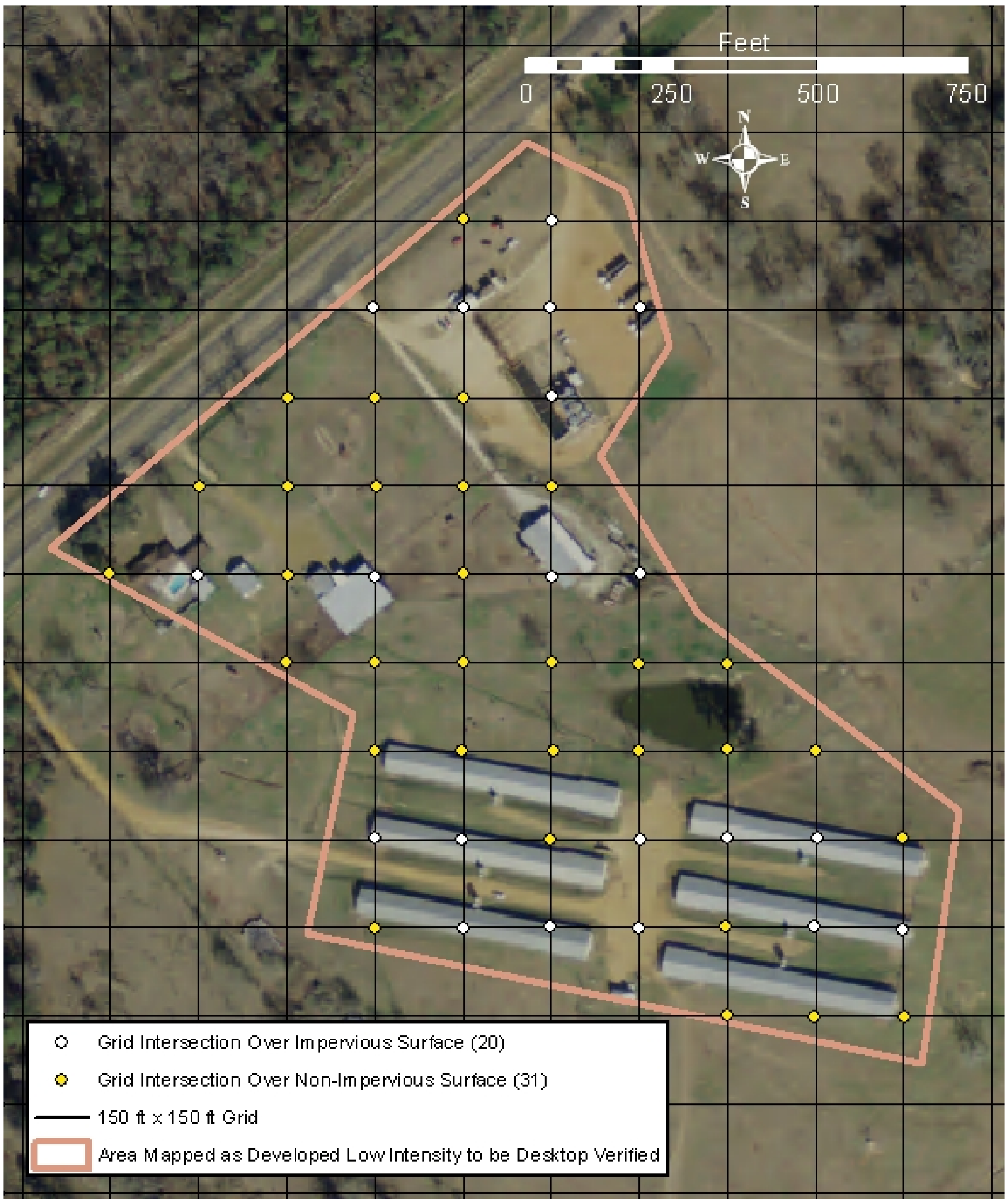


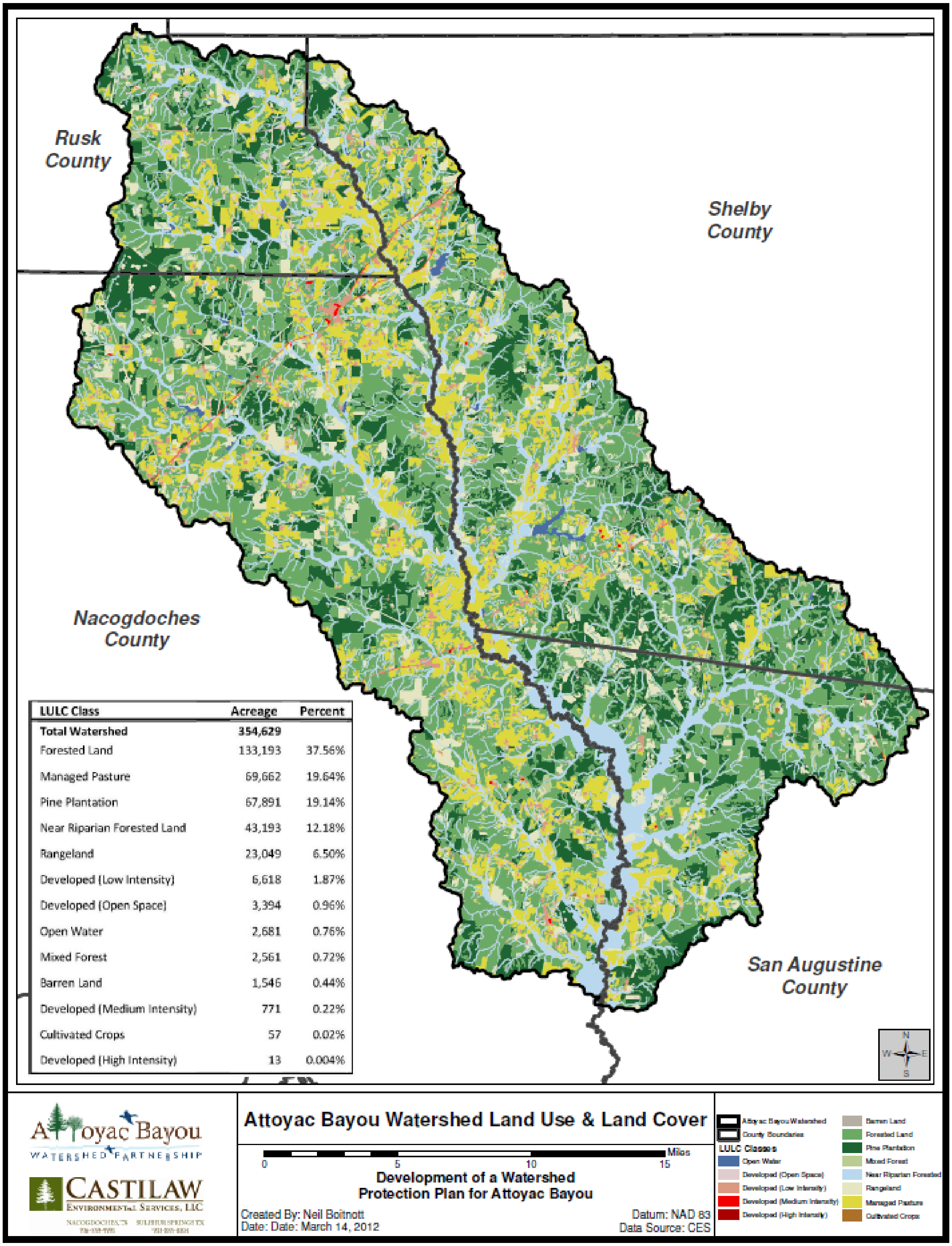
Figure 2 – Example of desktop accuracy assessment

Accuracy Assessment Results

Results of the ground truthing and desktop accuracy assessments indicated the overall average accuracy of the LULC dataset was 87% with a standard deviation of 12%. Accuracy varied by LULC class, with five (5) classes exhibiting 100%, and the lowest accuracy was 67% for an individual LULC class (Table 3). The final LULC develop for the Attoyac Bayou is presented in Figure 3.

Table 3. Accuracy of individual LULC classes.

Attoyac Bayou Watershed LULC Accuracy Assessment			
Mapped As (LULC Code)	Number of Points Sampled	Sample Points Matching LULC Layer	Percent Accuracy
11	3	3	100%
21	17	17	100%
22	21	16	76%
23	10	7	70%
24	3	3	100%
31	11	9	82%
41	13	11	85%
42	10	9	90%
43	6	4	67%
44	5	5	100%
71	5	5	100%
81	14	12	86%
82	4	3	75%
Average			**87%**



LULC Class	Acreage	Percent
Total Watershed	**354,629**	
Forested Land	133,193	37.56%
Managed Pasture	69,662	19.64%
Pine Plantation	67,891	19.14%
Near Riparian Forested Land	43,193	12.18%
Rangeland	23,049	6.50%
Developed (Low Intensity)	6,618	1.87%
Developed (Open Space)	3,394	0.96%
Open Water	2,681	0.76%
Mixed Forest	2,561	0.72%
Barren Land	1,546	0.44%
Developed (Medium Intensity)	771	0.22%
Cultivated Crops	57	0.02%
Developed (High Intensity)	13	0.004%

Figure 3 – Final LULC map for the Attoyac Bayou watershed

References

Borel, K., Gregory, L., Karthikeyan, R. 2012. “Modeling support for the Attoyac Bayou bacteria assessment using SELECT.” Texas Water Resources Institute, Technical Report XXX.

Fuller, S., Schwab, S., Castilaw, A., Gregory, L. 2012. “Attoyac Bayou recreational use attainability analysis. Texas Water Resources Institute, Technical Report 445.