TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 21, 2011

Andrew Sansom
Executive Director
River Systems Institute
Texas State University
601 University Drive
San Marcos, Texas 78666-4616

Re: Spring Lake Watershed Characterization and Management Recommendations Report
Quality Assurance Project Plan (QAPP)
Approval Date: June 16, 2011 (Update due: June 16, 2012)

Dear Mr. Sansom:

The above named QAPP has been approved. The original QAPP and signature pages are enclosed as documentation of approval.

In accordance with the terms of the QAPP, **please ensure that copies of this document and any subsequent amendments are distributed to each sub-tier participant as noted in Section A3 of the QAPP.** This approval letter must be available for review during a monitoring systems audit.

Should you have questions, please contact me at (512) 239-0425.

Sincerely,

Kyle Girten
Quality Assurance Specialist

enclosure

cc: Sharon Coleman, Senior Quality Assurance Specialist, MC 165
Lauren Bilbe, Project Manager, MC 203

Spring Lake Watershed Characterization and Management Recommendations Report
Quality Assurance Project Plan

River Systems Institute at Texas State University
San Marcos, Texas 78666

Funding Source:

Nonpoint Source Protection Program CWA §319(h)
Prepared in cooperation with the Texas Commission on Environmental Quality
and the U.S. Environmental Protection Agency
Federal ID #99614613

Effective Period: One year from date of final approval

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

Andrew Sansom
Executive Director
601 University Drive
San Marcos, Texas 78666
(512) 245-9200
as22@txstate.edu

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A1 APPROVAL PAGE

Texas Commission on Environmental Quality

Field Operations Support Division

Stephen Stubbs, QA Manager — Date 6-16-11

Kyle Girten, QA Specialist — Date 6/16/11
Quality Assurance Team

Water Quality Planning Division

Monica Harris, Manager — Date 6/10/2011
Water Quality Planning and Implementation Section

Kerry Niemann, Manager — Date 6/16/2011
Nonpoint Source Program

Nancy Ragland, Team Lead — Date 6/15/11
Data Management and Analysis

Lauren Bilbe — Date 6/9/11
Project Manager, Nonpoint Source Program

Anju Chalise — Date 6/10/2011
Project QA Specialist Nonpoint Source Program

River Systems Institute (RSI) at Texas State University

Andrew Sansom — Date

Benjamin Schwartz, QA Officer — Date 6-7-2011

Weston Nowlin, QA Officer — Date 6-7-2011

Edwards Aquifer Research and Data Center (EARDC)

Joe Guerrero, Laboratory Director — Date 6/7/11

Joe Guerrero, Laboratory QA Officer — Date 6/7/11

The contractor will secure written documentation from additional project participants (e.g., subcontractors, laboratories) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The contractor will maintain this documentation as part of the project's quality assurance records. This documentation will be available for review. (See sample letter in Attachment 1 of this document.)

A2 TABLE OF CONTENTS

A3 DISTRIBUTION LIST

Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

The TCEQ QA Specialist will provide original versions of this project plan and any amendments or revisions of this plan to the TCEQ Project Manager and the RSI at Texas State University Project Manager. The TCEQ Project Manager will provide copies of this project plan and any amendments or revisions of this plan to the TCEQ Data Management and Assessment Work Leader and to the Environmental Protection Agency (EPA) Project Officer within two weeks of approval. The TCEQ Project Manager will document receipt of the plan and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

Nancy Ragland, Team Lead
Data Management and Analysis
MC-234
(512) 239-6546

U.S. Environmental Protection Agency Region 6
State/Tribal Section
1445 Ross Avenue
Suite # 1200
Dallas, TX 75202-2733
Leslie Rauscher, Project Officer
(214) 665-2773

The RSI at Texas State University will provide copies of this project plan and any amendments or revisions of this plan to each project participant defined in the list above. The RSI at Texas State University will document receipt of the plan by each participant and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

River Systems Institute at Texas State University
601 University Drive
San Marcos, Texas 78666

Andrew Sansom, Project Manager
(512)-245-9200

Weston Nowlin and Benjamin Schwartz, Quality Assurance Officers
(512)-245-8794 and (512) 245-7608

Joe Guerrero, Laboratory Supervisor
(512) 245-2329

Joe Guerrero, Laboratory Quality Assurance Officer
(512) 245-2329

List of Acronyms

AWRL	Ambient Water Reporting Limit
AA	Above Quantification
BMP	Best Management Practice
CAP	Corrective Action Plan
CAR	Corrective Action Report
CFS	Cubic Feet per Second
CMP	Continuous Monitoring Program
CTD	Conductivity/Temperature/Depth
COC	Chain of Custody
CVS	Calibration Verification Sample
CWA	Clean Water Act
DMP	Data Management Plan
DMRG	Data Management Reference Guide
DO	Dissolved oxygen
DQO	Data Quality Objectives
EARDC	Edwards Aquifer Research and Data Center
EMC	Event Mean Concentrations
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
GRTS	Grant Reporting and Tracking System
HDPE	High-density Polyethylene
IT	Information Technology
LCS	Laboratory Control Sample (formerly Lab Control Standard)
LCSD	Laboratory Control Sample Duplicate (formerly Laboratory Control Standard Duplicate)
LOD	Limit of Detection
LOQ	Limit of Quantitation (formerly reporting limit)
MS	Matrix Spike
NCR	Nonconformance Report
NELAC	National Environmental Lab Accreditation Conference
NH_4^+	Ammonium
NLCD	National Land Cover Dataset

NO_3^{2-}	Nitrate
NPS	Nonpoint Source
NMP	Nutrient Management Plan
NU	Number of measurements per 24-hour period
NVSS	Non-Volatile Suspended Solids
Ortho-P	Orthophosphate
ORP	Oxidation-Reduction Potential
PPP	Public Participation Plan
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Materials
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QPR	Quarterly Progress Reports
RPD	Relative Percent Difference
RSI	River Systems Institute
SLOC	Station Location
SMRF	San Marcos River Foundation
SOP	Standard Operating Procedure
SpC	Specific Conductance
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TN	Total Nitrogen
TP	Total Phosphorus
TPWD	Texas Parks and Wildlife Department
TSS	Total Suspended Solids
TWQI	Texas Water Quality Inventory
TXSTATE	Texas State University
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

A4 PROJECT/TASK ORGANIZATION

TCEQ

Field Operations Support Division

Kyle Girten
Lead QA Specialist
Assists the TCEQ Project Manager in QA related issues. Serves on planning team for NPS projects. Participates in the planning, development, approval, implementation, and maintenance of the QAPP. Determines conformance with program quality system requirements. Coordinates or performs audits, as deemed necessary and using a wide variety of assessment guidelines and tools. Concurs with proposed corrective actions and verifications. Monitors corrective action. Provides technical expertise and/or consultation on quality services. Provides a point of contact at the TCEQ to resolve QA issues. Recommends to TCEQ management that work be stopped in order to safe guard project and programmatic objectives, worker safety, public health, or environmental protection.

Water Quality Planning Division

Kerry Niemann, Manager
NPS Program
Responsible for management and oversight of the TCEQ NPS Program. Oversees the development of QA guidance for the NPS program to be sure it is within pertinent frameworks of the TCEQ. Monitors the effectiveness of the program quality system. Reviews and approves all NPS projects, internal QA audits, corrective actions, reports, work plans, and contracts. Enforces corrective action, as required. Ensures NPS personnel are fully trained and adequately staffed.

Lauren Bilbe
TCEQ NPS Project Manager
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with projects. Develops lines of communication and working relationships between the contractor, the TCEQ, and the EPA. 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. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP. Assists the TCEQ QAS in technical review of the QAPP. Responsible for verifying that the QAPP is followed by the contractor. Notifies the TCEQ QAS of particular circumstances which may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action.

Anju Chalise
TCEQ NPS Project Quality Assurance Specialist
Assists Lead Quality Assurance Specialist (QAS) with NPS QA management. Serves as liaison between NPS management and Agency Quality Assurance management. Responsible for NPS guidance development related to program QA. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP.

Rebecca Ross
TCEQ NPS Data Manager
Responsible for coordination and tracking of NPS data sets from initial submittal through NPS Project Manager review and approval. Ensures that data is reported following instructions in the Surface Water Quality Monitoring Data Management Reference Guide (January 2010, or most current version). Runs automated data validation checks in SWQMIS and coordinates data verification and error correction with NPS Project Managers' data review. Generates SWQMIS summary reports to assist NPS Project Managers' data reviews. Provides training and guidance to NPS and Planning Agencies on technical data issues. Reviews QAPPs for valid stream monitoring stations. Checks validity of parameter codes, submitting entity code(s), collecting entity code(s), and monitoring type code(s). Develops and maintains data management-related standard operating procedures for NPS data management. Serves on planning team for NPS projects.

RSI at Texas State University

Andrew Sansom
RSI Project Manager
Responsible for ensuring tasks and other requirements in the contract are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with the TCEQ. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Ensures adequate training and supervision of all monitoring and data collection activities. Complies with corrective action requirements.

Weston Nowlin
Contractor QAO
Responsible for coordinating development and implementation of the QA program. Responsible for writing and maintaining the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Responsible for identifying, receiving, and maintaining project QA records. Responsible for coordinating with the TCEQ QAS to resolve QA- related issues. Notifies the contractor Project Manager and TCEQ Project Manager of particular circumstances which may adversely affect the quality of data. Responsible for validation and verification of all data collected according with Table 4

procedures and acquired data procedures after each task is performed. Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques. Conducts laboratory inspections. Develops, facilitates, and conducts monitoring systems audits.

Joe Guerrero
Laboratory Manager
Responsible for supervision of laboratory personnel involved in generating analytical data for this project. Responsible for ensuring that laboratory personnel involved in generating analytical data have adequate training and a thorough knowledge of the QAPP and all SOPs specific to the analyses or task performed and/or supervised. Responsible for oversight of all operations, ensuring that all QA/QC requirements are met, and documentation related to the analysis is completely and accurately reported. Enforces corrective action, as required. Develops and facilitates monitoring systems audits.

Joe Guerrero
Laboratory QAO
Monitors the implementation of the QAM and the QAPP within the laboratory to ensure complete compliance with QA objectives as defined by the contract and in the QAPP. Conducts internal audits to identify potential problems and ensure compliance with written SOPs. Responsible for supervising and verifying all aspects of the QA/QC in the laboratory. Performs validation and verification of data before the report is sent to the contractor. Insures that all QA reviews are conducted in a timely manner from real-time review at the bench during analysis to final pass-off of data to the QA officer.

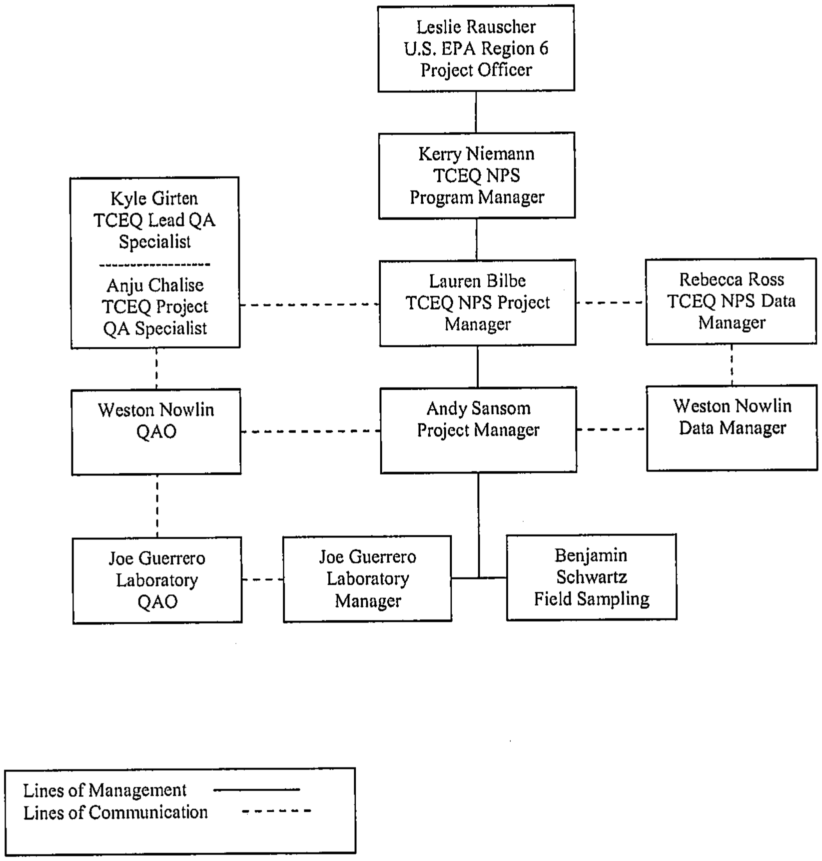
Weston Nowlin
Contractor Data Manager
Responsible for the acquisition, verification, and transfer of data to the TCEQ. Oversees data management for the study. Performs data QAs prior to transfer of data to TCEQ. Responsible for transferring data to the TCEQ in the Event/Result file format specified in the DMRG. Ensures data are submitted according to workplan specifications. Provides the point of contact for the TCEQ Data Manager to resolve issues related to the data.

Benjamin Schwartz
Contractor Field Supervisor
Responsible for supervising all aspects of the sampling and measurement of surface waters and other parameters in the field. Responsible for the acquisition of water samples and field data measurements in a timely manner that meet the quality objectives specified in Section A7 (Table A.1), as well as the requirements of Sections B1 through B8. Responsible for field scheduling, staffing, and ensuring that staff are appropriately trained as specified in Sections A6 and A8.

U.S. EPA Region 6

Leslie Rauscher
EPA Project Officer
Responsible for managing the CWA Section 319 funded grant on the behalf on EPA. Assists the TCEQ in approving projects that are consistent with the management goals designated under the State's NPS management plan and meet federal guidance. Coordinates the review of project workplans, draft deliverables, and works with the State in making these items approvable. Meets with the State at least semi-annually to evaluate the progress of each project and when conditions permit, participate in a site visit on the project. Fosters communication within EPA by updating management and others, both verbally and in writing, on the progress of the State's program and on other issues as they arise. Assists the regional NPS coordinator in tracking a State's annual progress in its management of the NPS program. Assists in grant close-out procedures ensuring all deliverables have been satisfied prior to closing a grant.

Figure A4.1. Organization Chart - Lines of Communication



A5 PROBLEM DEFINITION/BACKGROUND

The San Marcos River is an ecologically unique spring-fed ecosystem located along the margin of the Edwards Plateau in central Texas. Spring Lake, located in the City of San Marcos, is the headwaters of the San Marcos River where artesian spring water from the Edwards Aquifer emerges into the lake from approximately 200 openings. This spring system is the second-most productive in the state. The importance of the springs has become evident during recent droughts. During portions of the 1996 drought, the San Marcos and Comal Springs combined accounted for 70% or more of flows in the Guadalupe River reaching Victoria and nearly 40% of flows that reached the San Antonio Bay.

Spring Lake is a horseshoe-shaped water body with two main regions: the Spring Arm and the Slough Arm. Most of the hydrological inputs to Spring Lake occur from spring openings in the Spring Arm. Sink Creek, the lake's only significant surface water tributary, discharges into the Slough Arm of the lake.

Due to the relatively large spring water influence, Spring Lake and the upper river reaches are characterized by clear water, abundant and productive macrophytes and a relatively large number of endemic and native species. Spring Lake and the upper sections of the river exhibit nearly constant seasonal flows and water temperatures of ~22°C; this relative environmental constancy has led to a high number of endemic species in the headwaters. However, the potential sensitivity of the headwaters to environmental perturbation, and the limited geographic range of many of the spring-adapted organisms, have led to the designation of a large number of federally- and state-listed taxa in the headwaters of the San Marcos River. The San Marcos salamander (*Eurycea nana*), Texas wild rice (*Zizania texana*), the fountain darter (Etheostoma fonticola), the Comal Springs riffle beetle (*Heterelmis comalensis*), and the Texas Blind Salamander (*Typhlomolge rathburni*) are all present in the headwaters, and the Edwards Aquifer immediately below Spring Lake and are listed by US Fish and Wildlife Service as endangered or threatened. The Guadalupe Roundnose minnow (*Dionda nigrotaeniata*) and the Bigclaw River Shrimp (*Macrobrachium carcinus*) also occur in the headwaters, and have been identified by the Texas Comprehensive Wildlife Conservation Strategy as species of "high priority" for conservation.

