State General Revenue Nonpoint Source Grant Program

Assessment of Water Quality and Watershed Planning for the Leona River
TSSWCB Project 11-50

Quality Assurance Project Plan - Modeling
Revision 1

Texas State Soil and Water Conservation Board

Prepared by

Texas Institute for Applied Environmental Research
Stephenville, Texas
and
Texas AgriLife Research
Spatial Sciences Laboratory

Effective Period: TSSWCB Approval through End of Contractual Period

Questions concerning this quality assurance project plan should be directed to:

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A1 Approval Sheet

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Pamela Casebolt — Date: 4/17/13
Quality Assurance Officer

Texas Institute for Applied Environmental Research (TIAER)

Nikki Jackson — Date: 08 April 2013
Project Manager

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Todd Adams — Date: 06 Apr 2013
Project Data Manager

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Project Lead

A2 Table of Contents

A3 Distribution List

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LIST OF ACRONYMS

AU	Assessment Unit
BAEN	Biological and Agricultural Engineering
BASINS	Better Assessment Science Integrating point and Non-point Sources
BSLC	Bacteria Source Load Calculator
BST	Bacterial Source Tracking
CAFO	Concentrated animal feeding operation
CAR	Corrective Action Report
CBMS	Computer Based Mapping System
CD	Compact Disc
CD-ROM	Compact Disc Read-only memory
CWA	federal Clean Water Act
DAR	drainage area ratio
DEM	digital elevation model
DMR	Discharge Monitoring Report
DQO	Data Quality Objective
DOQQ	Digital ortho quarter quads
ECHO	Enforcement and Compliance History Online
EPA	U.S. Environmental Protection Agency
FDC	Flow duration curve
GIS	Geographic Information System
GPS	Global positioning system
GSD	Ground sample distance
ICIS	Integrated Compliance Information System
I-Plan	TMDL Implementation Plan
LDC	Load duration curve
LULC	Land use/land cover
MS4	Municipal Separate Storm Sewer System
MOS	Margin of Safety
NAD	North American Datum
NAIP	National Agriculture Imagery Program
NASS	National Agricultural Statistics Service
NDOP	National Digital Orthophoto Program
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPS	Nonpoint Source
NRA	Nueces River Authority
NPDES	National Pollutant Discharge Elimination System
NRCS	USDA Natural Resources Conservation Service
NWS	National Weather Service
OSSF	On-site sewage facility
PDOP	Position dilution of precision
PM	Project Manager
QA	Quality Assurance
QC	Quality Control

QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QPR	Quarterly Progress Report
r/w	read/write
SAML	Soil and Aquatic Microbiology Lab, SCSC, Texas AgriLife Research
SCSC	Department of Soil and Crop Sciences, Texas AgriLife Research
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSL	Spatial Sciences Laboratory, Texas A&M University
SSURGO	Soil Survey Geographic
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TAMU	Texas A&M University
TCEQ	Texas Commission on Environmental Quality
TIAER	Texas Institute for Applied Environmental Research
TM	Thematic Mapper
TMDL	Total Maximum Daily Load
TNRIS	Texas Natural Resources Information System
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
UAA	Use Attainability Analysis
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal transverse mercator
WGS84	World Geodetic System of 1984
WPP	Watershed Protection Plan
WQMP	TSSWCB-certified Water Quality Management Plan
WWTF	Wastewater Treatment Facility

A4 Project/Task Organization

Texas State Soil and Water Conservation Board, Temple, Texas
Provides project oversight at the State level.

Ashley Alexander, TSSWCB Project Manager
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with project. Develops lines of communication and working relationships between TIAER and TSSWCB. Tracks deliverables to ensure that tasks are completed as specified in the contract. Responsible for ensuring that the project deliverables are submitted on time and are of acceptable quality and quantity to achieve project objectives. Participates in the development, approval, implementation, and maintenance of the QAPP. Assists the TSSWCB QAO in technical review of the QAPP. Responsible for verifying that the QAPP is followed by project participants. Notifies the TSSWCB QAO of particular circumstances that may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action.

Pamela Casebolt, TSSWCB Quality Assurance Officer
Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB and project participants. Responsible for verifying that the QAPP is followed by project participants. Determines that the project meets the requirements for planning, QA, QC, and reporting under the NPS Grant Program. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures.

Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas
Responsible for general project oversight, coordination, administration; non-direct data collection for GIS inventory; assisting SSL with groundtruthing for land-use classification; performing modeling activities with the SELECT and LDC development; and development of project DQOs and QAPP.

Nikki Jackson Project Manager
Responsible for implementing and monitoring TSSWCB requirements in contracts, QAPPs, and QAPP amendments and appendices. Coordinates project planning activities and work of project partners. Responsible for coordinating attendance at conference calls, training, meetings, and related project activities with the TSSWCB. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Notifies the TSSWCB PM of particular circumstances that may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action. Responsible for assessing the quality of subcontractor/participant work; and submitting accurate and timely deliverables to the TSSWCB PM. Responsible for design of source survey in coordination with project partners.

Anne McFarland, Research Scientist
Responsible for supervising project modeling and data compilation activities including LDC analysis and SELECT modeling, GIS inventory development, and groundtruthing for land use classification conducted by SSL. Responsible for assisting with the design of a watershed source survey. Responsible for ensuring that personnel involved in qualitative data assessment are

adequately trained and have a thorough knowledge of the QAPP. Responsible for modeling oversight and ensuring that all QA/QC requirements are met, documentation related to the analysis is complete and adequately maintained, and that results are reported accurately. Responsible for ensuring that corrective actions are implemented, documented, reported and verified.

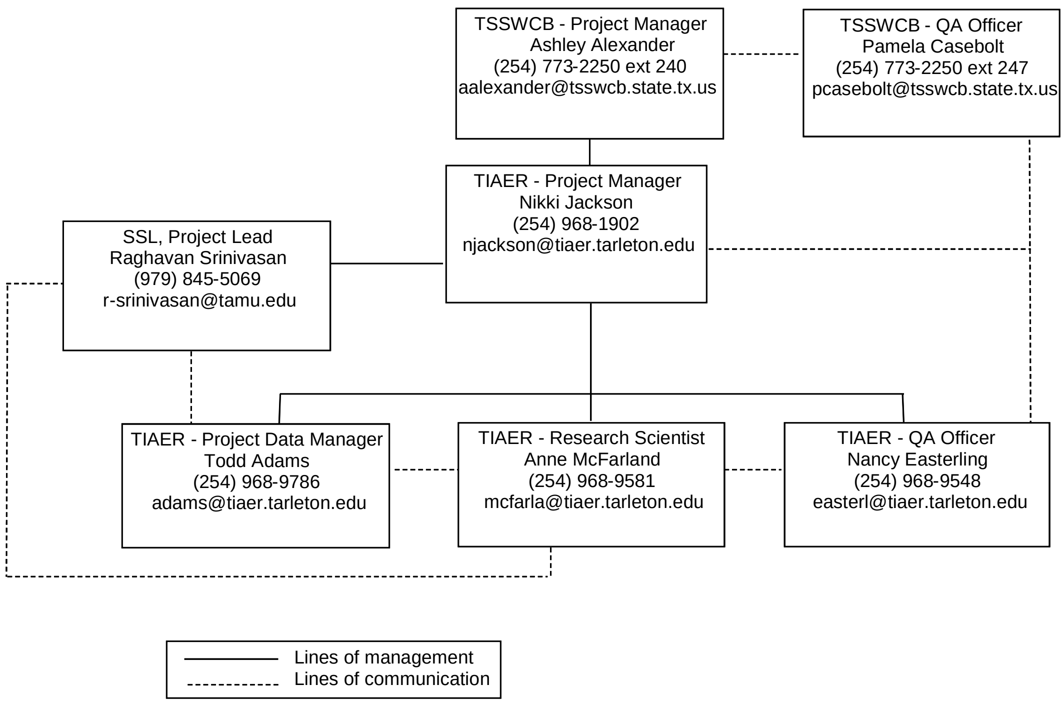
Nancy Easterling, Quality Assurance Officer
Responsible for coordinating development and implementation of the QA program. Participates in planning, development, approval, implementation, and maintenance of the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for identifying, receiving, and maintaining project QA records. Responsible for coordinating with the TSSWCB QAO to resolve TIAER QA-related issues. Notifies the TIAER PM of particular circumstances that may adversely affect the quality of data. Responsible for ensuring that TIAER corrective actions are implemented, documented, reported and verified. Coordinates the research and review of technical TIAER QA material and data related to water quality monitoring system design and analytical techniques.

Todd Adams, Project Data Manager
Responsible for acquisition and verification of watershed inventory data that will be maintained in a GIS, documentation of GIS data sources and metadata, ensuring the accuracy of GIS data, and for the transfer of GIS data to the TSSWCB. Oversees data management for the study including coordinating with SSL on the verification of ground control points for land-use classification. Performs data quality assurances prior to transfer of data to TSSWCB. Responsible for transferring data to the TSSWCB in an acceptable format. Ensures data are submitted according to workplan specifications.

Texas AgriLife Research, Spatial Sciences Laboratory, College Station, Texas
Responsible for developing updated land use classification including overseeing the evaluation of ground control points.

Raghavan Srinivasan, Project Lead
Responsible for coordinating and supervising LULC classification activities. Responsible for ensuring that personnel have adequate training and a thorough knowledge of SOPs specific to the classification of LULC. Responsible for oversight of all SSL operations and ensuring that all QA/QC requirements are met. Enforces corrective action for SSL data and procedures, as required.

Figure A4.1 Project Organization Chart



Note: The NRA and SCSC are also important project partners but are not directly involved with the project modeling and LULC classification tasks, and, thus, are not shown on the project organization chart for this modeling QAPP.