In addition to the high ecological value of the San Marcos River headwaters, the area also has substantial economic and cultural value for central Texas. Spring Lake and the upper river lie within the Texas State University campus and serve as a focal point for the campus and the City of San Marcos. Thousands of people visit the upper San Marcos every year for recreational activities such as swimming, tubing and kayaking, and glass bottom boat rides in the headwaters. While the exact number of recreational users of the San Marcos River and its headwaters is unknown, approximately 125,000 people per year take part in the various programs at the Aquarena Center on Spring Lake, and the City of San Marcos also estimates that two city parks in the upper section of the river receive more than 600 recreational visitors per day on a typical summer day (e.g., not 4th of July weekend). In addition, there have been major archeological finds of prehistoric human artifacts and animal remains in Spring Lake. Further downstream from Spring Lake, the San Marcos River supplies drinking water for a number of communities in the San Marcos – Guadalupe River drainage, including the cities of San Marcos (49,000 residents) and the City of Victoria (60,000 residents). Water quality and quantity is of principle concern to communities below the San Marcos River – Guadalupe River confluence because they are highly dependent upon the San Marcos River contribution to river flows, especially during relatively dry periods.

Texas State University and the City of San Marcos have taken significant measures to protect the water quality of Spring Lake. The University, a public institution currently owns the land the lake sits on and acts as a steward to protect the lake's current state. The city has put in place special ordinances to ban swimming and boating in the lake to protect endangered species habitat in the lake. Additionally, the city partners with the university to monitor water quality in the lake (bacterial testing). The City has acquired and will preserve 251 acres of land from a developer who had planned to build a conference facility immediately upstream of Spring Lake. The stormwater from this property flows directly into Spring Lake and Sink Creek just upstream of the lake. The most current plans for local action include a Watershed Protection Plan that will begin in the next few years. At this time, the City of San Marcos and Texas State University are funding a half-time watershed planner position.

Spring Lake has never been consistently monitored to collect the data necessary to assess the water body for the Texas CWA'305(b) Water Quality Inventory and CWA'303(d) List, despite the varied research projects conducted by faculty and students at Texas State University. Under a separate project funded with State dollars, TCEQ and the River System Institute (RSI) are working to deploy and operate two continuous water quality monitoring stations to collect temperature, dissolved oxygen, pH and specific conductance data sufficient to assess Spring Lake in the 2011 CWA 305(b) assessment. Data collected by the proposed project will augment the TCEQ/RSI data set with nutrient data from springs, and various reaches of Sink Creek. This represents a critical early step in characterizing the watershed to Spring Lake and Sink Creek.

Until now, there has not been an attempt to obtain high-resolution quality assured event-based data in order to target nutrient inputs to the lake or determine the influence of various sources of water on the algae and turbidity of the lake. What is known is that despite the system's high ecological, economic and cultural value, Spring Lake and the upper San Marcos River have recently experienced increased turbidity and major algal blooms following substantial rainfall events and the associated increases in surface and subsurface flows. Although there is an obvious and sometimes persistent deterioration of water quality during and after periods of high surface and ground water inputs to the lake, the relative pollutant load contributions of these sources in the watershed is unknown. Thus, determination of the relative nutrient and sediment inputs to the lake from the various hydrological sources is critical for the management and preservation of the lake. In particular, determination of inputs of phosphorus (P) are of greatest concern because productivity of the lake is extremely phosphorus limited due to the low levels of immediately bioavailable phosphorus (<5 µg orthophosphate - P/L) relative to the high levels of bioavailable nitrogen (~1600 µg NO_3^{2-} - N/L).

Among the potential sources of nutrient perturbation to the lake, one of the most likely sources is Sink Creek. Currently, the Sink Creek watershed is experiencing rapid and major land use changes. Sink Creek was historically an ephemeral stream that drained ranching and agricultural areas. However, rapid urban development along the I-35 Austin-San Antonio corridor has led to a substantial increase in impervious cover and urban lands in the watershed. Most of the land within the Sink Creek watershed is privately owned; however, the City of San Marcos recently purchased approximately 250 acres within the watershed as part of a "greenbelt" and the uppermost headwaters of Sink Creek are located on Freeman Ranch, a property owned by Texas State University. Because Sink Creek discharges into the relatively shallow and productive Slough Arm of Spring Lake, incidents of high precipitation and high surface waters inflows may function as the major contributor to the deterioration of lake water quality because of the land use changes within the Sink Creek watershed.

The relative contribution of nutrients from the spring openings during periods of high discharge also remains unclear. During periods of low precipitation and surface flows (e.g., summer and early fall) groundwater dominates hydrological and nutrient inputs to the lake. However, groundwater discharges to the lake also increase with precipitation, but the relative contribution of these groundwater flows to nutrient loading during high flow periods is unknown. In addition, there are numerous spring openings in Spring Lake that vary in flow rate and groundwater sources. Some openings discharge water from largely local sources, while other openings can discharge water from regional sources that are much older (>250 km away and >50 years old). The relative contribution of these various groundwater sources and how they vary seasonally and with local precipitation patterns is also unclear.

Another potential nutrient source to Spring Lake and the upper San Marcos River is the Texas State University Golf Course. The course lies immediately adjacent to the middle portion of the Slough Arm of Spring Lake, and maintenance practices from the course may lead to nutrient and sediment inputs to the lake. Again, the relative contribution of nutrient runoff from the golf course to algal blooms in the lake remains unknown.

Given the recent substantial water quality issues and the ecological, economic and cultural value of the Spring Lake system, understanding the relative NPS contributions of nutrients and suspended materials to Spring Lake via groundwater, the Sink Creek watershed, and the Texas State Golf Course is critical to preserve the biota and water quality of the lake.

This project takes an innovative approach to monitoring water quality and quantity from two distinct sources: ground water and surface water. The combination of tools and resources will help to provide a well-rounded description of the nutrient budget of Spring Lake and of watershed activities. These monitoring techniques will serve as an excellent example for the Central Texas Edwards Aquifer region, the state, and the nation by providing standard operating procedures for data analysis using different methods of water quantity and quality data collection.

This QAPP is reviewed by the TCEQ to help ensure that data generated for the purposes described above are scientifically valid and legally defensible. This process helps ensure that all data submitted to SWQMIS have been collected and analyzed in a way that guarantees their reliability and therefore can be used in water quality programs deemed appropriate by the TCEQ.

A6 GENERAL PROJECT/TASK DESCRIPTION

These monitoring programs and analyses outlined in this QAPP will provide the data required to (1) calculate a nutrient budget for Spring Lake and (2) to determine whether NPS nutrients arrive via Sink Creek, runoff from the Texas State University (TXSTATE) golf course, from groundwater sources (spring discharge), or a combination of these. These data, along with results from a Continuous Monitoring Program, a Storm Flow Monitoring Program, and a Routine Monitoring Program, will be presented to stakeholders to inform them of potential linkages between present and future land use practices and water quality of the lake. This last part of the NPS program will identify nutrient load reduction priorities and will be employed in creation of a report detailing recommended management measures with stakeholder input for potential future management strategies for Spring Lake and the watershed. Determination of the relative NPS contributions of groundwater, the Sink Creek watershed, and the Texas State Golf Course to water quality and algal problems in Spring Lake and the upper San Marcos River will aid in the identification of various NPS and point-source contributors to Spring Lake and the upper San Marcos River. Verifying NPS contributions to Spring Lake will aid in the protection of water quality for endangered species habitat and a tremendously important economic and cultural resource for central Texas. In addition, determination of NPS contributions can aid future investigation activities.

Implementation of the NPS assessment project for Spring Lake and the Upper San Marcos River will be conducted in five main parts. The first part of the NPS program will be a Continuous Monitoring Program which will continuously monitor basic water parameters at the major spring openings and in the Slough Arm of the lake. The second part of this project, a Storm Flow Monitoring Program, will monitor the nutrient and suspended solid loading from the Sink Creek watershed into the Slough Arm of Spring Lake. The third part of this project will establish a gauging station on Sink Creek just upstream from the Slough Arm of Spring Lake. Discharge measurements from this site will be coupled with the data from the Storm Flow Monitoring Program so that nutrient and suspended solid loads to Spring Lake from the Sink Creek watershed can be calculated. The fourth part of the Spring Lake NPS program will be a Routine Monitoring Program which will collect water quality and nutrient data at regular time intervals from Spring Lake to examine spatial and temporal patterns of nutrients within the lake. The last (fifth) part of this study part of this study will use GIS and remote sensing platforms to analyze land use characteristics of the Spring Lake and Sink Creek watersheds.

The first part of the project, The Continuous Monitoring Program within Spring Lake and the Sink Creek watershed, will determine the relative importance of surface water and ground water inflows to the nutrient and suspended solid inputs to Spring Lake. It is critical to note that the sites for the Continuous Monitoring Program will not be formally a part of TCEQ's CWQMN Program because the data will not be real-time transmitted to the TCEQ; however, the monitoring sondes in this portion of the project will collect continuous data that will be periodically downloaded from sondes and then sent to the TCEQ. Continuous Monitoring Program sites will be established at six locations in the lake to continuously measure and log basic water quality parameters. The six sites are located throughout the lake; five of the locations will be located within major spring openings/areas in the lake and one site will be in the Slough Arm of the lake. The Continuous Monitoring Program instruments (TROLL 9500 Professional-XP probes) will continuously measure and data-log temperature, dissolved oxygen (DO), specific conductance (SpC), pH, oxidation-reduction potential (ORP), and turbidity at high temporal resolution. Sondes will be programmed to collect these data every 15 minutes and data will be downloaded from sondes on a three- to four-week basis. TXSTATE will retrieve and download data from sondes (via SCUBA divers), and calibrate the sondes, and redeploy them into the lake within a 24 hour period.

If any of the continuously-monitored spring openings respond to precipitation or storm water flow events, then TXSTATE will target these spring openings for high-frequency sampling (via grab samples by SCUBA divers) to examine how spring openings respond to storm events. High resolution sonde data (temperature, DO, SpC, and turbidity) will be examined in relation to rainfall and storm events to determine if any spring openings merit additional high-frequency sampling. If specific spring openings obviously respond to storm events, then the high-frequency sampling will be conducted under the Storm Flow Monitoring Program (see section below). For example, if the turbidity and/or the SpC of the water emerging from a specific spring opening abruptly changes (e.g., a >10% change from the baseline or pre-storm values) during or after a storm event, then that spring opening will be targeted for high resolution sampling. Because it is unknown if the water quality of spring openings (and furthermore which spring openings) respond to rainfall and storm events, integration of this sampling is not included in this version of the QAPP; however, if high-frequency storm sampling of spring openings is deemed necessary, then TXSTATE will revise the QAPP to include any sites in the Storm Flow Monitoring sampling design.

The second portion of the project, the Storm Flow Monitoring Program, will sample three sites along the length of Sink Creek to determine NPS nutrient contributions from various portions of the watershed to Spring Lake. The three storm water sampling sites will be positioned within the watershed at the following locations: (1) within Sink Creek at the gaging station (see below) at the Lime Kiln Road crossing, (2) within Sink Creek below the largest retention structure on Freeman Ranch, and (3) within Sink Creek inside the headwaters location in Freeman Ranch.

Water samples from these sites will be collected by automated water samplers (Teledyne-ISCO 6712 Full-Size Samplers) which will collect water samples when there is flow present; Sink Creek is dry much of the time and only flows during storm events. Water samples collected by the automated samplers will be analyzed for total phosphorus (TP), orthophosphate - P, total

Kjeldahl N, Ammonia – N, Nitrate – N, and total suspended solids (TSS).

The nutrient and TSS data from the sampling site within Sink Creek at the gaging station at the Lime Kiln Road crossing will be coupled with surface water discharge values from the gaging station to calculate nutrient loading to the lake from the Sink Creek watershed. The site is located approximately 500 m upstream from the Slough Arm of the lake, thus will provide a reasonable estimate of the nutrients and TSS entering the lake. The masses (loading) of N, P, and TSS to the Slough Arm of the lake from the Sink Creek watershed will be calculated as

$$Q * C_{\text{N, P, or TSS}} * T = M_{\text{N, P, or TSS}}$$

where,

Q = the measured discharge from the Sink Creek gaging station just upstream from the lake

$C_{\text{N, P, or TSS}}$ = the concentration of N (nitrate-N, TKN, Ammonia-N), P (dissolved orthophosphate, total P) or TSS in the stream water during a storm pulse event at the gaging station.

T = the amount of time the ISCO sampler collected samples from flows (determined by the number of bottles filled during a storm event)

M = mass of constituent entering the Slough Arm of Spring Lake.

The third portion of the project involves the installation and operation of a hydrological gauging station on Sink Creek at the Lime Kiln Road crossing, located approximately 500 m upstream from the Slough Arm of Spring Lake. This site is dry a majority of the time, but during storm flow events, the creek will flow and water will discharge into Spring Lake. The installation of a gauging station is necessary to determine hydrological inputs, and thus nutrient loading from the Sink Creek watershed (see the second part of the project above). The USGS currently operates a gauging station on the San Marcos River below the outflow of Spring Lake; however, surface water inflows to the lake via the Sink Creek watershed are unknown. Construction of a hydrological and nutrient budget for the lake to determine the relative importance of nutrient loading from the Sink Creek watershed requires that we install the gauging station to measure hydrological inflows from Sink Creek.

The gauging station will consist of installing a pair of pressure transducers where Sink Creek runs underneath Lime Kiln Road. At the site, one pressure transducer will continuously measure atmospheric pressure above the high water line. Another pressure transducer will be mounted on the bottom of a concrete box culvert. Using these two coupled pressure transducers, TXSTATE will construct a discharge - pressure relationship and generate a rating curve. When flow is present at the site, a portable water velocity meter will be used to calculate discharge and these discharge measurements will be used (with the water pressure measurements) to generate the rating curve.

The fourth part of the Spring Lake NPS program will be a Routine Monitoring Program which will collect water quality and nutrient data at regular time intervals from Spring Lake and the upper river to examine spatial and temporal patterns of nutrients and TSS. There will be five sites monitored in the Slough and Spring Arms of the lake as well as in the upper San Marcos River. One site in the Slough Arm will be located in the upper Slough Arm at the bridge that crosses the Slough Arm and the second will be located downstream from the University golf course and immediately above the confluence with the Spring Arm of the lake. One site in the Spring Arm will be located approximately half-way down the arm, downstream from the major spring openings. The other site in the Spring Arm is located downstream from the confluence of the Slough Arm, but above the outfall of the lake (the waterfall at the old grist mill). These four sites in the lake were selected because they provide adequate spatial resolution to assess water quality throughout the lake and can be used to infer the influence of various features of the watershed/lake that can influence water quality (e.g., the golf course, major spring openings). The last Routine Monitoring site will be located 50 m downstream from the waterfall in the San Marcos River at the USGS San Marcos River Gaging Station. This location was selected because it will serve as an 'integrator' across all of the inputs to the upper river and Spring Lake. All sites will be sampled every 2 to 3 weeks, regardless of flow or meteorological conditions (i.e, a storm flow event is occurring at the time of sampling). All sites will be sampled for TP, orthophosphate - P, total Kjeldahl N, Ammonia – N, Nitrate – N, and TSS.

The last (fifth) part of this study will use GIS and remote sensing platforms to analyze land use characteristics of the Spring Lake and Sink Creek watersheds. Land-use data within the Sink Creek watershed will be from the most recent USGS/NLCD database. All data will be extracted using ArcInfo. The generation of data on landuse/landcover is not specifically covered in this QAPP. Data on landuse/landcover will be coupled with existing dye-trace and other hydrogeologic data to evaluate the most likely contributing zones for spring openings which may significantly contribute to Spring Lake. Maps of hydrologic and dye-trace data obtained from outside sources not associated with this project will be coupled with the landuse/lancover GIS data to depict the most likely source regions to springs in Spring Lake. The details of these outside data sources and the acceptance criteria are provided in Section B9 of this QAPP.

Revisions to the QAPP

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The most recently approved QAPPs shall remain in effect until revisions have been fully approved; reissuances (i.e., annual updates) must be submitted to the TCEQ for approval 60 days before the last version has expired. 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 and a copy of new, signed approval pages for the QAPP.

Amendments
Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives, and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the contractor Project Manager to the TCEQ Project Manager in writing using the QAPP Amendment shell. The changes are effective immediately upon approval by the TCEQ NPS Project Manager and QA Specialist, or their designees.

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 Contractor 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.

See Appendix B for the project-related work plan tasks related to data collection and schedule of deliverables for a description of work defined in this QAPP.

See Section B1 for monitoring to be conducted under this QAPP.

A7 QUALITY OBJECTIVES AND CRITERIA

Quantitative and qualitative information regarding measurement data needed to determine nutrient and sediment loading to Spring Lake and calculate a nutrient budget for the lake are given below in Tables A7.2 and A7.3.

The Continuous Water Quality Monitoring Program will be conducted to obtain information on the relative importance of surface water and ground water inflows to the nutrient and suspended solid inputs to Spring Lake. Several spring openings and the Slough Arm of the lake will be monitored to examine the temporal dynamics of water quality in the lake. Some of the data (temperature, dissolved oxygen, specific conductance, and turbidity) downloaded from sondes will be averaged over 24-hour time periods and uploaded, along with an accompanying number of measurements in each 24-hour time period, to TCEQ's Surface Water Quality Monitoring Information System (SWQMIS). The minimum and maximum values of pH over a 24-hour time period will be uploaded to SWQMIS.

The Storm Flow Monitoring Program will be used to estimate the nutrient and sediment loading to Spring Lake from the Sink Creek watershed. In addition, the concentration of nutrients and TSS from different points in the Sink Creek watershed will be used to identify locations within the watershed that may function as potential problematic areas in need of future attention. The nutrient and TSS concentration data will be uploaded into TCEQ's SWQMIS.

The Lime Kiln Road gauging station will be used to measure hydrological inputs to Spring Lake from the Sink Creek watershed. The hydrological inputs will be coupled with the nutrient and

TSS concentration data from the Lime Kiln Road crossing Storm Flow Monitoring site to calculate nutrient and sediment loading to Spring Lake from the Sink Creek watershed.
The Routine Monitoring Program will be collected via manual grab samples and will be used to determine the spatial and temporal variation in nutrients and TSS in Spring Lake and the upper San Marcos River. In addition, data will be used to infer the influence of various features of the watershed/lake that can influence water quality as well as the influence that spring water flows can have in buffering the potentially turbid and nutrient rich storm flows. Data will be imported into TCEQ's SWQMIS.

Only data collected that have valid TCEQ parameter codes assigned in Tables A7.1 – A7.4 will be stored in SWQMIS. Any parameters listed in these tables that do not have valid TCEQ parameter codes will not be stored in SWQMIS.

The Spring Lake Watershed Characterization and Management Recommendations Project will employ methods and techniques which have been determined to produce measurement data of a known and verifiable quantity which are sufficient to meet the objectives of the project.

The Measurement Quality Objectives (MQOs) and the Data Quality Objectives (DQOs) of the project are outlined in Tables A7.1, A7.2, A7.3, and A7.4. Although this project is not a site under the TCEQ's Continuous Water Quality Monitoring Network (CWQM), the quality control of this project has been developed to closely follow the objectives of that program, where possible.

A7.1 Continuous Water Quality Monitoring Program

Continuous Monitoring sites will be established in the lake and maintained for 3 years to continuously measure and log basic water quality parameters. The Continuous Monitoring Program instruments (TROLL 9500 Professional-XP multi-probes) will continuously measure and data-log temperature, dissolved oxygen (DO), specific conductance (SpC), pH, oxidation-reduction potential (ORP), and turbidity at high temporal resolution (every 15 minutes). Temporal patterns in data from springs will be directly coupled with temporal patterns in surface water discharge to the lake and with local precipitation data collected from the Spring Lake Meteorological Station (maintained and operated by the RSI).

Table A7.1 DQOs for Continuous Water Quality Monitoring TROLL 9500 Professional-XP Sondes

Parameter	Parameter Code	Units	Measurement Equipment	Method	Calibration Verification Sample (CVS)**
pH	00215 and 00216	pH/ units	In-Situ TROLL 9500 Professional-XP	Std. Method 4500-H⁺, EPA 150.2	± 0.5 pH units
pH	00223	NU	In-Situ TROLL 9500 Professional-XP	NA	NA
Dissolved Oxygen	89857	mg/L	In-Situ TROLL 9500 Professional-XP	ASTM #D88-05 Method C	% Saturation ±6% ±0.5 mg/L
Dissolved Oxygen	89858	NU	In-Situ TROLL 9500 Professional-XP	NA	NA
Specific Conductance	00212	µS/cm	In-Situ TROLL 9500 Professional-XP	Std. Method 2510, EPA 120.1	≤5% RPE
Specific Conductance	00222	NU	In-Situ TROLL 9500 Professional-XP	NA	NA
Temperature	00209	°C	In-Situ TROLL 9500 Professional-XP	Std. Method 2550B	+5% °C
Temperature	00221	NU	In-Situ TROLL 9500 Professional-XP	NA	NA
Tubidity	20485	NTU	In-Situ TROLL 9500 Professional-XP	ISO 7027	NA
Tubidity	20488	NU	In-Situ TROLL 9500 Professional-XP	NA	NA

*** CVS criteria for use in the 305(b) and 303(d) Lists per SWQM DQOs.*
NA = Not applicable, NU = Number of measurements in a 24 hour period, with sampling every 15 minutes (96 per 24-hours).

A7.2 Storm Flow Monitoring Program

The Storm Flow Monitoring Program will be used to estimate the nutrient and TSS loading to Spring Lake from the Sink Creek watershed. In addition, the concentration of nutrients and TSS from different points in the Sink Creek watershed will be used to identify locations within the watershed that may function as potential problematic areas in need of future attention.
Water samples collected by automated Teledyne-ISCO water samplers will be analyzed for total phosphorus (TP), orthophosphate - P, total Kjeldahl N, Ammonia – N, Nitrate – N, and total suspended solids (TSS).

Table A7.2 Measurement Performance Specifications for Storm Flow Monitoring Program (Automatic ISCO Water Samplers)

Parameter	Units	Matrix	Method	Parameter Code	AWRL	Limit of Quantitation (LOQ)	Recovery at LOQ (%)	Precision (RPD of LCS/LCSD)	Bias % Rec. of LCS	Completeness (%)
Total Phosphorous	mg/L	Water	SM 4500 PE	00665	0.06	0.05 mg/L	70-130	20	80-120	90
Orthophosphate - P	mg/L	Water	SM 4500 PE	70507	0.04	0.05 mg/L	70-130	20	80-120	90
Total Kjeldahl - N	mg/L	Water	EPA 351.2	00625	0.20	0.74 mg/L	70-130	20	90-110	90
Ammonia - N	mg/L	Water	EPA 351.1	00610	0.10	0.39 mg/L	70-130	20	90-110	90
Nitrate+Nitrite - N	mg/L	Water	EPA 353.2	00630	0.05	0.36 mg/L	70-130	20	90-110	90
Residue - Total Non-filterable	mg/L	Water	SM 2540 D	00530	4.00	2.5 mg/L	70-130	20	80-120	90

**the most up-to-date Ambient Reporting Limit (AWRL) is located at http://www.tceq.state.tx.us/assets/public/compliance/monops/crp/QA/awrlmaster.pdf*
** Data qualifier "AA" will be added to all orthophosphate, TKN, ammonia, and nitrate/nitrate data submitted to SWQMIS for this project.

References: US EPA Methods for Chemical Analysis of Water and Wastewater, Manual #EPA-600/4-79-020. American Public Health Association, American Water Works Association and Water Environment Federation, *Standard Methods for the Examination of Water and Waste Water*, 20th Ed., Texas Commission on Environmental Quality *Surface Water Quality Monitoring Procedures*, Volume 1

A7.3 Gauging Station at Lime Kiln Road Crossing for Hydrological and Nutrient Load Calculations

The installation, operation, and maintenance of the hydrological gauging station on Sink Creek at the Lime Kiln Road crossing will allow for determination of hydrological inputs, and thus nutrient loading from the Sink Creek watershed (see the Storm Flow Monitoring portion of the project). At the site, one pressure transducer (Schlumberger Baro-Diver) will continuously measure atmospheric pressure and another pressure/temperature/conductivity (CTD) logger (Schlumberger CTD-Diver) will be mounted on the bottom of the box culvert. A discharge – water pressure relationship will be used to generate a rating curve for the site. During storm events, a Marsh McBirney Flo-Mate portable water velocity meter will be used to calculate instantaneous discharge at the site. Pressure data from both transducers will be downloaded after the stormflow event.

Table A7.3 DQOs for Marsh-McBirney Flo-Mate Portable Flow Meter and Schlumberger Baro-Diver and CTD-Diver Pressure Transducers

Parameter	Parameter Code	SOP	Units	Method	Range	Resolution	Accuracy
Volumetric Flow Rate, Water Velocity	00061	Shallow Water (Intermittent Streams)	CFS	Marsh-McBirney Flo-Mate Portable Flow Meter	-0.5 to +20 ft/s	Velocity: 0.01ft Discharge: 0.1 ft/s	Velocity: + 2% of reading, plus zero stability Discharge: TBD
Stage, water depth	00065	AMPM-0008	Feet	Schlumberger CTD-Diver Schlumberger Baro-Diver	Temp (both instruments): -20°C to –80°C CTD Pressure: 10 m H2O Baro-Diver Pressure: 1.5 m H2O	Both Instruments Temp: 0.01°C Pressure: 0.2 cm H2O	Both Instruments Temp: + 0.1°C Pressure: + 0.5 cm H2O

A7.4 Routine Water Quality Monitoring Program

The Routine Monitoring Program which will collect water quality and nutrient data at regular time intervals from Spring Lake and the upper river to examine spatial and temporal patterns of nutrients and TSS. Five sites located throughout Spring Lake and the upper San Marcos River will be sampled every 2 to 3 weeks for TP, orthophosphate - P, total Kjeldahl N, Ammonia – N, Nitrate – N, and TSS.

Table A7.4 Measurement Performance Specifications for Routine Monitoring Program (Grab Samples)

Parameter	Units	Matrix	Method	Parameter Code	AWRL	Limit of Quantitation (LOQ)	Recovery at LOQ (%)	PRECISION (RPD of LCS/LCSD)	BIAS %Rec. of LCS	Completeness (%)
Total Phosphorus	mg/L	water	SM 4500 PE	00665	0.06	0.05 mg/L	70 – 130	20	80 - 120	90
Orthophosphate - P	mg/L	water	SM 4500 PE	70507	0.04	0.05 mg/L	70 – 130	20	80 - 120	90
Total Kjeldahl-N	mg/L	water	EPA 351.2	00625	0.2	0.74 mg/L	70 – 130	20	90 - 110	90
Ammonia - N	mg/L	water	EPA 350.1	00610	0.1	0.39 mg/L	70 – 130	20	90 - 110	90
Nitrate+Nitrite – N	mg/L	water	EPA 353.2	00630	0.05	0.36 mg/L	70 – 130	20	90 - 110	90
Residue - Total Non-filterable	mg/L	water	SM 2540 D	00530	4	2.5 mg/L	70 – 130	20	80 - 120	90

*the most up-to-date Ambient Reporting Limit (AWRL) is located at http://www.tceq.state.tx.us/assets/public/compliance/monops/crp/QA/awrlmaster.pdf
** Data qualifier "AA" will be added to all orthophosphate, TKN, ammonia, and nitrate/nitrate data submitted to SWQMIS for this project.

References: US EPA Methods for Chemical Analysis of Water and Wastewater, Manual #EPA-600/4-79-020. American Public Health Association, American Water Works Association and Water Environment Federation, *Standard Methods for the Examination of Water and Waste Water*, 20th Ed., Texas Commission on Environmental Quality *Surface Water Quality Monitoring Procedures*, Volume 1

Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. It is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions, and is an indication of random error.

For the Continuous Water Quality Monitoring Program, precision will be assessed through the bi-monthly to monthly use of calibration verification standards (CVSs). These standards are provided in Appendix J. The CVS is a verification standard and not an actual calibration standard. If data collected from the sondes are not bracketed by a successful CVS, the data will not be entered into SWQMIS.

For the Storm Flow Monitoring Program and the Routine Water Quality Monitoring Program, field splits will be used to assess the variability of sample handling, preservation, and storage, as well as the analytical process, and will be prepared by splitting samples in the field. Control limits for field splits are defined in Section B5.

Laboratory precision is assessed by comparing replicate analyses of laboratory control samples in the sample matrix (e.g. deionized water, sand, commercially available tissue) or sample/duplicate pairs in the case of bacterial analysis. Precision results are compared against measurement performance specifications and used during evaluation of analytical performance. Program-defined measurement performance specifications for precision of the samples collected for the Storm Flow Monitoring and the Routine Monitoring Programs are defined in Tables A7.2 and A7.4.

Bias

Bias is a statistical measurement of correctness and includes multiple components of systematic error. A measurement is considered unbiased when the value reported does not differ from the true value.

For the Continuous Water Quality Monitoring Program, bias will be assessed through the bi-monthly to monthly use of CVSs with known levels of the parameters to be measured. Results will be compared against measurement performance specifications. Program defined measurement performance specifications for bias in the Continuous Water Quality Monitoring Program are specified in Table A7.1.

For the Storm Flow Monitoring Program and the Routine Water Quality Monitoring Program, bias will be determined through the analysis of laboratory control samples and LOQ Check Standards prepared with verified and known amounts of all target analytes in the sample matrix (e.g. deionized water, sand, commercially available tissue) and by calculating percent recovery. Results will be compared against measurement performance specifications and will be used during evaluation of analytical performance. Program-defined measurement performance specifications for bias in the Storm Flow Monitoring and the Routine Monitoring Programs are specified in Tables A7.2 and A7.4.

Representativeness

Site selection, the appropriate sampling regime, the sampling of all pertinent media according to TCEQ SOPs, and use of only approved analytical methods will assure that the measurement data represents the conditions at the site. The data collected as a part of the Continuous Water Quality Monitoring Program (conducted with multiple multi-probe sondes) are considered to be spatially and temporally representative of the full range of water quality conditions over time. Continuous data are collected on a routine frequency and separated by even time intervals. For this project, water quality sondes will collect data from their respective sites every 15 minutes. For the Sink Creek Gauging Station and the Storm Flow Monitoring portions of the project, the sampling will define the frequency and magnitude of hydrological, nutrient, and suspended solid inputs to Spring Lake. In addition, the intent of the Storm Flow Monitoring program is to determine spatial differences in the water quality of runoff from different portions of the Sink Creek watershed as well as the temporal variability (within individual storm flow events and across storm events occurring in different seasons) in storm flow events. Storm water samples, which will be measured for the parameters listed in Table A7.2, will be collected for the duration of storm flow events. The temporal sampling regime of the automated water samplers during a storm event (six samples in the first 5 minutes, then six every 15 minutes, then six samples every 30 minutes, and then six samples every hour) will be used to accurately represent the overall water quality of each storm event. The data collected as a part of the Routine Water Quality Monitoring Program will be representative of the spatial and temporal variation in Spring Lake and the upper San Marcos River in the parameters provided in Table A7.4. Routine data collected for water quality assessment are considered to be spatially and temporally representative of routine water quality conditions. Water quality data are collected on a routine frequency and are separated by approximately even time intervals. In the Routine Water Quality

Monitoring portion of this project, samples will be collected every two to three weeks from all sites and, due to the regular sampling interval the sampling will not be biased toward any unusual conditions of flow, runoff, or season. At a minimum, samples will be collected over at least two seasons (to include inter-seasonal variation) and over two years (to include inter-year variation). Although data may be collected during varying regimes of weather and flow, the data sets will not be biased toward unusual conditions of flow, runoff, or season. The goal for meeting total representation of Sink Creek and Spring Lake will be tempered by the potential funding for complete representativeness.