A5 Problem Definition/Background

The Leona River (Segment 2109) is a tributary of the Frio River within the Nueces River Basin. The river flows 85 miles from US 83 in Uvalde County, through Zavala County, then to its confluence with the Frio River in Frio County (Figure A5.1). The watershed is approximately 429,244 acres. Cities within the watershed include Uvalde in Uvalde County and Batesville in Zavala County, both of which have wastewater discharge permits to the river.

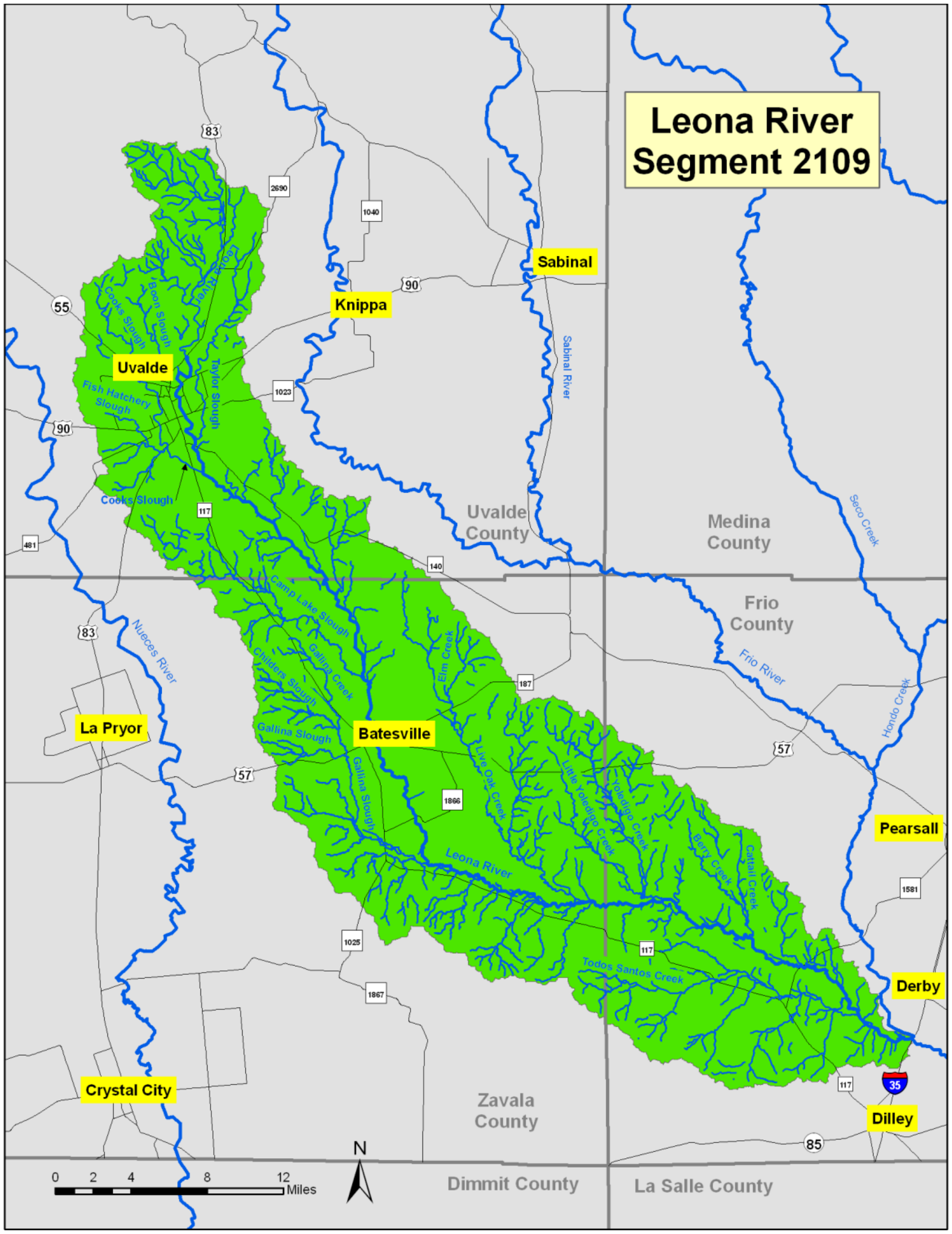


Figure A5.1 Map of Leona Watershed

The Leona River watershed is rural and land use is predominantly agriculture, including cropland and pastureland. According to the USDA NASS 2007 Census of Agriculture, approximately 2.4 million acres of land in Frio, Uvalde, and Zavala counties are farmland. Leading animal operations that exist in all three counties are beef cattle and sheep. Winter wheat production, oats, sorghum and cotton are among the leading crops harvested in all three counties. Large amounts of land are also used to grow forages such as hay, grass silage and greenchop in Uvalde and Frio counties, and Frio County had more than 58,000 acres in peanut production in 2007.

While mainly rural, the cities of Uvalde and Batesville are located within the watershed. Uvalde has an estimated population of 16,000, while about 1,300 people reside in Batesville. Both cities have WWTFs with discharges into the Leona River; Uvalde actually has 2 outfalls. Other permitted dischargers include Agrilink Foods, which discharges processing waste via irrigation and the U.S. Fish and Wildlife Service National Fish Hatchery in Uvalde, which discharges flush water intermittently into the Leona River.

The Leona River was first listed as having a bacteria impairment for contact recreation in the *2006 Texas Water Quality Inventory and 303(d) List*. It was listed as having a concern for bacteria in prior reports. It has also been listed as having a concern for nitrates beginning with the *2002 Texas Water Quality Inventory and 303(d) List*. The *2010 Texas Integrated Report* includes a bacteria impairment for all three AUs within the Leona River. The *2010 Texas Integrated Report* continues to note nitrates as a concern within all three AUs.

Historically, the Leona River was a popular place for swimming, canoeing, and fishing. Based on an editorial to the *Uvalde Leader News* on July 13, 2003, degradation began in the late 1960s. Increase runoff from agricultural fields, WWTF discharges, clearing of the riparian areas, and introduction of invasive plant species have all contributed to this degradation.

In 2004, NRA received a CWA §319(h) NPS Grant through the TSSWCB and the EPA, to design and implement an education program targeted at the headwater stream segments of the Nueces River Basin, including the Leona River. The Headwaters Stewardship program paved the way for an expanded sustained education effort by providing the education tools, enlightened audiences, and a cooperative capacity among local conservation organizations. This project will build on the success of the Headwaters Stewardship program.

The TCEQ and the TSSWCB established a joint, technical Task Force on Bacteria TMDLs in September 2006 charged with making recommendations on cost-effective and time-efficient bacteria TMDL development methodologies. The Task Force recommended the use of a three-tier approach that is designed to be scientifically credible and accountable to watershed stakeholders. The tiers move through increasingly aggressive levels of data collection and analysis in order to achieve stakeholder consensus on needed load reductions and strategies to achieve those reductions. In June 2007, the TCEQ and the TSSWCB adopted the principles and general process recommended by the Task Force and directed agency staff to incorporate the principles of the recommendations into projects that address bacteria impairments.

In accordance with the *Memorandum of Agreement between the TCEQ and the TSSWCB Regarding TMDLs, Implementation Plans, and WPPs*, the TSSWCB has agreed to take the lead role in addressing the bacteria impairments in this project's study area. Through this project, the TSSWCB and collaborating entities will work with local stakeholders to progress through the data collection and analysis components of the first two tiers of the Task Force recommended three-tier approach. The goal is to remove the waterbodies in the study area from the *303(d) List*; however, the mechanism is not predetermined. At the end of this assessment project, possible outcomes include: 1) waterbodies are achieving current water quality standards, 2) adequate data exists to support a UAA to change water quality standards, 3) adequate data exists to develop a WPP, or 4) adequate data exists to develop a TMDL and I-Plan for TCEQ adoption.

A6 Project/Task Description

The overall goal of this project is to provide stakeholders and agencies with sufficient information to address bacteria impairments on the Leona River through verification of use attainment, revision of water quality standards, or development of a WPP or TMDL. This will be done through the following tasks as outlined in the project workplan:

1) Project Administration - To effectively administer, coordinate, and monitor all work performed under this project including technical and financial supervision and preparation of status reports.
2) Quality Assurance - To develop and implement DQOs and QA/QC activities to ensure data of known and acceptable quality are generated through this project.
3) Bacterial Source Tracking - To conduct BST to assess and identify different sources contributing to bacteria loadings.
4) Survey and Inventory Possible Bacteria Sources - To develop a comprehensive GIS inventory for the study area and to assess the possible sources of bacteria loadings by conducting a watershed source survey. To classify current land use for the watershed through a combination of satellite based image classification schemes and where needed "heads-up digitizing" of NAIP aerial photos of the area.
5) Surface Water Quality Monitoring - To provide sufficient water quality data to characterize bacteria and nitrate loadings across the various flow regimes at a number of locations throughout the study area.
6) Assess Attainability of Recreational Use - To collect information that can be used to evaluate factors affecting attainment of recreational use in the Leona River.
7) Data Analysis and Watershed Modeling - To analyze and interpret data using LDCs and spatially explicit modeling to determine bacteria load reductions needed to achieve water quality standards and estimate loadings from various sources.
8) Public Participation and Stakeholder Facilitation - To facilitate public participation and coordinate stakeholder involvement to ensure that decision-making is founded on local input and that watershed action is successful.

For this project, TIAER will develop two separate QAPPs, one for water quality monitoring activities as addressed in Tasks 3, 5 and 6 of the workplan and one for watershed modeling activities addressed in Tasks 4 and 7 of the workplan. This QAPP addresses the modeling and GIS land use mapping of the project under Tasks 4 and 7.

SAML will provide BST data for the project. SAML input will be used for several portions of the modeling part of the project, although SAML project activities are covered under the QAPP for water quality monitoring activities.