Completeness

The completeness of the data is basically a relationship of how much of the data is available for use compared to the total potential data. Ideally, 100% of the data should be available. However, the possibility of unavailable data due to accidents, insufficient sample volume, broken or lost samples, etc. is to be expected. Therefore, it will be a general goal of the project that 90% data completion is achieved.

Comparability

Confidence in the comparability of routine data sets for this project and for water quality assessments is based on the commitment of project staff to use only approved sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP and in TCEQ SOPs. Comparability is also guaranteed by reporting data in standard units, by using accepted rules for rounding figures, and by reporting data in a standard format as specified in Section B10.

Limit of Quantitation

AWRLs (Tables A7.2 and A7.4) are used in this project as the *limit of quantitation (LOQ)* specification, so data collected under this QAPP can be compared against the TSWQS. Laboratory *limits of quantitation* (Tables A7.2 and A7.4) would ideally be at or below the AWRL for each applicable parameter. However, due to the substantial groundwater inputs, the water quality of Spring Lake and the upper San Marcos River is often exceedingly high (i.e., very high water clarity and low phosphorus concentrations) during periods between surface water storm flow events. Thus, it is possible that some samples collected as a part of the Routine Water Quality Monitoring Program will fall below the AWRLs and LOQs of some of the parameters provided in Table A7.4 (e.g., ammonium-N, TP, orthophosphate-P, and TSS). However, the LOQs for these parameters for the contracting lab on this project (Edwards Aquifer Research and Data Center) are similar to other NELAC certified labs in the area capable of these analyses. Thus, because the water quality of the Spring Lake/San Marcos River system can at times be very high and the general trend in area lab LOQs, changing labs for this project will not alleviate the issues of some parameters measuring below lab LOQs or that some LOQs are greater than the AWRLs. However, this issue should not impair interpretation of data and conclusions of this project; the intent of the project is to examine the role of storm events in the nutrient and suspended solid dynamics of the lake and river and many of these surface water storm events clearly exceed the LOQs and AWRLs allowing us to examine the magnitude of storm flow pulses and nutrient and TSS loading from watershed. During this project, if any sample measurements fall below the AWRLs or LOQs, it will be clearly reported as below those limits when data are reported to TCEQ. All data going into SWQMIS for ammonia, TKN, and orthophosphate will have the "AA" (Above Quantification) data qualifier associated with them.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria are provided in Section B5.

Analytical Quantitation

To demonstrate the ability to recover at the limit of quanititation, the laboratory will analyze an LOQ check standard for each batch of samples run.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria are provided in Section B5

A8 SPECIAL TRAINING/CERTIFICATION

Staff responsible for operating and maintaining the automated ISCO samplers and TROLL continuous water quality monitoring probes will undergo a one-day training event by the equipment manufacturer or the Field Supervisor. All personnel responsible for calibration of the TROLL sondes will undergo additional training by the Field Supervisor and will adhere to the calibration procedures outlined by the manufacturer for this project. In addition, the SCUBA divers collecting, downloading, and calibrating the TROLL water sondes will consist of pairs of individuals, with one of the individuals being Dr. Ben Schwartz, Dr. Weston Nowlin, or Benjamin Hutchins (a PhD student at TXSTATE). All divers will have NAUI Open Water SCUBA diver certification.

Field personnel will receive training in proper sampling and field analysis. Before actual sampling or field analysis occurs, they will demonstrate to the QA officer (in the field), their ability to properly operate the automatic samplers and retrieve the samples. The QA officer will sign off each field staff in their field logbooks.

Field staff who collect data shall undergo a training program to ensure that he/she has knowledge and skills required to collect data in accordance with TCEQ SWQM Procedures Manual.

Contractors and subcontractors must ensure that laboratories analyzing samples under this QAPP meet the requirements contained in section 5.4.4 of the NELAC standards (concerning Review of Requests, Tenders and Contracts).

Global Positioning System (GPS) equipment may be used as a component of the information required by the Station Location (SLOC) request process for creating the certified positional data that will ultimately be entered into the TCEQ's SWQMIS database. Any Positional data obtained by the Clean Rivers Program grantees using a Global Positioning System will follow the TCEQ's OPP 8.11 and 8.12 policy regarding the collection and management of positional data.

Positional data entered into SWQMIS will be collected by a GPS certified individual with an agency approved GPS device to ensure that the agency receives reliable and accurate positional data. Certification can be obtained in any of three ways: completing a TCEQ training class, completing a suitable training class offered by an outside vendor, or by providing documentation of sufficient GPS expertise and experience. Contractors must agree to adhere to relevant TCEQ policies when entering GPS-collected data.

In lieu of entering certified GPS coordinates, positional data may be acquired with a GPS and verified with photo interpolation using a certified source, such as Google Earth or Google Map. The verified coordinates and map interface can then be used to develop a new Station location.

A9 DOCUMENTS AND RECORDS

Laboratory Test Reports

Test/data reports from the laboratory must document the test results clearly and accurately. Routine data reports should be consistent with the NELAC standards (Section 5.5.10) and include the information necessary for the interpretation and validation of data. The requirements for reporting data and the procedures are provided.

- Report title
- Name and address of laboratory
- Name and address of client and project name
- Sample results
- Units of measurement
- Sample matrix
- Dry weight or wet weight (as applicable)
- Station information
- Date and time of collection
- LOQ and LOD (formerly referred to as the reporting limit and the method detection limit, respectively), and qualification of results outside the working range (if applicable)
- An explanation of failed QC and any non-standard conditions that may have affected quality
- A signature and title of laboratory director or designee

Electronic Data

Data will be submitted to the TCEQ in the event/result format specified in the TCEQ Data Management Reference Guide (DMRG) for upload to SWQMIS. The Data Summary as contained in Appendix C of this document will be submitted with the data. Data qualifier "AA" will be added to all orthophosphate, TKN, ammonia, and nitrate/nitrate data submitted to SWQMIS for this project.

Station location (SLOC) requests will be submitted to the TCEQ Project Manager for each sampling site to obtain a station identification number.

All reported events will have a unique TagID (see DMRG). A Tag Prefix must be requested from the TCEQ in accordance with the DMRG where the Submitting Entity does not already have one. TagIDs used in this project will be seven-character alphanumerics with the structure of the two-letter Tag prefix followed by a four digit number and ending with the character "N": for example - KI1234N, KI1235N, etc.

Submitting Entity, Collecting Entity, and Monitoring Type will reflect the project organization and monitoring type in accordance with the DMRG. The proper coding of Monitoring Type is essential to accurately capture any bias toward certain environmental condition (for example, high flow events). The Project Manager should be consulted to assure proper use of the Monitoring Type code.

Table A9.1 Examples of common Sample Descriptions, Associated TagID ('RV' has been requested by RSI), and associated Monitoring Type codes that will be used.

Sample Description	Submitting Entity	Collecting Entity	Monitoring Type
Biased Flow - Monitoring during rainfall runoff.	RV	RV	AF
Continuous Routine - Continuous monitoring not intentionally targeted toward any environmental condition (the summary statistics are coded "RT").	RV	RV	CT
Routine - monitoring to establish baseline conditions	RV	RV	RT

Given the multiple programs nested within the larger project outlined in this QAPP, data from each of the programs will be reported differently. Details of data submission and reporting are given below.

Data from the Continuous Water Quality Monitoring Program

Data generated from the Continuous Water Quality Monitoring Program via the TROLL 9500 Professional-XP sondes will be downloaded directly from sondes every 2 to 3 weeks. Because the data will be collected by sondes will be at a reasonably rapid temporal interval (every 15 minutes) and the data will not be direct transmitted to the TCEQ, data will be averaged before it is uploaded into SWQMIS. Data for each parameter from each sonde will be averaged over 24-hour periods prior to uploading into SWQMIS. The 24-hour averaged data will be entered into SWQMIS. Data will be submitted quarterly with summary data reports.

Table A9.2 Summary and Format of Data to be Submitted from the Continuous Water Quality Monitoring Program (Data from TROLL 9500 Professional-XP Sondes)

Parameter and units of measurement	Parameter Code	Frequency of Data Collection in Field	Format of Data Reported
Water temperature (°C)	00209	Every 15 minutes	24-hour average
Water temperature (°C)	00221	Every 15 minutes	NU
pH (standard units)	00215 and 00216	Every 15 minutes	24-hour Max/Min
pH (standard units)	00223	Every 15 minutes	NU
Dissolved oxygen (mg/L)	89857	Every 15 minutes	24-hour average
Dissolved oxygen (mg/L)	89858	Every 15 minutes	NU
Specific conductance (µmol/cm @25°C)	00212	Every 15 minutes	24-hour average
Specific conductance (µmol/cm @25°C)	00222	Every 15 minutes	NU
Turbidity (NTU)	20485	Every 15 minutes	24-hour average
Turbidity (NTU)	20488	Every 15 minutes	NU

Data from the Storm Flow Monitoring Program

The Storm Flow Monitoring Program will generate data on nutrient and TSS concentrations from different locations within the Sink Creek watershed. These data will be uploaded into SWQMIS. Data on nutrient and TSS concentrations will be automatically collected at high frequency over the period of each event, with most events lasting <24 hours. The concentration of nutrients and TSS in each storm water sample, from each sampling site, will be electronically reported.

Table A9.3 Summary and Format of Data to be Submitted from the Storm Flow Monitoring Program (Water Quality Data from Teledyne ISCO Samplers)

Parameter and units of measurement	Parameter Code	Frequency of Data Collection in Field	Format of Data Reported
Nitrate + nitrite - N (mg/L)	00630	Each event	Concentration in individual storm flow sample
Ammonia – N (mg/L)	00610	Each event	Concentration in individual storm flow sample
Total Kjeldahl – N (mg/L)	00625	Each event	Concentration in individual storm flow sample
Orthophosphate – P (mg/L)	70507	Each event	Concentration in individual storm flow sample
Total phosphorus – P (mg/L)	00665	Each event	Concentration in individual storm flow sample
Total suspended solids (mg/L)	00530	Each event	Concentration in individual storm flow sample

Data from the Sink Creek Gauging Station (Lime Kiln Road Crossing)

The Lime Kiln Road gauging station will be used to measure hydrological inputs to Spring Lake from the Sink Creek watershed. The hydrological inputs will be coupled with the nutrient and TSS concentration data from the Lime Kiln Road crossing Storm Flow Monitoring site to calculate nutrient and sediment loading to Spring Lake from the Sink Creek watershed. The average discharge (CFS) of water from the Sink Creek watershed into Spring Lake will be calculated for each storm flow event and will be uploaded into SWQMIS as average event data. Data will be submitted quarterly with summary data reports.

Table A9.4 Summary and Format of Data to be Submitted from the Lime Kiln Road Gauging Station (Data from Marsh-McBirney Flo-Mate Portable Flow Meter and Schlumberger Baro-Diver and CTD-Diver Pressure Transducers)

Parameter and units of measurement	Parameter Code	Frequency of Data Collection in Field	Format of Data Reported
Average stream flow (CFS)	00060	Daily	CFS per day

Data from the Routine Water Quality Monitoring Program

The Routine Monitoring Program will be collected via manual grab samples to measure the spatial and temporal variation in nutrients and TSS in Spring Lake and the upper San Marcos River. Data from each sampling date (collected every three weeks) for each sampling station will be uploaded into SWQMIS as conventional data. Data will be submitted quarterly with summary data reports.

Table A9.5 Summary and Format of Data to be Submitted from the Routine Monitoring Program (Water Quality Data Collected via Grab Samples)

Parameter and units of measurement	Parameter Code	Frequency of Data Collection in Field	Format of Data Reported
Nitrate + nitrite - N (mg/L)	00630	Every 3 weeks	Each sampling event
Ammonia – N (mg/L)	00610	Every 3 weeks	Each sampling event
Total Kjeldahl – N (mg/L)	00625	Every 3 weeks	Each sampling event
Orthophosphate – P (mg/L)	70507	Every 3 weeks	Each sampling event
Total phosphorus – P (mg/L)	00665	Every 3 weeks	Each sampling event
Residue, Total Non-filterable (mg/L)	00530	Every 3 weeks	Each sampling event

Records and Documents Retention Requirements

Document/Record	Location	Retention	Form
QAPP, amendments, and appendices	Org.	5 years	Paper
QAPP distribution documentation	Org.	5 years	Paper
Training records	Org.	5 years	Paper
Field notebooks or field data sheets	Org.	5 years	Paper
Field equipment calibration/maintenance l	Org.	5 years	Paper
Chain of custody records	Org.	5 years	Paper
Field SOPs	Org.	5 years	Paper
Laboratory QA manuals	Lab	5 years	Electronic
Laboratory SOPs	Lab	5 years	Electronic
Laboratory procedures	Lab	5 years	Electronic
Instrument raw data files	Lab	5 years	Electronic
Instrument readings/printouts	Lab	5 years	Paper + Electronic
Laboratory data reports/results	Lab	5 years	Electronic
Laboratory equipment maintenance logs	Lab	5 years	Electronic
Laboratory calibration records	Lab	5 years	Electronic
Corrective action documentation	Lab	5 years	Electronic

B1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

B1.1 Continuous Water Quality Monitoring Program Sampling Design Rationale

The Continuous Water Quality Monitoring Program within Spring Lake and the Sink Creek watershed will be established to determine the relative importance of surface water and ground water inflows to the nutrient and TSS inputs to Spring Lake. The Continuous Monitoring Program will also examine high-resolution changes in the spatial and temporal water quality of Spring Lake. Instruments at each site will continuously measure and log several water quality parameters; there will be six monitoring sites located within Spring Lake. The monitoring instruments (In Situ TROLL 9500 Professional-XP sondes) will continuously measure and data-log temperature, dissolved oxygen (DO), specific conductance (SpC), pH, oxidation-reduction potential (ORP), and turbidity at 15-minute intervals.

One site will be located within the Slough Arm, where the main surface water inputs occur. These data will be coupled with discharge data from the Sink Creek gauging station to examine the relative importance of surface water inputs to changes in basic water quality parameters in the Slough Arm of the lake. Five additional sites will be located at five major spring openings in the Spring Arm of the lake: Hotel Spring, Deep Hole spring, Crater Bottom spring, Cream of Wheat spring complex, and Diversion spring. Data from these spring openings will be used to monitor water quality of the major springs in the lake and to determine if these springs respond rapidly and/or significantly to precipitation/recharge events. These continuous data will be coupled with hydrological discharge and nutrient and TSS loadings from the Sink Creek gauging station to determine nutrient and TSS loadings to the lake from the Sink Creek watershed (see Section B1.3 below).

Table B1.1 Continuous Water Quality Monitoring Sites

TCEQ Station ID	Site Description	Latitude Longitude	Start Date	End Date	Sample Matrix	Monitoring Frequencies (per year)					
						DO	pH	ORP	SpC	Turbidity	Comments
20910	Hotel spring	29.89400 -97.93024	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min
20911	Deep Hole spring	29.89239 -97.93228	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min
20912	Diversion spring	29.89333 -97.93123	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min
20913	Cream of Wheat springs	29.89339 -97.93136	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min
20914	Crater Bottom	29.89385 -97.93016	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min
15496	Lake Slough Arm at bridge	29.89314 -97.92788	15 days from QAPP approval	8/31/2012	water	Cont#	Cont#	Cont#	Cont#	Cont#	Data collected every 15 min

**SLOC numbers in process of being requested*
Cont# = Continuous data collection

B1.2 Storm Flow Monitoring Program Sampling Design Rationale

The automated Storm Flow Monitoring Program along Sink Creek will sample three sites within the Sink Creek watershed to determine nutrient and TSS contributions from various portions of the watershed to Spring Lake. One site will be located in a relatively upstream and headwater portion of the Sink Creek watershed at the Fulton Ranch Road crossing. This site is located on the Freeman Ranch, a property owned by TXSTATE. The second site is located downstream at the outfall of a large man-made storm retention and groundwater recharge structure located on the Freeman Ranch. The last storm flow monitoring site is located further downstream, approximately 500 m from the input to the Slough Arm of Spring Lake. The last site is located where Sink Creek crosses underneath Lime Kiln Road. This site is also the location of the Sink Creek gauging station. Thus, the nutrient and TSS concentration data collected from storm flow water samples will be coupled with the discharge data calculated from the gauging station to estimate the loading of nutrients and TSS to Spring Lake from the Sink Creek watershed.