Task 4: Survey and Inventory Possible Bacteria Sources

Activities under Task 4 include developing a comprehensive GIS inventory for the study area, assessing the possible sources of bacteria loadings by conducting a watershed source survey, and classifying current land use for the watershed through a combination of satellite based image classification schemes and where needed "heads-up digitizing" of NAIP aerial photos of the area.

Direct data collection under subtask 4.2 for updating the land classification and non-direct data sources for subtask 4.1 associated with the GIS inventory are covered by this QAPP. The data from subtasks 4.1 and 4.2 will be used to support subtasks 4.3 and 4.4 involving development and implementation of the source survey.

Task 4 is comprised of the following four subtasks, the first two of which are covered by this QAPP:

- **Subtask 4.1:** TIAER will develop a comprehensive GIS inventory for the study area. Data should include the most recent information available on land use, elevation, soils, stream networks, reservoirs, roads, public parklands, municipalities and satellite imagery or aerial photography. Locations of SWQM stations, USGS gages, public access points to the waterbodies, floodwater-retarding structure, wetlands, TPDES permittees (including WWTFS, CAFOs and MS4s), and subdivisions should also be included. Sites permitted for land application of sewage sludge and septage should be included. Locations of possible bacteria sources, identified in subtask 4.4, should be incorporated. The cumulative impact of TSSWCB-certified WQMPs on the management of agricultural and silvicultural lands should be documented.

- **Subtask 4.2:** SSL will perform a combination of satellite based image (2006-2009) classification schemes and where needed “heads-up digitizing” of the 2006-2009 NAIP aerial photos of the watershed using ESRI’s ArcGIS 9.x software. SSL will identify individual LULC classes and delineate them in shapefile or ArcGIS grid format with a minimum mapping unit of 2 ac on screen. LULC classes will be comparable to USGS NLCD. SSL will verify LULC classification through field sampling and TIAER-conducted groundtruthing information to an accuracy of 80% or greater. Ground control points used in the field sampling will be collected for at least ten locations per land use type using GPS units with an accuracy of 1-10 m.

- **Subtask 4.3:** TIAER will collaborate with NRA to facilitate a meeting of local stakeholders and technical experts to design a source survey (also known as a sanitary survey) that better characterizes the possible sources of bacteria loadings. The source survey should be developed so that it represents warm and cool seasons and low and high flow conditions. The source survey should evaluate sources like WWTFs, central sewage collection systems, OSSFs, and MS4s. TPDES compliance issues should be examined. Wildlife, livestock and non-domestic animal populations should be examined. SCSC will assist TIAER in designing the source survey.

- **Subtask 4.4:** TIAER will conduct the source survey as designed in subtask 4.3.

Deliverables

- Technical Report describing results from the source survey
- LULC for the watershed in shapefile or ArcGIS grid format

Task 7: Data Analysis and Watershed Modeling

Task 7 activities involve analyzing and interpreting data using LDCs and spatially explicit modeling to determine bacteria load reductions needed to achieve water quality standards and estimate loadings from various sources. Task 7 is comprised of the following three subtasks, which are covered by this QAPP:

- **Subtask 7.1:** TIAER will conduct a LDC analysis of all historic and existing water quality monitoring data from the study area. LDCs will be developed for at least one critical index site per each AU for segment 2109. LDCs shall be consistent with 1) EPA's *An Approach for Using LDCs in the Development of TMDLs*, 2) EPA's *Options for Expressing Daily Loads in TMDLs,* and 3) EPA's *Development of Duration-Curve Based Methods for Quantifying Variability and Change in Watershed Hydrology and Water Quality*. Initial LDC development will be completed using available USGS gage flow data and the drainage area ratio approach. As gaging information becomes available from subtask 5.5, the approach for estimating historical flow data may be revised.

- **Subtask 7.2:** Using water quality monitoring data collected by TIAER through Task 5 and assimilated data collected by TCEQ and NRA during the same time period, TIAER will refine LDCs developed in subtask 7.1. LDCs will be used to determine bacteria load reductions needed to achieve water quality standards. LDCs shall also be developed for nitrogen parameters.

- **Subtask 7.3:** TIAER will conduct watershed modeling for the study area. Utilizing information from the GIS inventory (subtask 4.1) and the source survey (subtasks 4.3 and 4.4), TIAER will develop a spatially explicit or mass balance model, such as the SELECT, for the study area. Modeling will be conducted on the Leona River watershed to estimate loadings from various sources and to identify critical loading areas within the watershed. TIAER will work with SCSC to 1) integrate BST results (Task 3) into the model, to the extent possible, and 2) address and reconcile discrepancies between BST and modeling results.

Deliverables

- Draft Technical Report detailing preliminary LDC analysis
- Technical Report detailing final LDC analysis
- Technical Report describing watershed modeling results

<u>Modeling Analysis Descriptions</u>

Statistical Models

- SELECT
- LDC

Spatially Explicit Load Enrichment Calculation Tool (SELECT)

The Center for TMDL and Watershed Studies at Virginia Tech has been involved in TMDL development for bacteria impairments. The Center personnel developed a systematic process for source characterization that includes the following steps:

- inventorying bacterial sources (including livestock, wildlife, humans, and pets);
- distributing estimated loads to the land as a function of land use and source type; and
- generating bacterial load input parameters for watershed-scale simulation models.

This process provides a consistent approach that is necessary to develop comprehensive bacteria TMDLs. The Center personnel developed a software tool, the BSLC, to assist with the bacterial source characterization process and to automate the creation of input files for water quality modeling (Zeckoski, et al., 2005); however, BSLC does not spatially reference the sources.

A spatially-explicit tool, SELECT has been developed by SSL and the Biological and Agricultural Engineering Department at TAMU to calculate contaminant loads resulting from various sources within a watershed (Teague et al., 2009). SELECT spatially references the sources, and was developed under ArcGIS 9 environment. SELECT will calculate and allocate loading to a stream from various sources within a watershed. All loads will be spatially referenced. In order to allocate the *E. coli* load throughout the selected watershed, estimations of the source contributions will be made. This in turn allows the sources and locations to be ranked according to their potential contribution within watershed. The populations of agricultural animals, wildlife, and domestic pets will be calculated and distributed throughout each watershed according to appropriate land use. The land use/land cover used will be the one developed as part of this QAPP. Furthermore, point sources such as WWTFs will be identified and their contribution quantified based on flow and outflow concentration. Septic system contribution will also be estimated based on criteria including distance to a stream, soil type, failure rate, and age of system. Once the watershed profile is developed for each potential source, the information can be aggregated to the sub-watershed level to identify the top contributing areas in the watershed.

Load Duration Curve

This is a simple and an effective first-step methodology to obtain loadings under varying flow regimes (EPA, 2007a; Cleland, 2003). A duration curve is a graph that illustrates the percentage of time during which a given parameter's value is equaled or exceeded. For example, a FDC uses the hydrograph of the observed or estimated stream flows to calculate and depict the percentage of time the flows are equaled or exceeded.

A LDC, which is related to the FDC, shows the corresponding relationship between the contaminant loadings and stream flow conditions at the monitoring site. In this manner, it assists in determining patterns in pollution loading (point sources, nonpoint sources, erosion, etc.) depending on the streamflow conditions. Based on the observed patterns, specific restoration plans can be implemented that target a particular kind of pollutant source. Another main advantage of the LDC method is that it can also be used as a technical framework for the development of TMDLs or WPPs (EPA, 2007a).

LDCs will be developed in two stages, using only historical data and then using additional project-collected data. LDCs will be developed for both bacteria and nitrogen for each of the three AUs at an index station for long-term monitoring stations with more than 10 observations.

Land Use/Land Cover Development

The project will classify current land use for the Leona River watershed through a combination of satellite based image classification schemes and where needed "heads-up digitizing" of aerial photos. The land use classification scheme to be used in this delineation will include:

- Developed Open Space - 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 - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
- Developed Medium Intensity - 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- 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.
- Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.
- Barren Land - (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 – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover.
- Near Riparian Forested Land – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover. These areas are found in near proximity (within 30-60 m) to streams, creeks and/or rivers.
- Low Density Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% but less than 50% of total vegetation cover.
- Rangeland – Areas of unmanaged shrubs, grasses, or shrub-grass mixtures
- Pasture/Hay - 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.
- Cropland - 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.

A7 Quality Objectives and Criteria

The objective of this section is to ensure that data collected meets the DQOs of the project. The major objective is to identify specific sources of bacteria entering the Leona River. A secondary objective is to evaluate sources of nitrates. At the end of this two-year assessment project, possible outcomes include: 1) waterbodies are achieving current water quality standards, 2) adequate data exists to support a UAA to change water quality standards, 3) adequate data exists to develop a WPP, or 4) adequate data exists to develop a TMDL and I-Plan for TCEQ adoption.

Land Use/Land Cover Update

A combination of image (2004-2010) classification schemes and where needed "heads-up digitizing" of the 2004 and 2010 NAIP aerial photos of the area in ESRI's ArcGIS 9.x software will be used to classify the current LULC. NAIP provides two main products: 1 meter GSD ortho imagery rectified to a horizontal accuracy of within +/- 3 meters of reference DOQQs from the NDOP (2004 imagery); and, 2 meter GSD ortho imagery rectified to within +/- 20 meters of reference DOQQs (2005 imagery). The tiling format of NAIP imagery is based on a 3.75' x 3.75' quarter quadrangle with a 360 meter buffer on all four sides. NAIP quarter quads are rectified to the UTM coordinate system, NAD83 and cast into a single predetermined UTM zone.

As a point of comparison, USGS NLCD 2006 are created with Landsat TM images. Each image is precision terrain-corrected using 3-arcsecond digital terrain elevation data, and georegistered using ground control points. The resulting root mean square registration error is less than 1 pixel, or 30 meters. This data will be overlaid with the LULC produced to evaluate the general accuracy of the LULC assessment. To achieve the needed precision and accuracy, the LULC classification scheme to be used in this delineation will include the twelve classifications discussed in Section A6. Individual LULC classes will be identified and delineated with a minimum mapping unit of 2 acres on screen.