An ISCO 6712 automatic sampler will be located at each Storm Flow Monitoring site. A liquid level actuator is integrated with each ISCO such that samplers will only collect water when a water level actuator is wetted; the water level actuators are routed through a PVC pipe housing to approximately 12-18 inches above the dry creek bed. Previous observation indicates that this height is sufficient to allow ISCO sampler to collect water during storm flow events and not during periods when there is relatively light rain and some pooling of non-flowing water at the sites. The ISCO samplers contain a carousel of 24 1-liter bottles and will be programmed to collect 1-L water samples (after the actuator is wetted) on the following schedule: the first set of 6 bottles will be collected every 5 minutes, the second group of 6 will be filled every 15 minutes, the third group of 6 will be filled every 30 minutes, and the last group of 6 samples will be filled after every hour. Thus, the ISCO will sample over an 11-hour interval, which is adequate to capture most storm flow events in Sink Creek. However, if there is still storm flow occurring after the 11-hour interval, the samples will be removed and another carousel of clean bottles will be placed within the ISCO to sample on the 1-hour interval until the storm flow is below the water level actuator. The time sampling intervals (every 5 min, then every 15 min, etc) were selected based upon repeated observations of storm flows in Sink Creek and the determination that most suspended solids and other materials are transported in the first hours of a storm flow event.

Sink Creek will flow only irregularly, thus it is difficult to predict when and where sustained creek flows will occur and thus the number of sampling events that will occur during the project. It is estimated that Sink Creek will flow three to eight times per year into Spring Lake and this frequency is dependent upon the magnitude and frequency of large precipitation events within a given year. Samples will be collected from the Storm Flow Monitoring sites as long as there is sustained flow at a site. In addition, there is no requirement that there be a set amount of time between storm events in order for an event to qualify for sampling.

Table B1.2 Storm Flow Monitoring Sites

TCEQ Station ID	Site Description	Latitude Longitude	Start Date	End Date	Sample Matrix	Monitoring Frequencies (per year)		
						Nutrients	Residue, Tot. Non-Filterable	Comments
20916	Sink Creek Lime Kiln crossing	29.90566 -97.93055	15 days from QAPP approval	8/31/2012	water	3 to 8	3 to 8	Sampling tied to flow events
20917	Sink Creek flood retention structure	29.919426 -97.973355	15 days from QAPP approval	8/31/2012	water	3 to 8	3 to 8	Sampling tied to flow events
20918	Sink Creek headwaters (Fulton Ranch Road Crossing)	29.924304 -98.00911	15 days from QAPP approval	8/31/2012	water	3 to 8	3 to 8	Sampling tied to flow events

**SLOC numbers in process of being requested*

B1.3 Sink Creek Hydrological Gauging Station Sampling Design Rationale

The installation of a hydrological gauging station is necessary to determine the flows of Sink Creek and the associated nutrient and TSS loading contributions to Spring Lake. The combination of surface flows and nutrient concentrations will be used to calculate seasonal and annual surface water nutrient loadings to Spring Lake. These data will aid in determining the relative contributions of groundwater versus surface water nutrient and TSS loading to the lake. This information will also provide a basis for determining nutrient and sediment sources to the lake and to prioritize any future plans for nutrient management for Spring Lake and the watershed.

The gauging station for Sink Creek will be located at the Lime Kiln Road crossing, approximately 500 m upstream from the Slough Arm of Spring Lake. This site is dry most of the time, but flows periodically during storm events. The gauging station will consist of installing a pair of pressure transducers near at a concrete box culvert that runs underneath Lime Kiln Road.

The concrete box culvert is the location of the Sink Creek crossing at the road. The box culvert is newly constructed (less than 5 years old). At the site, one pressure transducer (Schlumberger Baro-Diver) will continuously measure atmospheric pressure and will be mounted within a PVC pipe above the high water line. Another pressure/temperature/conductivity (CTD) logger (Schlumberger CTD-Diver) will be mounted on the bottom of the box culvert in a fixed PVC pipe that will be submerged when flow occurs at the site. Using these two coupled pressure transducers, TXSTATE will construct a discharge - pressure (water pressure corrected for atmospheric pressure) relationship and generate a rating curve for the Lime Kiln Road site. When flow is present at the site, crews of 3-4 individuals will use a Marsh Marsh McBirney Flo-Mate portable water velocity meter to calculate discharge at the site. These discharge measurements will be coupled with pressure measurements to generate the rating curve. Crews will collect discharge measurements in order to capture the variation in discharge which occurs at the site. Crew will attempt to capture at least 5 events of varying magnitudes to generate the rating curve. Calculations of discharge and generation of the rating curve will be relatively straight forward because the concrete culvert directs flow under the road, the dimensions of the culvert are easily determined, and there is little evidence of any backlogging of water and extensive pooling at the site. In addition, crews will periodically inspect the site and perform maintenance to remove any debris and keep vegetation from growing around the site.

Table B1.3 Sink Creek Hydrological Gauging Station Site

TCEQ Station ID	Site Description	Latitude Longitude	Start Date	End Date	Sample Matrix	Monitoring Frequencies	
						Discharge	Comments
20916	Sink Creek at Lime Kiln crossing	29.90566 -97.93055	15 days from QAPP approval	8/31/2012	water	3 to 8	Sampling tied to flow events

**SLOC number in process of being requested*

B1.4 Routine Water Quality Monitoring Program Sampling Design Rationale

The Routine Water Quality Monitoring Program will be established within Spring Lake and the upper San Marcos River to assess spatial and temporal patterns of nutrients and water quality. TXSTATE personnel will collect grab samples from sites every two to three weeks. Sampling will occur on the routine two- to three-week schedule, regardless of flow or weather conditions. Sampling on a two- to three-week basis will capture reasonably high resolution in spatial and temporal patterns of water quality. In addition to identification of general spatial and temporal patterns of nutrients and TSS in the lake, the Routine Water Quality Monitoring Program will potentially provide information on the impact of the TXSTATE golf course in the Slough Arm of the lake. For example, if nutrients and/or suspended sediment concentrations increase in the portion the Slough Arm adjacent to the golf course without other apparent nutrient loading sources, then this result would suggest that the TXSTATE golf course is a potential water quality problem for Spring Lake.

The following five sites will be a part of the Routine Water Quality Monitoring program: (1) within the upper Slough Arm of Spring Lake at the bridge crossing, (2) within the lower Slough Arm of Spring Lake, below the Texas State University Golf Course, (3) within the upper Spring

Arm of Spring Lake below the outflows of the major spring sites within the lake, (4) within the lower Spring Arm of Spring Lake, and (5) at the USGS gauging station in the San Marcos River.

Table B1.4 Routine Water Quality Monitoring Program Sites

TCEQ Station ID	Site Description	Latitude Longitude	Start Date	End Date	Sample Matrix	Monitoring Frequencies (per year) Nutrients	Residue, Tot. Non-Filterable	Comments
15496	Lake Slough Arm at bridge	29.89314 -97.92788	15 days from QAPP approval	8/31/2012	water	16	16	Sampled every 2-3 weeks
20920	Lake Slough Arm at Wetland Walk	29.89121 -97.93058	15 days from QAPP approval	8/31/2012	water	16	16	Sampled every 2-3 weeks
20921	Lake Spring Arm at Sub	29.89320 -97.93130	15 days from QAPP approval	8/31/2012	water	16	16	Sampled every 2-3 weeks
20922	Lake Spring Arm Above Falls	29.89019 -97.93459	15 days from QAPP approval	8/31/2012	water	16	16	Sampled every 2-3 weeks
20923	San Marcos River 50m below falls at old mill bldg.	29.88972 -97.93427	15 days from QAPP approval	8/31/2012	water	16	16	Sampled every 2-3 weeks

**SLOC requests have been made*

B2 SAMPLING METHODS

TXSTATE personnel associated with the project which conduct field sampling will adhere to Section B2 of this QAPP.

Field Sampling Procedures

B2.1 Continuous Water Quality Monitoring Program Sampling

The Manufacturer's Operator Manual (MOM) for the In Situ TROLL 9500 Professional-XP sondes is located in Appendix E. Sondes will be deployed at each site and will be retrieved every 3 to 4 weeks by TXSTATE SCUBA divers. Data will be downloaded from sondes in Dr. Benjamin Schwartz's lab at TXSTATE. After downloading data, a CVS check will be run to check whether the sonde was operating within specifications while deployed. Then, within 24 hours of another deployment, the sonde will be calibrated again. In order to control for inherent variation in parameter values from different sondes, each sonde will be designated permanently to a sampling site and will only be deployed/reployed to that site.

The method of deployment of sondes at each site varies due to the conditions that exist at each site. The sonde at the Slough Arm site will be suspended in the water column (above the sediments) from a float and the float will be anchored to the bottom of the lake to prevent movement of the sonde. The sondes deployed at Hotel Spring, and Deep Hole Spring will be weighted with approximately 10 lbs of dive weights and placed within the spring orifice, out of direct sunlight. The sondes at Crater Bottom Spring and Diversion Spring will be housed inside a large PVC pipe with a removable end-cap on one end (for access), and the other end of the pipe having a permanent end-cap. Holes will be drilled in the pipe and permanent end-cap to allow water to flow freely past the sonde, while positioning the probe end of the sonde directly into the spring opening. The PVC pipe will be weighted with sandbags or wedged into the opening to prevent movement of the pipe and sonde. The sonde at the Cream of Wheat spring complex will be housed inside a custom-made stainless steel dome-shaped hood which will be lowered over a cluster of the small springs at the site. The sonde will be suspended from inside the hood and there will be two PVC pipes in the top of the hood. One pipe will be open to the water outside the hood, allowing flow of water out of the hood. The other pipe will be capped but will have a hook to suspend the sonde down into hood; the cap is removable and the sonde will be removed through this pipe.

Table B2.1 Methods and Equipment for Continuous Water Quality Monitoring

River Basin	Site Location	Data Collection Time	Sampling Method	Telemetry/Data Acquisition	Station Parameters
Guadalupe	Hotel spring	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH
Guadalupe	Deep Hole spring	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH
Guadalupe	Diversion spring	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH
Guadalupe	Cream of Wheat springs	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH
Guadalupe	Crater Bottom	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH
Guadalupe	Lake Slough Arm at bridge	Every 15 minutes	Sonde: In-situ	Data manually downloaded	Temp, SpC, DO, ORP, Turbidity, pH

B2.2 Storm Flow Monitoring Program Sampling

The operation and installation of the ISCO 6712 samplers will follow all guidelines and recommendations set forth by the manufacturer. MOM with the Installation and Operation Guide is located in Appendix E.

All ISCO samplers will be placed on raised wooden platforms above the flood stage. However, because all ISCOs will be might not be above the maximum flood stage during extreme flow events, there is a possibility that samplers may be inundated. If this occurs, samplers will be inspected, repaired, or replaced if necessary. At the Sink Creek crossing site at Lime Kiln Road, the ISCO sampler will be placed in a metal storage box (commercial construction site tool storage box) and locked to prevent the public from accessing the sampler. The water intake line and the cable to the water level actuator will be housed in a PVC conduit and buried in a trench to the creek bed. The other two ISCO samplers will be located on TXSTATE property, so public access to the samplers is very limited and only requires that the standard ISCO housing be locked. Again, water intake lines and actuator cables will be housed within PVC conduits.

Each ISCO sampler will contain a carousel of 24 1-liter bottles and will be programmed to collect 6 1-L water samples every 5 minutes, then every 15 minutes, then every 30 minutes, and then every hour. This will be programmed using the MOM. During or immediately following (within 24 hours) rain events, field personnel will travel to Storm Flow sites to determine if flow occurred. If the sampler was triggered, then the carousel will be removed, the bottles capped and taken to the lab. Due to the close proximity of the field sites to the analytical lab (less than 15 minute drive), filtration and preservation of samples will occur in the lab. Each sample will be split into aliquots as needed, preserved as appropriate, kept in a cooler on ice and transported to the lab where they will be stored at ≤ 6° C. The sample volumes, container types, minimum sample volume, preservation requirements, and holding time requirements are specified in Table B2.2.

Table B2.2 Storm Flow Monitoring Program Sample Information

Parameter	Matrix	Sample Type	Container*	Preservation	Sample Volume	Holding Time
Nitrite+nitrate-N Ammonia-N Total Phosphorus-P	water	Automated Grab	250 ml HDPE	ice. <6oC, not frozen. dark. pH<2 with H2SO4	250 mL	28 days
Orthophosphate-P	water	Automated Grab	250 ml HDPE	ice. <6oC, not frozen. dark	250 mL	48 hours
Residue. Total Non-filterable	water	Automated Grab	500 ml HDPE	ice, <6oC, not frozen. dark	500 mL	7 days

B2.3 Sink Creek Gauging Station Sampling

The gauging station for Sink Creek will be located at the Lime Kiln Road crossing, approximately 500 m upstream from the Slough Arm of Spring Lake. All installation, maintenance, and data collection work on the gaging station will be done in accordance guidelines and methods in USGS Water Supply Paper 2175, Volumes 1 and 2 (See Appendix F).

Briefly, the gauging station will consist of installing a pair of pressure transducers near at a concrete box culvert that runs underneath Lime Kiln Road. The concrete box culvert is the location of the Sink Creek crossing at the road. The box culvert is newly constructed (less than 5 years old). At the site, one pressure transducer (Schlumberger Baro-Diver) will continuously measure atmospheric pressure and will be mounted within a PVC pipe above the flood stage. Another pressure/temperature/conductivity (CTD) logger (Schlumberger CTD-Diver) will be mounted on the bottom of the box culvert in a fixed PVC pipe housing that will be submerged when flow occurs at the site. Using these two coupled pressure transducers, TXSTATE will construct a discharge - pressure (water pressure corrected for atmospheric pressure) relationship and generate a rating curve for the Lime Kiln Road site. When flow is present at the site, crews of 3-4 individuals will use a Marsh Marsh McBirney Flo-Mate portable water velocity meter to measure velocity and water depth (via the flow meter wading rod) in order to calculate discharge. These discharge measurements will then be coupled with pressure measurements to generate the rating curve. Pressure data will be downloaded from transducers using the MOMs and the flow meter will be used in accordance with the MOM (See Appendix E). Crews will attempt to capture at least 5 events of varying magnitudes to generate the rating curve.

Table B2.3 Methods and Equipment for Sink Creek Hydrological Gauging Station

River Basin	Site Location	Data Collection Time	Sampling Method	Telemetry/Data Acquisition	Station Parameters
Guadalupe	Sink Creek at Lime Kiln Road Crossing	Continuous	Schlumberger CTD-Diver	Data manually downloaded	Water pressure
Guadalupe	Sink Creek at Lime Kiln Road Crossing	Continuous	Schlumberger Baro-Diver	Data manually downloaded	Atmospheric pressure
Guadalupe	Sink Creek at Lime Kiln Road Crossing	Event Based	Portable Flow Meter	Data manually collected	Water velocity

B2.4 Routine Water Quality Monitoring Sampling

The Routine Water Quality Monitoring Program will be established within Spring Lake and the upper San Marcos River to assess spatial and temporal patterns of nutrients and water quality in. TXSTATE personnel will collect grab samples from sites every two to three weeks. Sampling will occur on the routine two- to three-week schedule, regardless of flow or weather conditions. Sample collection will follow the field sampling procedures for conventional parameters documented in the TCEQ Surface Water Quality Monitoring Procedures Manual (most recent addition). The routinely collected grab samples will be handled and preserved similarly to the samples collected for the Storm Flow monitoring program. Each sample will be split into aliquots, preserved as appropriate, kept in a cooler on ice and transported to the lab where they will be stored at < 6° C. The sample volumes, container types, minimum sample volume, preservation requirements, and holding time requirements are specified in Table B2.4.