Representativeness will be addressed by evaluating ground control points also referred to as reference points for at least ten locations per land use type (minimum of 120 ground control points). Much of the Leona River watershed is private land, so access to some areas may be limited. TIAER will conduct this GPS survey utilizing the Trimble GeoXT model GPS receivers. GeoXT receivers will collect data in the WGS84 and be set to collect data from a minimum of 4 satellites and a PDOP value of 6.0 or less to achieve the highest accuracy possible and still maintain productivity. Post-processing will be accomplished using the vendor's software package to further increase the data accuracy to sub-5 meters.

Once the ground control points are evaluated as outlined in the previous paragraph, the individual LULC classes will be verified through comparison with the ground control points to ensure an accuracy of 80% or greater for each class. This will be complemented with aerial photographs and other ancillary data described in Section B9. Comparability will be addressed by collecting, analyzing, and reporting the data as described in Section B2. A completeness goal of 100% is designated for the LULC classification of the watershed. Valid data is required for each LULC class mapped in order to complete the cover maps for each watershed.

LDC and SELECT Data Analysis

TIAER will conduct a phased modeling effort to develop pollutant source and loading information and estimates of needed bacteria load reductions. The objectives of the water quality modeling for this project are as follows:

1) Develop LDCs for nitrite-nitrogen+nitrate-nitrogen (NO_2-N+NO_3-N) and bacteria (*E. coli*) using historical data. LDCs will be developed for at least one critical index site per each AU for Segment 2109 and at historical monitoring sites with 10 or more observations. LDCs developed will be consistent with *An Approach for Using LDCs in the Development of TMDLs* (EPA 2007a), *Options for Expressing Daily Loads in TMDLs* (EPA 2007b), and *Development of Duration- Curve Based Methods for Quantifying Variability and Change in Watershed Hydrology and Water Quality* (EPA 2008). FDCs used in developing LDCs will be developed using available USGS gage flow data from stations within and near the watershed and the DAR approach as described by Asquith et al. (2006). Data on the Edwards Aquifer levels for the Uvalde station may also be used to aid in adjustments for baseflow conditions, along with a baseflow filter program using methods outlined by Arnold and Allen (1999). If sufficient gaging information becomes available from monitoring conducted during the project, the approach for estimating historical flow data may be revised.
2) Update LDCs developed using historical water quality data with water quality data collected under Task 5. LDCs will be used to estimate needed load reductions for NO_2-N+NO_3-N and bacteria for at least one index site per AU along the waterbody and at historical monitoring sites with 10 or more observations.
3) Conduct watershed modeling using the SELECT approach for the Leona River. Information collected in Tasks 3, 4, 5, 7 and 8 as described in the project work plan will be incorporated with information from LDC analyses to estimate pollutant loadings from various sources within the watershed and identify potentially critical loading areas. The modeling will be performed on the Leona River watershed with the objective of estimating loadings from various sources and to identify critical loading areas within the watershed. TIAER will work with SCSC to address and reconcile discrepancies between BST and modeling results.

LDC – The LDC approach has been utilized in the development of several TMDLs and WPPs as an initial screening tool to evaluate the actual temporal load trends in streams (EPA, 2007a; Cleland, 2003). In cases of exceedances, it is necessary to determine the required load reduction in that region near the monitoring station. The load reductions will be based on the midpoint of each the following flow regime categories based on the flow duration interval as defined in EPA (2007):

- High Flows (0-1% flow duration)
- Moist Conditions (10-40% flow duration interval)
- Mid-Range Flows (40-60% flow duration interval)
- Dry Conditions (60-90% flow duration interval)
- Low Flows (90-100% flow duration interval).

In order to do this a load regression model based on the relationship of monitoring data to flow will be developed using the USGS program LOADEST (Runkel et al., 2004). The LDCs will incorporate an explicit MOS by setting a target for indicator bacteria and nitrate loads that is 5 percent lower than the geometric mean criterion for bacteria and the screening level for nitrate.

SELECT – This modeling approach was developed by SSL and BAEN (Teague et al., 2009) and the technology transferred to the TIAER project team. The approach is similar to the BSLC (Zeckoski, et al. 2005) that is used in TMDL development. High quality spatial data (LULC data developed under Task 4 of this project, SSURGO soils data, NHD, etc.) will be processed and utilized in SELECT approach. Distributions for input parameters for SELECT will be created based on literature values, expert knowledge, and stakeholder input from Task 3 and subtasks 4.3 and 4.4. Source categories for SELECT will include, at a minimum, livestock, wildlife, pets, OSSFs, and WWTFs.

A8 Special Training/Certification

Land Use/Land Cover Update

No special certifications are required for LULC classification. However, all personnel involved in classification of LULC will have the appropriate education and training required to adequately perform their duties. SSL technicians will be experienced or trained in using ESRI's ArcINFO and ArcVIEW.

TIAER staff engaged in ground verification will have appropriate education and training and will be experienced in using GPS receivers capable of 1-10 meter accuracy. TIAER has staff certified with TCEQ for the collection of GPS data and these staff members will maintain their certification throughout the project.

LDC and SELECT Data Analysis

All TIAER personnel involved in all model activities will have the appropriate education and training required to adequately perform their duties. No special certifications are required.

A9 Documents and Records

Land Use/Land Cover Update

Digital files of land cover data for the Leona River watershed will be produced in shapefile or ArcGIS grid format and stored on CD-ROM disks. Multi-color hard copy maps of land cover can be produced at various geographic scales from these digital files. SSL will produce a hard copy land cover map of the watershed. Other products will be produced as required by the TSSWCB, cooperators and other project data users.

Metadata documentation will be developed and will document data sources, processing techniques, accuracy assessment, and other pertinent information.

Appendix A represents the field data collection form used for this project for ground control point verification. Other records and documentation to be developed for this project include the following: digital files of spatial data, field data, and scanned photographs.

Records of field data, original aerial photos, digital files used for classifying LULC and accuracy assessment, and any CARs (Appendix B) will be maintained and archived by SSL on data servers and backed up nightly for at least five years after the end of the project.

LDC and SELECT Data Analysis

All modeling records, including modeler's notebooks and electronic files, will be archived by TIAER for at least five years after completion of the project. These records will document model testing, calibration, and evaluation and will include documentation of written rationale for selection of models, record of code verification (hand-calculation checks, comparison to other models), sources of historical data, source of new theory, calibration and sensitivity analyses results, and documentation of adjustments to parameter values due to calibration. Electronic data on the project computers and the network server are backed up daily to a tape drive. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Project Documentation

TIAER will electronically produce QPRs for the TSSWCB combining information from all project partners and will note activities conducted in connection with audits, items or areas identified as potential problems (e.g., CARs impacting data quality), and any variations or supplements to the QAPP.

CARs will be utilized when necessary (Appendix B). CARs will be maintained in an accessible location for reference at TIAER. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP, when appropriate.

Individuals listed in Section A3 at TIAER and SSL will be notified of approval of the most current version of the QAPP by the TIAER PM. The TIAER PM will also ensure that the recent version of the QAPP is distributed to those on the Section A3 List. Current copies of the QAPP will be kept on file for all individuals on the TIAER distribution list to be signed out in the QAPP logbook kept by the department secretary. A copy of the QAPP will be disseminated to SSL by the TIAER PM.

The final project reports will be produced electronically and as a hard copy and all files used to produce the final report will be saved electronically by TIAER and SSL for at least five years after the end of the project.

The documents and records that describe, specify, report, or certify activities are listed in Table A9.1. The TSSWCB may elect to take possession of records at the conclusion of the specified retention period.

Table A9.1. Records and Documents Retention Requirements

Document/Record	Location	Retention	Form
QAPPs, amendments, and appendices	TIAER	5 years	Paper/Electronic
QAPP distribution documentation	TIAER	5 years	Paper/Electronic
Field data, aerial imagery & digital data used in LULC classification	SSL	5 years	Electronic
Raw GIS data files	SSL for LULC and TIAER for other	5 years	Electronic
Modeler's notebooks & electronic data files	TIAER	5 years	Electronic
Model output files	TIAER	5 years	Electronic
QPR/CAR/final report/data	TIAER/SSL/TSSWCB	5 years	Paper/Electronic

Revisions to the QAPP

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date of QAPP approval, or revised and reissued within 120 days of significant changes, whichever is sooner. The most recently approved QAPP shall remain in effect until revisions have been fully approved; re-issuances (i.e., annual updates) must be submitted to the TSSWCB for approval before the anniversary date. If the entire QAPP is current, valid, and accurately reflects the project goals and organization's policy, the annual reissuance may be done by a certification that the plan is current. This can be accomplished by submitting a cover letter stating the status of the QAPP.

Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives, and methods; address deficiencies and non-conformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the TIAER PM to the TSSWCB PM in writing. The changes are effective immediately upon approval by the TSSWCB PM and QAO.

Amendments to the QAPP and the reasons for the changes will be documented, and revised pages will be forwarded to all persons on the QAPP distribution list by the TIAER QAO. Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

B1 Sampling Process Design

Land Use/Land Cover Update

The production of a LULC classification is an iterative process based on data from satellite imagery, aerial photography, existing maps and field reconnaissance. NAIP satellite imagery from 2004-2010 has been obtained and will be paired with ground-truthed field data. LULC will be assigned to twelve categories according to the category descriptions provided in Section A6.

Ground reference data must be collected to “train” the computer software to recognize the spectral reflectance of various land cover categories represented in the NAIP imagery. Since ground reference data generally cannot be collected for the entire project area, representative samples will be used.

TIAER staff with guidance from SSL will collect LULC information for at least ten actual ground locations per land use category throughout the watershed for use in mapping land cover. These ground control points will be used to conduct supervised classifications of remote sensing data from satellite imagery. These data will also be used for accuracy assessment as outlined in Section B5.

Field data will be collected according to standard protocols. SSL will review field data and assign appropriate classification prior to digitizing the data for GIS analysis. Descriptions of LULC that cannot be assigned a class corresponding to the scheme used in labeling classes will be rejected.

Types and numbers of samples required: SSL will identify at least 10 representative ground locations for each land cover class.

Sampling Locations and frequencies: SSL has a goal of 120 field sites across the watershed with a minimum of 10 sites for each LULC class.

LDC and SELECT Data Analysis

Not relevant.

B2 Sampling Methods

Land Use/Land Cover Update

Phase 1 Acquisition:

Ancillary data will be used to classify the satellite based images into classes. SSL will use existing aerial photos, topographic maps and previous classifications as sources to define LULC polygons. The geographic location of the ancillary polygons is known and is overlaid to the same locations on the imagery.

Phase 2 Acquisition:

Field sampling by qualified TIAER staff will be used to verify individual LULC classes identified and delineated in preliminary classifications. Ground control points used in the field sampling will be collected with a goal of at least 10 locations per land use type using GPS units with an accuracy of 1-10 m.

LULC categories are identified in the field by an observer who is knowledgeable about LULC identification and classification standards. Observed LULC classifications are recorded on data forms (Appendix A). No specialized equipment is used to collect the LULC data.

Ancillary data will be used to supplement the sample data gathered by the field personnel. These sources include color infrared, black and white and color aerial photography of the same time period as the imagery and other sources that become available during the classification process.

All ancillary data that arrives in the SSL in non-digital form will be inspected for accuracy and appropriateness by the SSL PM and then digitized for use in the GIS classification process. Where applicable, aerial photos will be scanned on a flatbed scanner and the resultant images will be geo-rectified using a specialized software program. The rectified image will be viewed in a GIS application and the necessary data from the image will be traced. Attribute information will be attached to each traced polygon and saved as a file. Where data can be matched visually from a paper copy to a digital source it will be digitized directly on the screen without scanning.

Documentation of Field Sampling Activities

Field sampling activities are documented on field data forms by TIAER staff (Appendix A). For all visits, site identification, date, time, personnel, and conditions at the site are recorded.

Recording Data

For the purposes of this section and subsequent sections, all personnel follow the basic rules for recording information as documented below:

1. Legible writing in indelible, waterproof ink with no modifications, write-overs or cross-outs;
2. Changes should be made by crossing out original entries with a single line, entering the changes, and initialing and dating the corrections.
3. Close-outs on incomplete pages with an initialed and dated diagonal line.

Deviations from Sampling Method Requirements or Sample Design, and Corrective Action

CARs document root cause(s); programmatic impact(s); specific corrective action(s) to address any deviations; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and the means by which completion of each corrective action will be documented. CARs will be included with QPRs. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TSSWCB immediately both verbally and in writing.

<u>LDC and SELECT Data Analysis</u>

Not relevant.

B3 Sampling Handling and Custody

Land Use/Land Cover Update

Field data forms are hand delivered or mailed back to the SSL via business reply envelopes. All ancillary data sources are filed by watershed in the SSL. When hardcopy data are digitized or otherwise entered into the computer, backups of the digital files to removable media will be made to ensure no loss of data due to machine failure.

LDC and SELECT Data Analysis

Not relevant.

B4 Analytical Methods

Land Use/Land Cover Update

Phase 1 Classification:

The SSL is using a combination of image classification schemes and heads-up digitizing of NAIP aerial photos of the area to conduct the land cover classification of the watershed. NAIP quarter quads are rectified to the UTM coordinate system, NAD83 and cast into a single predetermined UTM zone.

The spectral classes from each scene covering the watershed are first labeled into the twelve LULC categories using whatever ground information is available, including aerial photos, topo maps and previous classifications. The land use classification scheme to be used is described in Section A6. Individual LULC classes will be identified and delineated in shapefile or ArcGIS grid format with a minimum mapping unit of 2 acres on screen. Ground truth sample polygons are then divided into two randomly selected groups, one for training data for supervised classifications and the other for classification accuracy testing.

Phase 2 Classification:

Trimble eCognition Developer image classification software and ESRI ArcGIS software will be used to classify images in Phase 2. Classification will be done using the geographic extents of three NAIP county mosaics. The product of the Phase 1 classification will be used as input to the supervised classification process. One category will be selected as the focus of a classification operation. Appropriate ground samples and ancillary polygons containing LULC data, located and labeled by SSL personnel, will be matched with corresponding areas on the original images and the image polygons will be classified using on-screen interpretive techniques to an accuracy of 80% or greater. The process will be repeated for each LULC category using field samples and other ancillary data.

As a point of comparison, USGS NLCD is created with Landsat TM images. Each image is precision terrain-corrected using 3-arc-second digital terrain elevation data, and georegistered using ground control points. The resulting root mean square registration error is less than 1 pixel, or 30 meters.

A detailed account of data processing techniques will be documented in metadata according to the established standards. ESRI ArcCatalog software will be used to record the metadata for this project.

LDC and SELECT Data Analysis

Not relevant.

B5 Quality Control

Land Use/Land Cover Update

Assessing the accuracy of land cover mapping products is an elusive and challenging process that calls for continuing research and development within GIS and remote sensing technology. The criteria for accuracy assessment reflect the need to balance the requirements for rigor and defensibility with practical limitations of cost and time. The assessment methods must be scientifically sound and economically feasible.

The basic unit of the land cover mapping process is a polygon of 2 acres that represents a LULC class with a relatively homogenous composition. An accuracy assessment will be conducted by selecting a sample of locations (e.g., centroids of mapped polygons) from the final version of the land cover map and determining the true land cover classification at these locations. These data are frequently called the reference data set. Properly executing an accuracy assessment involves knowing the nature of the created map, identifying the field methods for obtaining the reference data, designing a sound method for selecting reference data, actually collecting the data, conducting statistical analyses, and reporting the results.

This project has a goal of mapping land cover with 80% accuracy. Thematic accuracy will be measured as a percentage of the land cover map classified correctly overall and by cover type with a standard error no greater than 8%.

Summary of steps and standards used in Accuracy Assessment:

1. Produce a final land cover map, classification, and description of land cover classes that will be assessed.
2. Identify the methods for obtaining reference data.
3. Design a sampling protocol that meets the desired statistical precision.
4. Collect the reference data, test their reliability, and archive the database.
5. Compare the reference data to the map, conduct analyses, and report the results.

Step 1: A final version of a land cover map will be produced as described in section B4. Twelve cover classes will be delineated on the satellite imagery. Because classification will be done in phases, one scene at a time, it will not be necessary to wait until the mapping is completed for the entire watershed to begin accuracy assessment. Knowledge of the characteristics of the map to be assessed is important in determining the sampling frame (number, size, and classification of polygons). The methodology used to collect the reference data will match the classification system of the cover map.

Step 2: Field collected data will be used as the primary source of reference data to assess the quality of the final cover map. Ground-truthing involves physically visiting the site in question to determine its true land cover type and will require substantial cooperator support and coordination. The SSL PM and SSL personnel will develop a field sampling plan that will guarantee consistency between reference data and the needs of the assessment project and future remapping, (i.e., the method of collecting the field data will enable the land cover to be identified at the same level of detail as the land cover map). QC will be achieved by assuring that the GPS receiver performance is tested as noted in Section B6. Statistical checks will be performed on the data during the post-processing phase and the data will be compared to known map coordinates and features using USGS topographic maps and other appropriate map sources of known quality.

The design of the assessment study will be stratified by, and only by, land cover types present in the final land cover map. The protocol for selecting field sampling sites will be based on the number of land cover classes (12), the number of polygons within each class, and the number of samples needed to accomplish statistical precision.

With a minimum mapping unit of 2 acres, it is anticipated that the occurrence of other unmapped cover types (inclusions) within a polygon will cause few problems in collecting field data. Nevertheless, the SSL PM has developed field protocols to ensure that each mapped cover type can be correctly identified in the field. The characteristics of land cover types that may affect these protocols are: polygon sizes (small, medium, large), polygon shapes (linear or non-linear), and heterogeneity of the land cover (degree of patchiness and size of inclusion patches). To minimize some of these potential issues, ground control points should be selected from the center of parcels that are at least 5 time the area of the minimum mapping unit. These land units should be as homogenous as possible in the landscape with only minimal within patch variation. When possible, areas that are chosen will have a small edge to area ratio which means that the patches have a large interior area relative to the length of the edge. In the case of stream segments that are linear and narrow in nature, the most continuous areas should be selected.

An individual measurement will result in a decision as to whether or not the field reference point agrees with the land cover map's label of that polygon. Accuracy is the statistical reduction of many samples into a statement of percent agreement.

Step 3: Sampling units are defined here as all areas within the project area geographically contiguous and of homogenous primary attribute, that is, vector polygons or contiguous raster clusters of the same primary land cover type code. Land cover maps are based on algorithmic clustering of TM pixels with the resultant categories being spectrally similar. Therefore, pixels are probably not independent of each other. Although polygon boundaries are not precise, they are believed to represent real patterns on the ground and the polygon is the defined feature that should be assessed. Therefore, the sampling unit is defined as a mapped polygon. The sample frame is the list of all polygons that comprise the final land cover map.

The sampling protocol for accuracy assessment will be designed to meet the statistical precision needed to accomplish the stated objectives for accuracy and standard error. Field sites will be selected through a stratified, two-stage probability sample. Accuracy assessment field data will be recorded on forms and returned to the SSL for analysis (Appendix A). Probability sampling, as opposed to purposive selection of "representative" elements or haphazard selection of convenient elements, is now a standard scientific tool since it guards against selection biases and it leads to objective statistical inferences. Stratification will ensure good geographic spread of the sample across the state and will provide a representative sample of alliances.