Table B2.4 Routine Water Quality Monitoring Program Sample Information

Parameter	Matrix	Sample Type	Container*	Preservation	Sample Volume	Holding Time
Nitrite+nitrate-N Ammonia-N Total Phosphorus-P	water	Grab	250 ml HDPE	ice, <6oC, not frozen, dark, pH<2 with H2SO4	250 mL	28 days
Orthophosphate-P	water	Grab	250 ml HDPE	ice, <6oC, not frozen, dark	250 mL	48 hours
Residue, Total Non-filterable (TSS)	water	Grab	1000 ml HDPE	ice, <6oC, not frozen, dark	750 mL	7 days

Processes to Prevent Cross Contamination

Procedures outlined in the *TCEQ Surface Water Quality Procedures* outline the necessary steps to prevent cross-contamination of samples. These include such things as direct collection into sample containers and the use of commercially pre-cleaned sample containers.

Documentation of Field Sampling Activities

Field sampling activities are documented on the Field Data Reporting Forms as presented in Appendix G. For all visits, station ID, location, sampling time, sampling date, sampling depth, preservatives added to samples, and sample collector's name/signature are recorded. Values for all measured field parameters are recorded. Detailed observational data are recorded including water appearance, weather, biological activity, stream uses, unusual odors, specific sample information, missing parameters, days since last significant rainfall, and flow severity.

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.

Sampling Method Requirement or Sampling Process Design Deficiencies and Corrective Action

Examples of sampling method requirement or sample design deficiencies include but are not limited to such things as inadequate sample volume due to spillage or container leaks, failure to preserve samples appropriately, contamination of a sample bottle during collection, storage temperature and holding time exceedance, sampling at the wrong site, etc. Any deviations from the QAPP and appropriate sampling procedures may invalidate resulting data and may require corrective action. Corrective action may include for samples to be discarded and re-collected. It is the responsibility of the TXSTATE Project Manager, in consultation with the TXSTATE 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 NPS Project Manager both verbally and in writing in the project progress reports and by completion of a corrective action plan (CAP).

The definition of and process for handling deficiencies and corrective actions are defined in Section C1.

B3 SAMPLING HANDLING AND CUSTODY

Sample Labeling
Samples from the field are labeled on the container with an indelible marker. Label information will include:

1. Site identification
2. Date and time of collection
3. Preservative added, if applicable
4. Sample type (i.e., analysis(es)) to be performed

Sample Handling

The following sampling and related equipment will be required for each sampling event related to the *Continuous Water Quality Monitoring* portion of this project:

- SCUBA equipment
- In situ TROLL sondes
- Ice chests
- End covers for sondes
- Field data sheets and/or field log book

When sondes are retrieved from Spring Lake, they will be immediately capped with the end covers to protect the probes and then placed into coolers. All sondes will have a specified permanent designation number associated with it so that personnel know the site location from which the sonde was removed. The sondes will then be transported immediately to TXSTATE to the lab of Dr. Benjamin Schwartz. In the lab, sondes will be inspected for damage/fouling and the data will be downloaded. After a sonde has its data downloaded, it will be uncapped and then put through the calibration procedure outlined elsewhere in this QAPP. Thus, personnel will know that the data is downloaded from a sonde when it has been uncapped. After calibration, the sondes will be re-capped, put back into the cooler, and transported back to Spring Lake for redeployment.

The following sampling and related equipment will be required for each sampling event related to the *Storm Flow Monitoring* portion of this project:

- De-ionized water
- Ice
- ISCO samplers
- Replacement sample bottle carousels with empty bottles
- Sample bottles for analyses, duplicates, field splits
- Sample labels
- Ice chests
- Field data sheets and/or field log book

After a storm flow event, the 24-bottle carousel will be removed by field personnel and the bottles will be capped onsite and taken to TXSTATE. The carousel will be replaced with empty clean bottles. Field sites are less than 15 minute drive from TXSTATE and EARDC, so each set of carousel bottles will be placed in a cooler with ice and transported to TXSTATE for splits and preservation. The initial preservation and splits will occur in the TXSTATE lab of Dr. Weston Nowlin or Dr. Benjamin Schwartz. All sample bottles will be labeled and will not be capped for transport to EARDC until preservation has occurred (if required). Personnel will walk samples down the hall to EARDC (it is in the same building as Dr. Nowlin's and Dr. Schwartz's labs) will be handed over to EARDC personnel. At that time, the chain of custody forms will be completed. EARDC will perform filtrations and will ensure proper preservation of the sample from that point.

The following sampling and related equipment will be required for each sampling event related to the *Sink Creek Gauging Station* portion of this project:

- CTD and Baro-divers
- Marsh McBirney Flo-Mate with wading rod
- Field data sheets and/or field log book

During a storm flow event, a group of 3-4 personnel will travel to the Sink Creek gauging station site and perform an assessment of discharge at the site. Two personnel will be responsible for collection of the data from the stream itself and one will ensure the data is properly recorded in the field log book/field data sheets. Calculations to determine discharge (requiring channel width, channel depth profiles, and multiple velocity measurements) will be performed in the lab after the field data collection. After the storm event has passed, the same personnel will retrieve the Baro- and CTD Divers and download the data from them for the time period the discharge measurements were taken. Both the Divers download data optically. After downloading the data, the Divers will be replaced at the gauging station site.

The following sampling and related equipment will be required for each sampling event related to the *Routine Water Quality Monitoring* portion of this project:

- De-ionized water
- Ice
- ISCO samplers
- Replacement sample bottle carousels with empty bottles
- Sample bottles for analyses, duplicates, field splits
- Sample labels
- Ice chests
- Field data sheets and/or field log book

During routine monitoring, field personnel will fill pre-labeled HDPE bottles and the bottles will be capped onsite and taken to TXSTATE. Field sites are less than 15 minute drive from TXSTATE and EARDC, so each set of bottles will be placed in a cooler with ice and transported to TXSTATE for splits and preservation. The initial preservation and splits will occur in the TXSTATE lab of Dr. Weston Nowlin or Dr. Benjamin Schwartz. All sample bottles will not be recapped and labeled as preserved until preservation has occurred (if required). Personnel will then walk samples down the hall to EARDC (it is in the same building as Dr. Nowlin's and Dr. Schwartz's labs) will be handed over to EARDC personnel. At that time, the chain of custody forms will be completed. EARDC will perform filtrations and will ensure proper preservation of the sample from that point.

Sample Tracking

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis.

A sample is in custody if it is in actual physical possession or in a secured area that is restricted to authorized personnel. The COC form is used to document sample handling during transfer from the field to the laboratory and among contractors. The following information concerning the sample is recorded on the COC form (See Appendix H).

1. Date and time of collection
2. Site identification
3. Sample matrix
4. Number of containers
5. Preservative used
6. Analyses required
7. Name of collector
8. Custody transfer signatures and dates and time of transfer

Sample Tracking Procedure Deficiencies and Corrective Action

All deficiencies associated with chain-of-custody procedures as described in this QAPP are immediately reported to the Contractor Project Manager. These include such items as delays in transfer, resulting in holding time violations; violations of sample preservation requirements; incomplete documentation, including signatures; possible tampering of samples; broken or spilled samples, etc. The TXSTATE Project Manager in consultation with the TXSTATE QAO will determine if the procedural violation may have compromised the validity of the resulting data. Any failures that have reasonable potential to compromise data validity will invalidate data and the sampling event should be repeated. The resolution of the situation will be reported to the TCEQ NPS Project Manager in the project progress report. Corrective Action Plans will be prepared by the Contractor QAO and submitted to TCEQ NPS Project Manager along with project progress report.

The definition of and process for handling deficiencies and deficiencies, nonconformances, and corrective action are defined in Section C1.

B4 ANALYTICAL METHODS

The analytical methods for the different portions of this project are listed in Tables A7.1, A7.2 A7.3, and A7.4 under Section A7. Laboratories collecting data under this QAPP are compliant with the NELAC Standards.

Copies of laboratory SOPs are retained by the contractor and are available for review by the TCEQ. Laboratory SOPs are consistent with EPA requirements as specified in the method.

Standards Traceability
All standards used in the field and laboratory are traceable to certified reference materials. Standards and reagent preparation is fully documented and maintained in a standards log book. Each documentation includes information concerning the standard or reagent identification, starting materials, including concentration, amount used and lot number; date prepared, expiration date and preparer's initials/signature. The bottle is labeled in a way that will trace the standard or reagent back to preparation. Standards or reagents used are documented each day samples are prepared or analyzed.

Deficiencies, Nonconformances and Corrective Action Related to Analytical Methods

Analytical Method Deficiencies and Corrective Actions

Deficiencies in field and laboratory measurement systems involve, but are not limited to such things as instrument malfunctions, failures in calibration, blank contamination, quality control samples outside QAPP defined limits, etc. In many cases, the field technician or lab analyst will be able to correct the problem. If the problem is resolvable by the field technician or lab analyst, then they will document the problem on the field data sheet or laboratory record and complete the analysis. If the problem is not resolvable, then it is conveyed to the TXSTATE Laboratory Supervisor, who will make the determination and notify the TXSTATE QAO. If the analytical system failure may compromise the sample results, the resulting data will not be reported to the TCEQ. The nature and disposition of the problem is reported on the data report which is sent to the TXSTATE Manager. The TXSTATE Project Manager will include this information in the CAP and submit with the Progress Report which is sent to the TCEQ NPS Project Manager.

The TCEQ has determined that analyses associated with the remark codes holding time exceedance, sample received unpreserved, estimated value, etc. may have unacceptable measurement uncertainty associated with them. This will immediately disqualify analyses from submittal to SWQMIS. Therefore, data with these types of problems should not be reported to the TCEQ. Additionally, any data collected or analyzed by means other than those stated in the QAPP, or data suspect for any reason should not be submitted for loading and storage in SWQMIS.

B5 QUALITY CONTROL

Sampling Quality Control Requirements and Acceptability Criteria

Field Splits - On every field sampling event for the Storm Flow and Routine Monitoring Programs, approximately every 10th sample will be used as a field split. However, if less than 10 samples are collected from site in a given month, then field splits will be collected once per month. A field split is a single sample subdivided by field staff immediately following collection and submitted to the laboratory as two separately identified samples according to the *SWQM Procedures*. Split samples are preserved, handled, shipped, and analyzed identically and are used to assess variability in all of these processes. Field splits apply to conventional samples only.

The precision of field split results is calculated by relative percent difference (RPD) using the following equation:

$$RPD = (X_1-X_2)/((X_1+X_2)/2))$$

A 30% RPD criteria will be used to screen field split results as a possible indicator of excessive variability in the sample handling and analytical system. If it is determined that elevated quantities of analyte (i.e., > 5 times the RL) were measured and analytical variability can be eliminated as a factor, than variability in field split results will primarily be used as a trigger for discussion with field staff to ensure samples are being handled in the field correctly. Some individual sample results may be invalidated based on the examination of all extenuating information. The information derived from field splits is generally considered to be event specific and would not normally be used to determine the validity of an entire batch; however, some batches of samples may be invalidated depending on the situation. Professional judgment during data validation will be relied upon to interpret the results and take appropriate action. The qualification (i.e., invalidation) of data will be documented on the Data Summary. Deficiencies will be addressed as specified in this section under Deficiencies, Nonconformances, and Correction Action related to Quality Control.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria

Batch – A batch is defined as environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same NELAC-defined matrix, meeting the above mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 25 hours. An **analytical batch** is composed of prepared environmental samples (extract, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.

Method Specific QC requirements – QC samples, other than those specified later this section, are run (e.g., sample duplicates, surrogates, internal standards, continuing calibration samples, interference check samples, positive control, negative control, and media blank) as specified in the specific methods. The requirements for these samples, their acceptance criteria or instructions for establishing criteria, and corrective actions are method-specific.

Detailed laboratory QC requirements and corrective action procedures are contained within the individual laboratory quality manuals (QMs). The minimum requirements that all participants abide by are stated below.

Limit of Quantitation (LOQ) – The laboratory will analyze a calibration standard (if applicable) at the LOQ on each day project samples are analyzed. Calibrations including the standard at the LOQ will meet the calibration requirements of the analytical method or corrective action will be implemented.

LOQ Check Standard – An LOQ check standard consists of a sample matrix (e.g., deionized water, sand, commercially available tissue) free from the analytes of interest spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is used to establish intra-laboratory bias to assess the performance of the measurement system at the lower limits of analysis. The LOQ check standard is spiked into the sample matrix at a level less than or near the LOQ for each analyte for each batch samples that are run.

The LOQ check standard is carried through the complete preparation and analytical process. LOQ Check Standards are run at a rate of one per analytical batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

The percent recovery of the LOQ check standard is calculated using the following equation in which %R is percent recovery, SR is the sample result, and SA is the reference concentration for the check standard:

$$\%R = SR/SA * 100$$

Measurement performance specifications are used to determine the acceptability of LOQ Check Standard analyses as specified in Table A7.1.

Laboratory Control Sample (LCS) - An LCS consists of a sample matrix (e.g., deionized water, sand, commercially available tissue) free from the analytes of interest spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is used to establish intra-laboratory bias to assess the performance of the measurement system. The LCS is spiked into the sample matrix at a level less than or near the mid point of the calibration for each analyte. In cases of test methods with very long lists of analytes, LCSs are

prepared with all the target analytes and not just a representative number, except in cases of organic analytes with multipeak responses.
The LCS is carried through the complete preparation and analytical process. LCSs are run at a rate of one per analytical batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

Results of LCSs are calculated by percent recovery (%R), which is defined as 100 times the measured concentration, divided by the true concentration of the spiked sample.

The following formula is used to calculate percent recovery, where %R is percent recovery; SR is the measured result; and SA is the true result:

$$\%R = SR/SA * 100$$

Measurement performance specifications are used to determine the acceptability of LCS analyses as specified in Tables A7.1 and A7.4.

Laboratory Duplicates – A laboratory duplicate is prepared by taking aliquots of a sample from the same container under laboratory conditions and processed and analyzed independently. A laboratory control sample duplicate (LCSD) is prepared in the laboratory by splitting aliquots of an LCS. Both samples are carried through the entire preparation and analytical process. LCSDs are used to assess precision and are performed at a rate of one per batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

For most parameters, precision is calculated by the RPD of LCS duplicate results as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, X_1 and X_2, the RPD is calculated from the following equation:

$$RPD = (X_1 - X_2)/\{(X_1+X_2)/2\} * 100$$

Laboratory equipment blank - Laboratory equipment blanks are prepared at the laboratory where collection materials for metals sampling equipment are cleaned between uses. These blanks document that the materials provided by the laboratory are free of contamination. The QC check is performed before the metals sampling equipment is sent to the field. The analysis of laboratory equipment blanks should yield values less than the LOQ. Otherwise, the equipment should not be used.

Matrix spike (MS) –Matrix spikes are prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Percent recovery of the known concentration of added analyte is used to assess accuracy of the analytical process. The spiking occurs prior to sample preparation and analysis. Spiked samples are routinely prepared and analyzed at a rate of 10% of samples processed, or one per batch whichever is greater. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples. The information from these controls is sample/matrix specific and is not used to determine the validity of the entire batch. The MS is spiked at a level less than or equal to the midpoint of the calibration or analysis range for each analyte. Percent recovery (%R) is defined as 100 times the observed concentration, minus the sample concentration, divided by the true concentration of the spike.

The results from matrix spikes are primarily designed to assess the validity of analytical results in a given matrix and are expressed as percent recovery (%R). The laboratory shall document the calculation for %R. The percent recovery of the matrix spike is calculated using the following equation in which %R is percent recovery, SSR is the observed spiked sample concentration, SR is the sample result, and SA is the reference concentration of the spike added:

$$\%R = (SSR - SR)/SA * 100$$

Measurement performance specifications for matrix spikes are not specified in this document.

The results are compared to the acceptance criteria as published in the mandated test method. Where there are no established criteria, the laboratory shall determine the internal criteria and document the method used to establish the limits. For matrix spike results outside established criteria, corrective action shall be documented or the data reported with appropriate data qualifying codes.