Two stages of sampling will be employed. In the first stage, large tracts of land (e.g., counties, Landsat scenes, or some other convenient unit) will be selected in a stratified sample. In the second stage, sampling points within the large tracts will be selected. The reason for sampling in two stages, as opposed to sampling sites directly, is that direct sampling of sites would lead to a widely-scattered sample with high logistical costs.

Because cost of collecting field data could be limiting, consideration will be given to stratifying according to the relative cost or effort required to measure the sampling site.

Step 4: GIS methods will be used to select sampling units from the sampling frame which consists of all the polygons in a vector map.

Field surveys will use methods similar to those used to collect data for classification purposes to determine the accuracy of the classification (Appendix A). However, reference data will be collected by well-trained field observers from TIAER who have no knowledge of the primary attribute given by the land cover map for the sampling unit. This will involve providing each observer with coordinates and a map showing the polygon to be sampled but without the associated land cover type label. The field maps will typically have base information such as roads, streams, and locational grids such as UTM coordinates.

Observers will be trained in the typical techniques used for land use inventories. They will also be given training in the classification scheme employed in the land cover mapping process. They will be provided written guidelines in the form of the LULC class descriptions to assure that consistent, repeatable results are obtained (Appendix A).

The field data for each sampling unit will be assigned a pointer that identifies its location on the land cover map. Reference data will be compiled as a GIS coverage containing both the locations of samples and their attributes. Metadata will include a description of the method used by the SSL analyst to determine agreement between the map and reference data and a measure of observer reliability in order to replicate the published LULC map. Field forms will be archived and GIS data managed in accordance with procedures outlined in this document.

Step 5: Measurements from field sampling units will be compared with labeled polygons on the land cover map. As a first step in statistical analysis, agreements, or lack thereof, will be tabulated in a matrix whose rows represent mapped categories and columns represent observed cover types. The resulting error matrix is a contingency table which represents the probabilities of every possible correct or incorrect classification.

Statistical analyses of the measurements from the assessment sample need to recognize that the data arise from a complex sample. It is not valid to analyze these data as if they are independent and identically distributed. Analyzing data from a stratified two-stage sample as if they were independent and identically distributed will typically lead to confidence intervals which are unrealistically narrow and hypothesis tests which reject too easily. That is, the precision of the analysis is overstated. Proper methods for dealing with data from stratified two-stage samples will be employed in this study. Section B10 described the procedure if the LULC does not achieve 80% accuracy.

Limitations and Constraints: In planning accuracy assessments, three general constraints (technology, logistics, and cost) must be considered because of the limitations they place on the ability to obtain ideal data sets.

Technological constraints: This category of constraints includes measurement errors relating to acquiring field observations. Error in determining the true location of the sampling unit in the field should not be a major problem in Texas because the terrain is moderate and bisected by an elaborate system of roads and highways. Sampling units will be outlined in advance on topographic maps, county road maps, and aerial photos (if available) and provided to field observers. Also, field observers will usually be able to survey entire sampling units, thereby reducing error caused by inadequate integration of all attributes of a unit.

Logistical constraints: Most sampling units will be located in close proximity of a road and can be visited without great expense. Few locations will be inaccessible due to dangerous terrain. If sampling measurements cannot be made at a site due to inaccessibility, then these sites will be dropped from the sampling scheme and replaced with more accessible ones.

Financial constraints: An accuracy assessment will be conducted that is a reasonable balance between available funding and scientific soundness.

LDC and SELECT Data Analysis

Not relevant.

B6 Instrument/Equipment Testing, Inspection and Maintenance

Land Use/Land Cover Update

Equipment testing will be accomplished by the GPS operator prior to, during and after field use. Built-in equipment diagnostics and functionality checks will be utilized in accordance with manufacturer guidelines. Issues will be documented with TIAER.

LDC and SELECT Data Analysis

Not relevant.

B7 Instrument/Equipment Calibration and Frequency

Land Use/Land Cover Update

GPS receivers cannot be calibrated. However, a number of settings can be changed (e.g., maximum PDOP, signal-to-noise ratio, filter coefficient, etc.) which will affect operation of the unit. In general, manufacturer default settings will be employed for optimum data accuracy.

LDC and SELECT Data Analysis

Not relevant.

B8 Inspection/Acceptance of Supplies and Consumables

Land Use/Land Cover Update

The primary consumables for GPS operations are batteries for units that do not use non-removable, rechargeable batteries. During the equipment testing, inspection and maintenance periods, batteries will be examined by the GPS operator for functionality, charge and compatibility with manufacturer's specifications. Fully charged, backup batteries will be taken to the field for use when recharging is not an option.

Supplies used by SSL will be inspected upon receipt by the SSL PM for visible signs of damage. Supplies will be purchased from reputable vendors to ensure quality. TIAER GPS units use rechargeable batteries obviating the need for supply purchase.

LDC and SELECT Data Analysis

Not relevant.

B9 Non-Direct Measurements

The non-direct measurements required for the LULC update, LDC and SELECT data analysis, and the GIS inventory are summarized in Table B9.1 with additional details provided below.

Land Use/Land Cover Update

The display of GPS ground points will be accomplished by overlaying the collected points on map features of comparable quality. This provides a road network, topographic features and other map elements that can place the collected points in the context of real-world features. This is an additional quality check, since large deviations from expected locations would cause the data and processing methods to be rechecked. Standard map products of known quality will be used.

NAIP aerial photos (2004-2010) of the area will be used as the primary data source for constructing the LULC map. NAIP provides two main products: 1 meter GSD ortho imagery rectified to a horizontal accuracy of within +/- 3 meters of reference DOQQs from the NDOP; and, 2 meter GSD ortho imagery rectified to within +/- 20 meters of reference DOQQs. The tiling format of NAIP imagery is based on a 3.75' x 3.75' quarter quadrangle with a 360 meter buffer on all four sides. NAIP quarter quads are rectified to the UTM coordinate system, NAD83 and cast into a single predetermined UTM zone.

Because most historical data are of known and acceptable quality and were collected and analyzed in a manner comparable and consistent with needs for this project, no limitations will be placed on their use, except where known deviations have occurred.

LDC and SELECT Data Analysis

All data used in the modeling procedures for this project were collected in accordance with approved QA measures under the state’s Clean Rivers Program, TCEQ, Texas Water Development Board, USDA, NWS, and USGS. Future data collection carried out by TIAER through Tasks 3 and 5 of the project will be incorporated into the modeling process as the data become available. Those data will be collected under a separate water quality monitoring QAPP for TSSWCB Project 11-50.

GIS data to be used are 2004-2010 NAIP aerial photos, SSURGO and CBMS soils, and NHD, Census data (2000), Census of Agriculture data from USDA NASS (NASS, 2007), and the USGS 30-meter resolution DEM. Depending on the accessibility to the GIS layers from different data sources, efforts will be made to update the spatial data to the most recently available data.

Comprehensive GIS Inventory

Under subtask 4.1 a comprehensive GIS survey will be conducted for the study area. All data used in the GIS survey for this project are collected in accordance with approved QA measures under the TCEQ, Texas Water Development Board, USDA, and USGS. GIS data to be used are 2004-2010 NAIP aerial photos, SSURGO and CBMS soils, USGS NLCD and NHD, Census data (2000), Census of Agriculture data from USDA NASS (2007), and the USGS 30-meter resolution

DEM. Depending on the accessibility to the GIS layers from different data sources, efforts will be made to update the spatial data to the most recently available data.

Because most historical data are of known and acceptable quality and were collected and analyzed in a manner comparable and consistent with needs for this project, no limitations will be placed on their use, except where known deviations have occurred.

Table B9.1 Non-Direct (Acquired) Data Required for LULC, LDCs and SELECT

Data Type	Data Source	Applicable Date or Other Attributes	Use/Relevance
Aerial photography	USDA Farm Service Agency NAIP	2004-2010	LULC development; GIS inventory
Routine ambient water quality data: bacteria, forms of nitrogen	TCEQ, collected by TCEQ and NRA, TCEQ website in SWQMIS	Full historical data range (1970s – present)	LDC development
DEMs 10-m resolution; GIS data	EPA-BASINS website preferred; webGIS, USGS National Seamless Server and GeoCommunity websites as alternatives. [Large data volume.]	N/A	Segmentation delineation and elevation data for SELECT; GIS inventory
Agricultural census data	USDA NASS website	County level agricultural statistics (2007 data)	Input data to SELECT; GIS inventory
Soils data; GIS data (SSURGO)	NRCS website; SSURGO databases [Large data volume]	SSURGO is the most detailed soil maps developed by NRCS	Input data to SELECT; GIS inventory
Daily streamflow for Leona River and adjacent rivers (e.g., Nueces and Frio Rivers)	USGS web site. [Large data volume.]	Streamflow Leona: 3/2003 – present Streamflow: Nueces - 1939 – Present; Frio – 1915 - Present	LDC development of flows using DAR
Edwards Aquifer Level data	Edwards Aquifer Authority website	Aquifer levels for Uvalde (1940 to present)	Aid in development of baseflows for LDCs
Municipal & Industrial WWTF permits	TCEQ	TPDES/NPDES permit	SELECT development; GIS inventory

Data Type	Data Source	Applicable Date or Other Attributes	Use/Relevance
Municipal & Industrial WWTF data (monthly discharged flow)	TCEQ Information Resources Division data and USEPA ECHO website (EPA ICIS-NPDES). [Small data volume. DMR provided by permit holders.]	Limited DMR data available from EPA website; more complete records from TCEQ; preferred data range 1960s to present	LDC and SELECT development; GIS inventory
Miscellaneous geographic data (roads, streams, boundaries, etc.) [Required for physical presentation of maps in reports, largely not needed for modeling.]	TNRIS; North Carolina State Univ. Libraries geospatial data services website; USGS NHD; U.S. Census Bureau website; Montana State University Geographic Locater website. [Large data volume.]	N/A	Input data to SELECT; GIS inventory; development of various maps needed for the project

B10 Data Management

Land Use/Land Cover Update

Field Collection

TIAER staff with guidance from SSL will visit the watershed and verify ground control points identified by SSL for at least ten locations per land use type using GPS receivers with an accuracy of 10 m. Site identification, date, time, personnel, and conditions at the site will be noted on Field Survey Forms (Appendix A).