Method blank –A method blank is a sample of matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as the samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination from the analytical process. The analysis of method blanks should yield values less than the LOQ. For very high-level analyses, the blank value should be less then 5% of the lowest value of the batch, or corrective action will be implemented.

The method blank shall be analyzed at a minimum of once per preparation batch. In those instances for which no separate preparation method is used (example: volatiles in water) the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

Quality Control or Acceptability Requirement Deficiencies and Corrective Actions

Sampling QC excursions are evaluated by the Contractor Project Manager, in consultation with the Contractor QAO. In that differences in sample results are used to assess the entire sampling process, including environmental variability, the arbitrary rejection of results based on pre-determined limits is not practical. Therefore, the professional judgment of the TXSTATE Project Manager and QAO will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Field blanks for trace elements and trace organics are scrutinized very closely. Field blank values exceeding the acceptability criteria may automatically invalidate the sample, especially in cases where high blank values may be indicative of contamination which may be causal in putting a value above the standard. Notations of field split excursions and blank contamination are noted in the quarterly report and the final QC Report. Equipment blanks for metals analysis are also scrutinized very closely.

Laboratory measurement quality control failures are evaluated by the laboratory staff. The disposition of such failures and the nature and disposition of the problem is reported to the TXSTATE Laboratory QAO. The Laboratory QAO will discuss with the TXSTATE Project Manager. If applicable, the TXSTATE Project Manager will include this information in the CAP and submit with the Progress Report which is sent to the TCEQ NPS Project Manager.

The definition of and process for handling deficiencies and deficiencies, nonconformances, and corrective action are defined in Section C1.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

All laboratory tools, gauges, instrument, and equipment testing and maintenance requirements are contained within EARDC laboratory QAM(s). Testing and maintenance records are maintained and are available for inspection by the TCEQ. Instruments requiring daily or in-use testing may include, but are not limited to, water baths, ovens, autoclaves, incubators, refrigerators, and laboratory pure water. Critical spare parts for essential equipment are maintained to prevent downtime. Maintenance records are available for inspection by the TCEQ.

Field crew will inspect and perform maintenance as required on the In Situ TROLL 9500 Professional-XP sondes used in the *Continuous Water Quality Monitoring* portion of this project on a 3- to 4-week basis. Sondes will be inspected when they are removed from Spring Lake and immediately before they are redeployed into the lake. All maintenance and inspection duties will correspond with calibration procedures (see Section B7 below). All inspection, testing, and maintenance will follow the MOM and be recorded in log books. If a sonde is found to be not working properly, it will be repaired or replaced with a spare sonde. If a spare sonde is used, then it will be clearly noted in the logs. The original sonde will be redeployed as soon as it is repaired. Equipment records are kept on all field equipment and a supply of critical spare parts/consumables will be maintained by the TXSTATE Field Supervisor.

The ISCO samplers used in the *Storm Flow Monitoring* portion of this project will be inspected on a bi-monthly basis, if there has been no storm flow event in the intervening time period. All inspection, testing, and maintenance will follow the MOM and be recorded in log books. The setup and programming of the ISCO samplers is in Appendix I. Batteries in ISCOs will be replaced as needed. ISCOs will also be inspected for insects (ants) to make sure that they do not form a nest inside the sampler. When samples are collected after or during a storm flow event, then personnel will make sure all carousel bottles that were to be filled were in fact filled. If the ISCO requires repairs, it will be taken back to TXSTATE for repairs. A replacement ISCO will be placed at the site until the original ISCO is repaired; the original will be redeployed at the site. Equipment records are kept on all field equipment and a supply of critical spare parts/consumables will be maintained by the TXSTATE Field Supervisor.

The CTD and Baro-Divers used in the *Sink Creek Gauging Station* portion of this project will be inspected on a bi-monthly basis (at same time as ISCOs), if there has been no storm flow event in the intervening time period. All inspection, testing, and maintenance will follow the MOM and be recorded in log books. When a storm flow event occurs personnel will collect Divers and take them to them to TXSTATE and download pressure data. At that time, personnel will assure that Divers have power and that they are logging data. If a Diver requires repair, it will be repaired as needed. A replacement Diver will be placed at the site until the original Diver is repaired; the original will be redeployed at the site. The Marsh McBirney Flo-Mate velocity meter will be inspected and tested prior to field crews traveling to a site to perform discharge measurements. All inspection, testing, and maintenance will follow the MOM and be recorded in log books. There are five Marsh-McBirney flow meters at TXSTATE, so if a flow meter is found not to work, then a replacement will be used. Equipment records are kept on all field equipment and a supply of critical spare parts/consumables will be maintained by the TXSTATE Field Supervisor. Crews will periodically inspect the site and perform maintenance to remove any debris and keep vegetation from growing around the site.

B7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Detailed laboratory calibrations are contained within the QAM(s).

Field crew will inspect and perform calibration on the In Situ TROLL 9500 Professional-XP sonde *Continuous Water Quality Monitoring* on a 3- to 4-week basis. SCUBA crews will remove sondes and bring them back to the lab for downloading of field data. After downloading the data, each sonde will be calibrated on the appropriate schedule for the various parameters. The detailed procedures are given in Appendix J. The procedures address the frequency of calibration for each parameter as well as how issues of mineral precipitation and biofouling are dealt with.

The ISCOs used as a part of the *Storm Flow Monitoring* portion of this project will be inspected every 2 to 3 weeks if no flow event has occurred in the intervening period. The ISCOs have no specific calibration procedure associated with them other than the MOM's recommendations. The initial calibration of the pumping volume to fill bottles will be performed in the lab prior to the deployment in the field. This calibration will be performed according to the MOM.

The CTD and Baro-Divers used in the *Sink Creek Gauging Station* portion of this project will be inspected to assure that Divers have power and that they are logging data. Pressure measurements by Divers are only calibrated by the manufacturer and will be sent to the Schlumberger if requiring repairs or calibration. The Marsh McBirney Flo-Mate velocity meter will be inspected and tested prior to field crews traveling to a site to perform discharge measurements. If needed, the Flow-Mate can be 'zeroed' in the lab prior to taking field measurements. Zeroing will be performed according to the MOM and be recorded in log books. The Flo-Mate can only be calibrated by the manufacturer; if a Flo-Mate is not working properly, then it will be sent to the manufacturer for repair and/or calibration.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

New batches of supplies are tested before use to verify that they function properly and are not contaminated. The laboratory QAM provides additional details on acceptance requirements for laboratory supplies and consumables.

All incoming sample bottles and consumables used for field work will be inspected at the time of arrival to assure that they are not contaminated and meet the requirements for the project.

B9 NON-DIRECT MEASUREMENTS

As a part of the laboratory objectives of this project, non-direct measurements from computer databases, spreadsheets, programs, etc., will not be used in this project.

The last portion of this study will determine landcover/landuse patterns in the Sink Creek watershed. Landcover/landuse determinations in the Sink Creek watershed will use GIS and remote sensing platforms to analyze land use characteristics of the Spring Lake and Sink Creek watersheds. Land-use data within the Sink Creek watershed will be from the most recent USGS/NLCD database at 30 m resolution. Currently, this is 2001 data; however there is a planned update to 2006 data that is not yet available. All data will be extracted using ArcInfo and watershed area and basin delineation will be done using the tools in the ArcHydro extensions to ArcInfo.

Data on landuse/landcover will be coupled with existing dye-trace and other hydrogeologic data to evaluate the most likely contributing zones for spring openings which may significantly contribute to Spring Lake. Maps of hydrologic and dye-trace data obtained from outside sources not associated with this project will be coupled with the landuse/lancover GIS data generated by this project. We will not be directly and explicitly using data from these external sources, but will use the general and overall conclusions reached by these studies on groundwater flow path directions and time scales of ground water movement. Thus, data from these external studies are not specifically covered under this QAPP. Rather, the quality of the data derived from these studies will be covered under the QAPP for each particular study or by the individual entity's data quality assurance/quality control practices. However, we will only use sources which have either internal or external peer-review standards (e.g., Edwards Aquifer Authority, peer-reviewed scholarly publications). These data will be compiled, have the quality assurance evaluated, and subsequently analyzed by TXSTATE personnel, namely Drs. Benjamin Schwartz and Weston Nowlin. Examples of some primary sources for these data (and links to the studies where possible) are given below:

1) Quick, RA, and AE Ogden. 1985. Hydrochemistry as a means of delineating groundwater flow patterns in the Edwards Aquifer, San Marcos, Texas, USA. Karst Water Resources (Proceedings of the Ankara-Analytica Symposium. IAHS Publication no. 161.
http://iahs.info/redbooks/a161/iahs_161_0497.pdf

2) Johnson SB, and GM Schindel. 2008. Evaluation of the option to designate a separate San Marcos pool for critical period management. Edwards Aquifer Authority Report No. 08-01.
http://www.edwardsaquifer.org/files/Final_San_Marcos_Springs_Report.pdf

3) Hunt, BB, BA Smith, J Beery, D Johns, and N Hauwert. 2006. Summary of 2005 groundwater dye tracing, Barton Springs segment of the Edwards Aquifer, Hays and Travis counties, central Texas. Barton Springs/Edwards Aquifer Conservation District, BSEACD Report of Investigations 2006-0530.
http://www.bseacd.org/uploads/AquiferScience/HR_Dye_BSEACD_report_2006.pdf

4) LBG-Guyton Associates. 2004. Evaluation of augmentation methodologies in support for in-situ refugia at Comal and San Marcos Springs, Texas. Edwards Aquifer Authority.
http://www.gbra.org/documents/conservation/ea/other/springflowaugmentationfinalreport.pdf

5) Thompson GM, and JM Hayes. 1979. Trichlorofluoromethane in groundwater – a possible tracer and indicator of groundwater age. Water Resources Research 15;546-554.

If relevant new data and reports become available over the course of this project, as described in Objective 3 of the project Work Plan (Appendix B), these data will be described in the Data Inventory Report. Because the data we will directly generate in ArcGIS and the overall conclusions about the directional flow paths and time scales of groundwater transport taken from the external data sources are not specifically addressed under this QAPP, these data will not be directly uploaded into the SWQMIS database. Rather, they will be a part of reports to TCEQ and will be used for the stakeholder meeting portion of this project (see Workplan). All data collected under this QAPP and any acquired or non-direct measurements will comply with all requirements/guidance of the project.

B10 DATA MANAGEMENT

Personnel

Section A4 lists responsibilities and lines of communication for data management personnel.

Data Path

Samples are collected and are transferred to the laboratory for analyses as described in Sections B1 and B2. Sampling information (e.g. site location, date, time, sampling depth, etc.) is used to generate a unique sampling event in an interim database built on an autogenerated alphanumeric key field. Measurement results from both the field data sheets and laboratory data sheets are manually entered into the interim database for their corresponding event. Customized data entry forms facilitate accurate data entry. Following data verification and validation, the data are exported from the interim database to prepare ASCII delimited text files for reporting in TCEQ format. Once TCEQ approval of the data is obtained, the interim data are loaded into SWQMIS by TCEQ data managers

See Appendix K for the Data Management Process Flow Chart

Record-keeping and Data Storage

TXSTATE recordkeeping and document control procedures are contained in the water quality sampling and laboratory SOPs and this QAPP. Original field and laboratory data sheets are stored in the TXSTATE offices in a fireproof file in accordance with the record-retention schedule in Section A9. Two copies of the database are backed up each Friday on magnetic tape. One copy is stored in a fireproof safe in the RSI office, and one copy is stored off-site (e.g., Freeman Aquatic Biology Building, Texas State University). If necessary, disaster recovery will be accomplished by information resources staff using the backup database.

Archives/Data Retention

Complete original data sets are archived on permanent paper media and retained on-site by the Contractor for a retention period specified in section A9

Data Verification/Validation

The control mechanisms for detecting and correcting errors and for preventing loss of data during data reduction, data reporting, and data entry are contained in Sections D1, D2, and D3.

Forms and Checklists

See Appendix G for the Field and Laboratory Data Sheets.

See Appendix C for the Data Summary.

Data Handling

Data are processed using the Microsoft Access 2000 suite of tools and applications. Data integrity is maintained by the implementation of password protections which control access to the database and by limiting update rights to a select user group. No data from external sources are maintained in the database. The database administrator is responsible for assigning user rights and assuring database integrity.

Hardware and Software Requirements

Hardware configurations are sufficient to run Microsoft Access 2000 under the Windows NT operating system in a networked environment. Information Resources staff are responsible for assuring hardware configurations meet the requirements for running current and future data management/database software as well as providing technical support. Software development and database administration are also the responsibility of the information resources department. Information Resources develops applications based on user requests and assures full system compatibility prior to implementation.

Information Resource Management Requirements

Texas State University Information Technology (IT) policy is contained in IT SOPs which are available for review at TXSTATE offices.

Quality Assurance/Control
See Section D of this QAPP.

C1 ASSESSMENTS AND RESPONSE ACTIONS

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	Contractor Project Manager	Monitoring of the project status and records to ensure requirements are being fulfilled.	Report to TCEQ in Quarterly Report
Laboratory Inspections	Dates to be determined by the TCEQ lab inspector	TCEQ Lab Inspector	Analytical and quality control procedures employed at the laboratory and the contract laboratory	30 days to respond in writing to the TCEQ to address corrective actions
Monitoring Systems Audit	Dates to be determined by TCEQ	TCEQ QAS	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Field sampling, handling and measurement; facility review; and data management as they relate to the NPS	30 days to respond in writing to the TCEQ to address corrective actions
Laboratory Inspection	Based on work plan and or discretion of contractor	Contractor QAO	Analytical and quality control procedures employed at the laboratory and the contract laboratory	30 days to respond in writing to the contractor QAO to address corrective actions
Monitoring Systems Audit	Based on work plan and or discretion of contractor	Contractor QAO	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Field sampling, handling and measurement; facility review; and data management as they relate to the NPS	30 days to respond in writing to the contractor QAO to address corrective actions
Site Visit	Dates to be determined by TCEQ	TCEQ PM	Status of activities. Overall compliance with work plan and QAPP	As needed

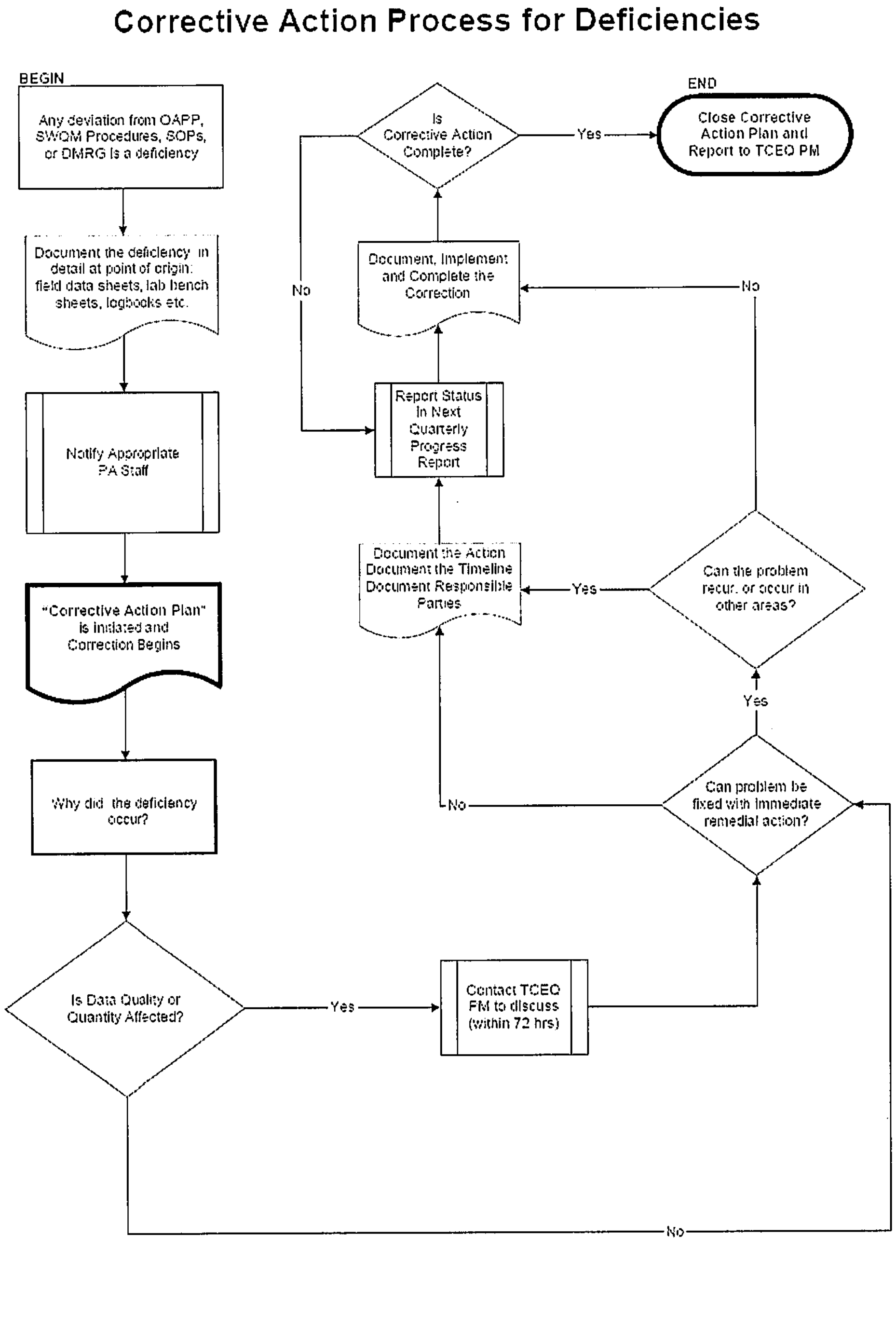
Corrective Action

CAPs 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, and develop an action plan
- Identify personnel responsible for action
- Establish timelines and provide a schedule
- Document the corrective action

To facilitate the process a flow chart has been developed (see Figure C1.1: Corrective Action Process for Deficiencies).