TIAER staff will validate LULC classification information by navigating to designated locations and documenting the LULC observed. Information will be recorded on the Field Survey Form (Appendix A). Forms will be copied and the copy kept at TIAER prior to hand delivering or mailing the original form to SSL.

All field observations will be manually entered by SSL into an electronic spreadsheet. The electronic spreadsheet will be created in Microsoft Excel software on an IBM-compatible microcomputer with a Windows XP Operating System. The project spreadsheet will be maintained on the computer's hard drive, which is also simultaneously saved in a network folder. All pertinent data files will be backed up monthly on an external hard drive. Current data files will be backed up on read/write (r/w) CDs weekly and stored in a separate area away from the computer.

Original data recorded on paper files will be stored for at least five years. Electronic data files will be archived to CD after approximately one year, and then stored with the paper files for the remaining 4 years.

Spatial Sciences Laboratory Data

Landsat TM imagery arrives in the SSL on CD. It is stored on CD until processing time when it is copied to the hard drive of a workstation. Data forms with field information arrive via hand-delivery or the US mail and are stored in raw form in the lab. Data from the forms are digitized and stored on the hard drive of a computer in the lab. Backup copies of all digital data are made to removable media. All data forms are checked prior to digitizing for accuracy and then after digitizing to assure correspondence to the original form. All necessary data from ancillary sources are digitized or copied to the hard drive of a computer in the SSL and then backup copies are made of the digital data. Where ancillary data have been digitized, the SSL PM checks that the original data correspond correctly to the digitized data.

A combination of IBM compatible microcomputers with a Windows XP Operating System and workstations using the UNIX operating system will be used to process the data. An effort was made to purchase machines with the most memory, largest hard drives and fastest processing speeds that were available at the time. Additional hard drive space and random access memory will be purchased as project needs require. A suite of software will be used to process the data. All software packages are industry standard and represent the best application available for each processing function.

All GIS and LULC data will be backed up on r/w CDs weekly and stored in separate area away from the computer. At least 10% of all data manually entered in the database will be reviewed for accuracy by the SSL Project Lead to ensure that there are no transcription errors. Hard copies of data will be printed and housed in the SSL for a period of five years.

Data Validation

Following LULC classification and delineation, LULC data will be validated and verified with field sampling ground control points to an accuracy of 80% or greater. Any LULC that does not meet this will be re-classified until an accuracy of 80% is achieved. No LULC that does not achieve 80% accuracy will be submitted to the TSSWCB.

Metadata Preparation

Metadata preparation will be accomplished by the GPS operator upon conclusion of the data processing phase using the EPA, *Geospatial Metadata Technical Specification v. 1.0*, November 2007.

Data Dissemination

As classification is completed, the SSL PM will provide a copy of the shapefile or ArcGIS grid format of the LULC via recordable CD media to the TIAER PM and the TSSWCB PM.

LDC and SELECT Data Analysis

Data Handling, Hardware, and Software Requirements

For data handling, TIAER utilizes standard, IBM compatible, desktop personal computers that utilize a MS Windows operating system. TIAER utilizes MS Access 2007 as the primary database management software. TIAER information resources staff is responsible for assuring that hardware configurations meet the requirements for running current and future data management/database software as well as providing technical support. Software include Microsoft® Word, Microsoft® Excel, Microsoft® Access, and a Statistical Analysis System database management system run through Windows XP operating system. All GIS analysis, done at TIAER, will be performed using ArcGIS 9.3.

Record-Keeping and Data Storage

TIAER record-keeping and document control procedures are contained in the TIAER Quality Assurance Manual and this QAPP. Original field and laboratory data sheets are stored in the TIAER offices, laboratory, and storage facility in accordance with the record-retention schedule in Section A9. As an electronic data protection strategy, TIAER utilizes Double Take software to mirror the Primary Aberdeen 1.2TB file server (raid 5 fault tolerant) that will be mirrored to a secondary Aberdeen Abernas211 file server (raid 5 fault tolerant). This provides instant fault recovery rollover capability in the event of hardware failure. TIAER also exercises complete backup of its Primary server to Linear Tape-Open 3 Quantum ValueLoader on a weekly basis, coupled with daily incremental backups. This provides a third level of fault tolerance in the event that both the primary and secondary servers are disabled. TIAER will maintain all cyclic back-up tapes for 26 weeks prior to reuse saving the first tape in the series indefinitely to preserve an historical snapshot. This will facilitate recovery of data lost due to human error. Backup tapes are stored in a secure area on the Tarleton State University campus and are checked periodically to ensure viability. If necessary, disaster recovery can also be accomplished by manually re-entering the data

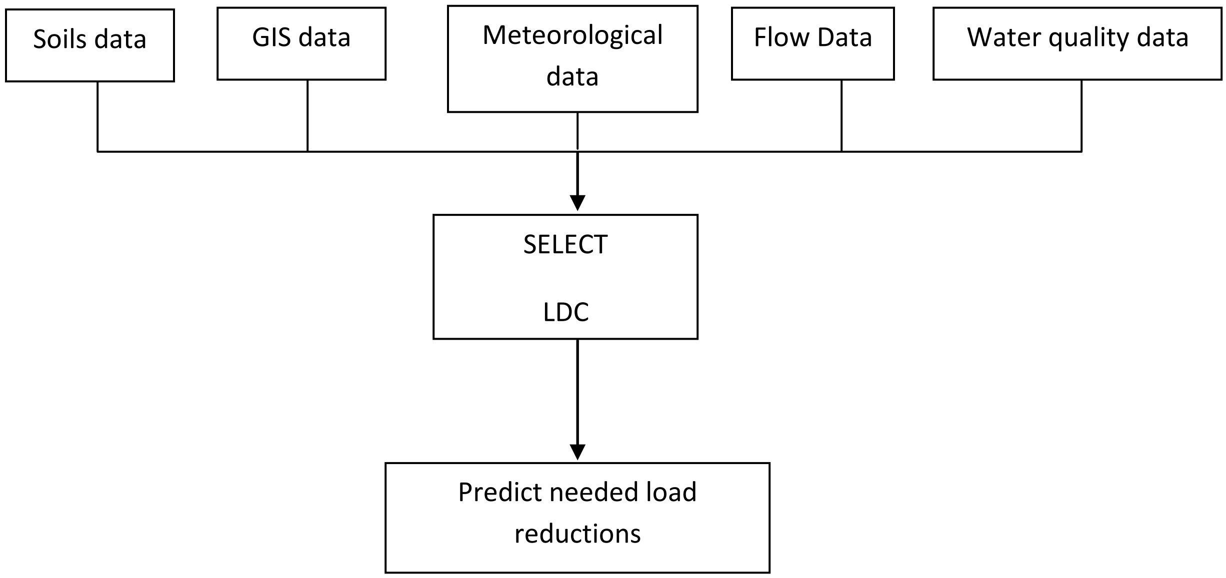
Archives and Data Retention

Original data recorded on paper files are stored for at least five years. Data in electronic format are stored on tape drives in a climate controlled, fire-resistant storage area on the Tarleton State University campus.

Data Path

The data path for information used in the LDC and SELECT data analysis efforts is depicted in Figure B10.1.

Figure B10.1 Data Path Diagram for LDC and SELECT Data Analysis



C1 Assessments and Response Actions

The following table presents types of assessments and response actions for data collection and analysis activities applicable to the QAPP and all facets of the project.

Table C1.1 Assessments and Response Requirements

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TIAER and SSL PMs	Monitor project status and records to ensure requirements are being fulfilled.	Report to TSSWCB in QPRs
Laboratory Inspection	At least once during the project period.	TSSWCB	Analytical and QC procedures employed at the laboratories	45 days to respond in writing to TSSWCB to address corrective actions
Technical Systems Audit	At least once during the project period.	TSSWCB	Assess compliance with QAPP; review facility and data management as they relate to the project	45 days to respond in writing to TSSWCB to address corrective actions
Monitoring Systems Audit	At least once during the project period.	TSSWCB	Assess compliance with QAPP; review field sampling, facility and data management as they relate to the project	45 days to respond in writing to TSSWCB to address corrective actions

In-house review of data quality and staff performance to assure that work is being performed according to standards will be conducted by all entities. If review shows that the work is not being performed according to standards, immediate corrective action will be implemented. CARs will be submitted to TSSWCB and documented in the QPRs.

The TSSWCB QAO (or designee) may conduct an audit of the technical systems activities for this project no less than once over the contractual period of the project. Each entity will have the responsibility for initiating and implementing response actions associated with findings identified during the on-site audit. Once the response actions have been implemented, the TSSWCB QAO (or designee) may perform a follow-up audit to verify and document that the response actions were implemented effectively. Records of audit findings and corrective actions are maintained by the TSSWCB PM and TIAER QAO. CARs will be submitted to the TSSWCB PM with the QPR. If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in agreements or contracts between participating organizations.

Corrective Action Process for Deficiencies

Deficiencies are any deviation from the QAPP. Deficiencies may invalidate resulting data and may require corrective action. Corrective action may include for samples to be discarded and recollected. Deficiencies are documented in logbooks, field data sheets, etc. by TIAER field or laboratory staff or SSL analysts. It is the responsibility of each respective entity's PM or Project Lead, in consultation with the TIAER QAO, to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP. In addition, these actions and resolutions will be conveyed to the TSSWCB PM both verbally and in writing in the QPRs and by completion of a CAR. All deficiencies identified by each entity will trigger a corrective action plan.

Corrective Action

CARs should:

- Identify the problem, nonconformity, or undesirable situation
- Identify immediate remedial actions if possible
- Identify the underlying cause(s) of the problem
- Identify whether the problem is likely to recur, or occur in other areas
- Evaluate the need for Corrective Action
- Use problem-solving techniques to verify causes, determine solution, develop an action plan
- Identify personnel responsible for action
- Establish timelines and provide a schedule
- Document the corrective action

The status of CARs will be included with QPRs. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TSSWCB immediately. The PM or Project Lead of each respective entity is responsible for implementing and tracking corrective actions. Records of audit findings and corrective actions are maintained by the Project Lead or PM of each respective entity. Audit reports and CARs will be submitted to the TSSWCB with the QPRs.

C2 Reports to Management

Reports to TSSWCB Project Management

All reports detailed in this section are contract deliverables and are transferred to the TSSWCB in accordance with contract requirements.

QPRs – Summarize project activities for each task; reports problems, delays, and corrective actions; and outlines the status of each task's deliverables. QPRs will be submitted by TIAER with input provided by each project entity.

Task 4 and 7 Reports – Summarize major tasks and include the following in association with these two tasks covered by this QAPP:

- Technical report describing results from the source survey
- LULC for the watershed in shapefile or ArcGIS grid format
- Draft Technical Report detailing preliminary LDC analysis
- Technical report detailing final LDC analysis
- Technical Report describing watershed modeling results

D1 Data Review, Verification, and Validation

Land Use/Land Cover Update

In summary, this project will use summer and winter scenes of Landsat TM imagery to conduct a general land cover inventory for each watershed. Ancillary data consisting of field surveys, available photography and existing vegetation maps will be used to classify vegetation and label distinct spectrally clustered polygons on the imagery. LULC classification will follow the methods and QC standards outlined in this QAPP (Section A7). The project has a goal of achieving 80 percent accuracy in the overall classification of LULC. The coverage will include the Leona River watershed with a minimum mapping unit of two acres. An independent set of ground reconnaissance data will be obtained to conduct the accuracy assessment analysis. Ground reconnaissance data will be reviewed and validated as outlined in Table D1.1.

Table D1.1 Ground Control Point Data Review, Validation, and Verification Criteria

Data Element	Reviewed By	Validation Criteria
Coordinate Data	SSL Project Lead	Consistent with Sampling Process Design
Coordinate Data	GPS Operator	GPS Mode Matches Field Log & GPS Internal Data
Coordinate Data	GPS Operator	Default Settings Match GPS Internal Data
Coordinate Data	GPS Operator	Standard Deviation below 3 Meters for Acceptance
Coordinate Data	GPS Operator	Good Fit when Data Plotted against Known Locations
Coordinate Data	GPS Operator	Meets National Map Accuracy Standards
Metadata	SSL Project Lead	Meets EPA Guidelines for Metadata Documentation

Because of inherent technological, logistical, and financial constraints (Section B6), it is possible that the accuracy goal may not be achieved for all LULC classes. However, accuracy assessment will be essential for validating the final LULC map and providing the user with a measure of reliability. Only those data that are supported by appropriate QC will be considered acceptable for use.

The procedures for verification and validation are described in Section D2, below. The SSL Project Lead is responsible for ensuring that data are properly reviewed, verified, and submitted in the required format for the project. Finally, the SSL QAO is responsible for validating that all data collected meet the DQOs of the project and are suitable for reporting.

LDC and SELECT Data Analysis

The procedures for verification and validation of data used in water quality modeling analysis are described in Section D2, below. The TIAER Research Scientist is responsible for ensuring that data are properly reviewed, verified, and submitted in the required format for the project database. Finally, the TIAER PM and QAO are responsible for validating that all data collected meet the DQOs of the project and are suitable for reporting.

D2 Verification and Validation Methods

Land Use/Land Cover Update

All field and laboratory data will be reviewed, verified and validated to ensure they conform to project specifications and meet the conditions of end use as described in Section A7. The SSL Project Lead is responsible for the integrity, validation and verification of the data generated or handled throughout each process for the tasks described in Table D2.1. The field and laboratory tasks ensure the verification of all raw data and electronically generated data. The field data will be verified and validated as described in Table D2.1.

Table D2.1 Field Data Verification and Validation Methods

Data Element	Validation Method
Coordinate Data	Compare Sampling Process vs. Field Log and Internal GPS Log
Coordinate Data	Compare GPS Planned Mode vs. Field Log and Internal GPS Log
Coordinate Data	Compare Manufacturer Default Settings vs. Internal GPS Log
Coordinate Data	95% of Coordinate Points fall within National Map Accuracy Standards when overlaid on known quality map features of similar accuracy

Verification, validation and integrity review of LULC data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the SSL PM. The LULC data generated are evaluated against ground control points and project specifications and are checked for errors. Potential outliers are identified by examination for unreasonable data. If a question arises or an error or potential outlier is identified, then issues will be resolved through mutual consultation between the SSL Project Lead, TIAER PM, TIAER QAO, TSSWCB PM, and TSSWCB QAO. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the SSL Project Lead consults with the TIAER PM to establish the appropriate course of action.

The final versions of the land cover maps and the accuracy assessment report will be peer reviewed by TIAER prior to their release to the TSSWCB and the public. Prior to release, the SSL Project Lead has responsibility for reviewing all data and verifying that final products achieve QAPP-defined goals for accuracy, completeness and acceptance criteria. The final version of each land cover map will be conveyed to users as digital GIS files in ArcINFO format on CD-ROM disks. Hard copy maps will also be provided to TIAER and TSSWCB as needed.

The final element of the validation process is consideration of any findings identified during assessments or audits conducted by the TSSWCB QAO. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the SSL Project Lead in coordination with the TIAER QAO validates that the data meet the DQOs of the project and are suitable for reporting to the TSSWCB.

LDC and SELECT Data Analysis

There is no validation and calibration for the SELECT model or LDC as they are data processors.

D3 Reconciliation with User Requirements

Land Use/Land Cover Update

Results of the ground truth survey conducted by TIAER and products developed by SSL will be evaluated against the DQOs established and user requirements to determine if any reconciliation is needed. Reconciliation concerning the quality, quantity or usability of the data will be reconciled with the user during the data acceptance process. Types of reconciliation may include reduction in the scope of the project in terms quality or quantity of data produced in meeting partial user requirements.

Once the final version of each LULC map is produced, the TSSWCB PM will review the product and the accuracy assessment report to determine if they fall within the acceptance limits as defined in this QAPP. Completeness will also be evaluated to determine if the completeness goal for this project has been met. If data quality indicators do not meet the project's requirements as outlined in this QAPP the data may be returned for revisions.

These data, and data collected by other organizations, will subsequently be analyzed and used for watershed assessment and modeling activities. Thus, data that do not meet requirements will not be submitted to the TSSWCB nor will be considered appropriate for any of the uses noted above.

LDC and SELECT Data Analysis

The SELECT modeling framework developed for this project will be used to evaluate bacteria loading in the Leona River watershed. It will provide information pertaining to watershed characteristics and to the prediction of possible pollution, the sources of this pollution and will provide critical information to assist in identifying management practices to prevent pollution loading in area streams.

The LDC framework utilized for this project will be used to evaluate bacteria and nitrogen parameters loading in relation to flow regimes in the Leona River. This approach will utilize historical flow data and flow data collected during this project and pair them with bacteria and nitrogen water quality data to illustrate times when loadings exceeds water quality goals. These analyses will aid in targeting best management practices to the most likely areas of bacteria and nitrate impairment.

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Appendix A

FIELD SURVEY FORM

Date: _______________

Name: ______________________________

Agency: _____________________________

Watershed: __________________________

Site Name: ___________________________

Point No.: _______

UTM Coordinates: ____________________________

OR

Latitude/Longitude: ___________________________

Land Use / Land Cover: Use description in Section A5 to determine LULC for this point:

Developed Open Space_____	Forested Land_____
Developed Low Intensity_____	Near Riparian Forested Land_____
Developed Medium Intensity_____	Low Density Forest_____
Developed High Intensity_____	Rangeland_____
Open Water_____	Pasture/Hay_____
Barren Land_____	Cultivated Crops_____

How confident are you of your assessment?
_____ High confidence _____ Medium confidence _____ Low confidence

Comments:

Appendix B
Corrective Action Report

Corrective Action Report
SOP-Q-105
CAR #:

Report Initiation Date ________ **Report By:** ____________________ **Procedure or QC Typ** ____________________

Deviation: ____________________

Analyte: ____________________

Affected Sample #s: ____________________

Sampling Station: ____________________

Project(s): ____________________

Attached Documentation:
- ☐ COC
- ☐ FDS
- ☐ FlowLink
- ☐ Flow8
- ☐ GM
- ☐ Log Book
- ☐ QC Sheet
- ☐ Memo
- ☐ Other

Details of the problem, nonconformance or out-of-control situation:

Possible Causes:

Corrective Actions Taken:

Corrective Actions Suggested:

CAR routed to: ____________________ **Date:** __________

Supervisor: ○ **Tier 1** (does not affect final data integrity) ○ **Tier 2** (data accepted but flag required) ○ **Tier 3** (possibly affects final data integrity)

Corrective actions taken for specific incident: ____________________

Corrective actions taken to prevent recurrences: ____________________

Corrective actions to be taken: ____________________

Responsible Party: ____________________ **Proposed completion date:** __________

Effect on data quality: ____________________

Responsible Supervisor: ____________________ **Date:** __________

Concurrence:

Program/Project Manager: ____________________ **Date:** __________
(Tier 3 CARs only)

Quality Assurance Officer: ____________________ **Date:** __________

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