Figure C1.1 Corrective Action Process for Deficiencies



Status of CAPs will be documented on the Corrective Action Status Table (See Appendix L) and included with Quarterly Progress Reports. 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 TCEQ immediately.

The TXSTATE Project Manager is responsible for implementing and tracking corrective actions. Corrective action plans will be documented on the Corrective Action Plan Form (See Appendix M) and submitted, when complete, to the TCEQ Project Manager. Records of audit findings and corrective actions are maintained by both the TCEQ and the TXSTATE QAO. Audit reports and corrective action documentation will be submitted to the TCEQ with the Quarterly Progress Report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work are specified in the TCEQ QMP and in agreements in contracts between participating organizations.

C2 REPORTS TO MANAGEMENT

Reports to TCEQ Project Management

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

Monitoring Systems Audit Report and Response - Following any audit performed by the Basin Planning Agency, a report of findings, recommendations and response is sent to the TCEQ in the quarterly progress report.

Quarterly Progress Report - Summarizes the Contractor's activities for each task; reports monitoring status, problems, delays, and corrective actions; and outlines the status of each task's deliverables.

Monitoring System Audit Response - The contractor will respond in writing to the TCEQ within 30 days upon receipt of a monitoring system audit report to address corrective actions.

Contractor Evaluation - The Contractor participates in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards.

Data Inventory Report – This report summarizes the existing data on the watershed, the geographic representation of the watershed, an evaluation of watershed landuse patterns, and the NPS source regions within the watershed.

Data Collection and Analysis Report – This report summarizes baseline information on existing NPS and point sources of pollution.

Identification of Potential Causes and Sources and Pollution and Estimation of Pollutant Loads Report – This report identifies the causes and sources, or groups of similar sources, that may need to be controlled to achieve the load reductions estimated in this watershed-based plan.

Final Project Report - Summarizes the Contractor's activities for the entire project period including a description and documentation of major project activities; evaluation of the project results and environmental benefits; and a conclusion. In addition, the Final Report will align closely with the language in the Scope of Work of this project, especially with regard to the generation of a 'Watershed Characterization and Management Recommendations Report."

Reports to Contractor Project Management

All laboratory analytical reports and applicable QA/QC data related to field and laboratory analysis will be collected and archived by TXSTATE and EARDC.

Reporting of project status, results of assessments (including data), and significant QA issues to project management will occur via email or verbal communication. Verbal communication will likely be the primary source of updates among participants at TXSTATE due to the close proximity of the individual entities involved (within the same building and on the same floor). If a substantial issue arises, project management may request a written document (other than email) in order to have documentation of the issue.

Reports by TCEQ Project Management

Contractor Evaluation - The Contractor participates in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurement and Contracts Section.

D1 DATA REVIEW, VERIFICATION, AND VALIDATION

For the purposes of this document, data verification is a systematic process for evaluating performance and compliance of a set of data to ascertain its completeness, correctness, and consistency using the methods and criteria defined in the QAPP. Validation means those processes taken independently of the data-generation processes to evaluate the technical usability of the verified data with respect to the planned objectives or intention of the project. Additionally, validation can provide a level of overall confidence in the reporting of the data based on the methods used.

All data obtained from field and laboratory measurements will be reviewed and verified for conformance to project requirements, and then validated against the data quality objectives which are listed in Section A7. Only those data which are supported by appropriate quality control data and meet the measurement performance specification defined for this project will be considered acceptable and used in the project.

The procedures for verification and validation of data are described in Section D2, below. The TXSTATE Field Supervisor is responsible for ensuring that field data are properly reviewed and verified for integrity. The Laboratory Supervisor is responsible for ensuring that laboratory data are scientifically valid, defensible, of acceptable precision and bias, and reviewed for integrity. The TXSTATE Data Manager will be responsible for ensuring that all data are properly reviewed and verified, and submitted in the required format to TCEQ for loading in SWQMIS. The TXSTATE QAO is responsible for validating a minimum of 10% of the data produced in each task. Finally, the TXSTATE Project Manager, with the concurrence of the TXSTATE QAO, is responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting to TCEQ.

D2 VERIFICATION AND VALIDATION METHODS

All data will be verified to ensure they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to project specifications. The staff and management of the respective field, laboratory, and data management tasks are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process. The field and laboratory tasks ensure the verification of raw data, electronically generated data, and data on chain-of-custody forms and hard copy output from instruments.

Verification, validation and integrity review of data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the manager of the task. The data to be verified (listed in Table D2.1) are evaluated against project performance specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. If a question arises or an error is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. 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 task manager consults with the higher level project management to establish the appropriate course of action, or the data associated with the issue are rejected and not reported to the TCEQ for storage in SWQMIS. The performance of these tasks is documented by completion of the Data Review Checklist and Summary (Appendix C).

The TXSTATE Project Manager and QAO are each responsible for validating that the verified data are scientifically valid, defensible, of known precision, bias, integrity, meet the data quality objectives of the project, and are reportable to TCEQ. One element of the validation process involves evaluating the data again for anomalies. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data, before data validation can be completed.

A second element of the validation process is consideration of any findings identified during the monitoring systems audit conducted by the TCEQ QAS assigned to the project. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the TXSTATE Project Manager, with the concurrence of the QAO validates that the data meet the data quality objectives of the project and are suitable for reporting to TCEQ.

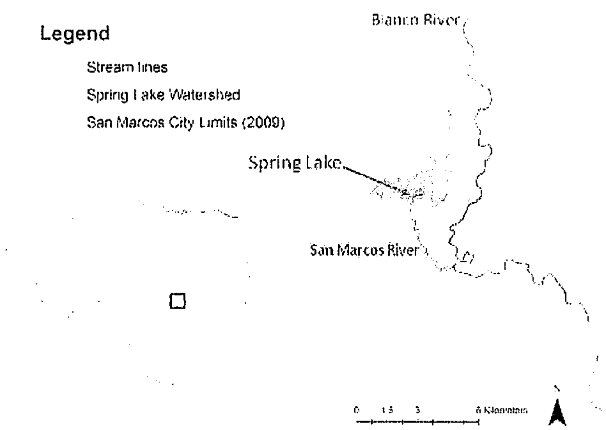
Table D2.1. Data Verification Procedures

Data to be Verified	Field Task	Laboratory Task	Lead Organization Data Manager Task
Sample documentation complete; samples labeled, sites identified	Y	Y	
Field QC samples collected for all analytes as prescribed in the TCEQ *SWQM Procedures Manual*	Y		
Standards and reagents traceable	Y	Y	
Chain of custody complete/acceptable	Y	Y	
Sample preservation and handling acceptable	Y	Y	
Holding times not exceeded	Y	Y	
Collection, preparation, and analysis consistent with SOPs and QAPP	Y	Y	Y
Field documentation (e.g., biological, stream habitat) complete	Y		
Instrument calibration data complete	Y	Y	
Bacteriological records complete	Y	Y	
QC samples analyzed at required frequency	Y	Y	Y
QC results meet performance and program specifications	Y	Y	Y
Analytical sensitivity (Minimum Analytical Levels/Ambient Water Reporting Limits) consistent with QAPP		Y	Y
Results, calculations, transcriptions checked	Y	Y	
Laboratory bench-level review performed		Y	
All laboratory samples analyzed for all parameters		Y	
Corollary data agree	Y	Y	Y
Nonconforming activities documented	Y	Y	Y
Outliers confirmed and documented; reasonableness check performed			Y
Dates formatted correctly			Y
Depth reported correctly			Y
TAG IDs correct			Y
TCEQ ID number assigned			Y
Valid parameter codes			Y
Codes for submitting entity(ies), collecting entity(ies), and monitoring type(s) used correctly			Y
Time based on 24-hour clock			Y
Absence of transcription error confirmed	Y	Y	Y
Absence of electronic errors confirmed	Y	Y	Y
Sampling and analytical data gaps checked (e.g., all sites for which data are reported are on the coordinated monitoring schedule)	Y	Y	Y
Field QC results attached to data review checklist			Y
Verified data log submitted			Y
10% of data manually reviewed			Y

D3 RECONCILIATION WITH USER REQUIREMENTS

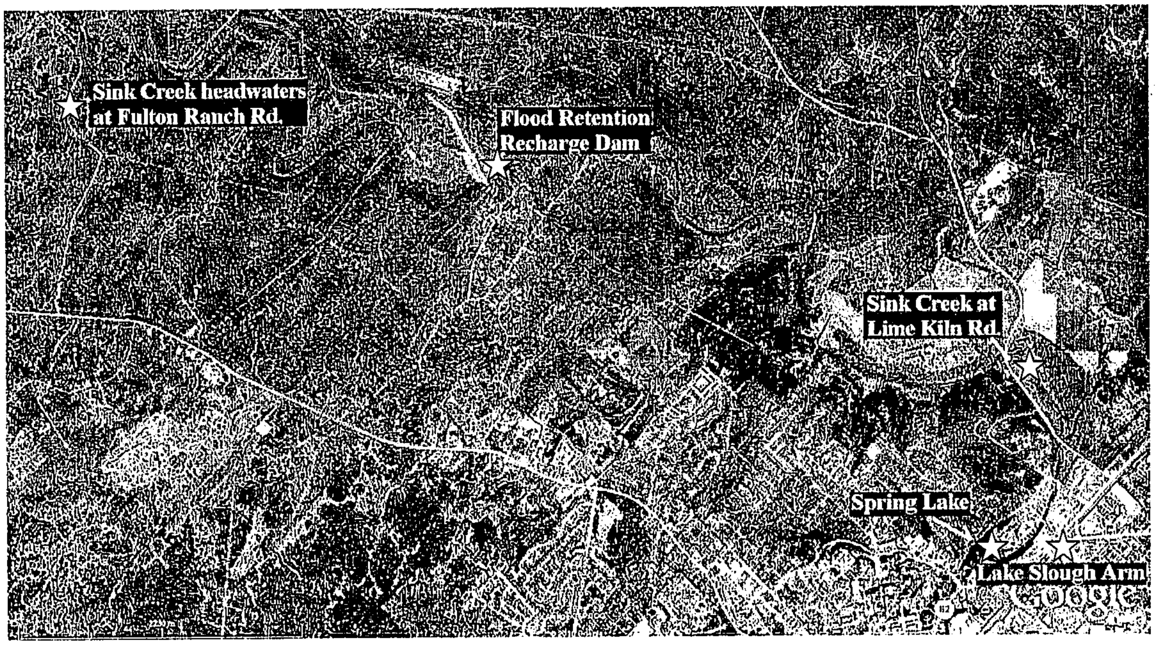
Data collected from this project will be analyzed by TXSTATE to report a Watershed characterization and potential NPS management recommendations stakeholders and the TCEQ. General recommendations on how to reduce potential sources of NPS and NPS loadings to Spring Lake and the upper San Marcos River will be the ultimate goal of the project. Neither field nor watershed characterization data that do not meet requirements will be used in the project or submitted to SWQMIS.

Appendix A. Area Location Maps



Appendix A1. Spring Lake and Sink Creek location map

Appendix A2. Spring Lake and Sink Creek watershed detailed satellite image



Appendix B. Work Plan

Project 1.02: Spring Lake Watershed Characterization and Management Recommendations Report

Subgrantee: Texas State University, River Systems Institute

Problem / Need Statement: The San Marcos River is an ecologically unique spring-fed ecosystem located along the margin of the Edwards Plateau in central Texas. Spring Lake, located in the City of San Marcos, is the headwaters of the San Marcos River where artesian spring water from the Edwards Aquifer emerges into the lake from approximately 200 openings. This spring system has been estimated to be the second-most productive system in the state. The importance of the springs has become evident during dry times. During portions of the 1996 drought, the San Marcos and Comal Springs combined accounted for 70% or more of flows in the Guadalupe River reaching Victoria and nearly 40% of flows that reached the San Antonio Bay.

Spring Lake is a horseshoe-shaped water body with two main regions: the Spring Arm and the Slough Arm. Most of the hydrological inputs to Spring Lake occur from spring openings in the Spring Arm. Sink Creek, the lake's only significant surface water tributary, discharges into the Slough Arm of the lake. Due to the relatively large spring water influence, Spring Lake and the upper river reaches are characterized by clear water, abundant and productive macrophytes and a relatively large number of endemic and native species. Spring Lake and the upper sections of the river exhibit nearly constant seasonal flows and water temperatures ~22°C; this relative environmental constancy has led to a high number of endemic species in the headwaters. However, the potential sensitivity of the headwaters to environmental perturbation, and the limited geographic range of many of the spring-adapted organisms, have led to the designation of a large number of federally- and state-listed taxa in the headwaters of the San Marcos River. The San Marcos salamander (Eurycea nana), Texas wild rice (Zizania texana), the fountain darter (Etheostoma fonticola), the Comal Springs riffle beetle (Heterelmis comalensis), and the Texas Blind Salamander (Typhlomolge rathburni) are all present in the headwaters, and the Edwards Aquifer immediately below Spring Lake and are listed by US Fish and Wildlife Service as endangered or threatened. The Guadalupe Roundnose minnow (Dionda nigrotaeniata) and the Bigclaw River Shrimp (Macrobrachium carcinus) also occur in the headwaters, and have been identified by the Texas Comprehensive Wildlife Conservation Strategy as species of "high priority" for conservation.

In addition to the high ecological value of the San Marcos River headwaters, the area also has substantial economic and cultural value for central Texas. Spring Lake and the upper river lie within the Texas State University campus and serve as a focal point for the campus and the city of San Marcos. Thousands of people visit the upper San Marcos every year for recreational activities such as swimming, tubing and kayaking and glass bottom boat rides in the headwaters. While the exact number of recreational users of the San Marcos River and its headwaters is unknown, approximately 125,000 people per year take part in the various programs at the Aquarena Center on Spring Lake, and the city of San Marcos also estimates that two city parks in the upper section of the river receive more than 600 recreational visitors per day on a typical summer day (e.g., not 4th of July weekend). In addition, there have been major archeological finds of prehistoric human artifacts and animal remains in Spring Lake. Further downstream from Spring Lake, the San Marcos River supplies drinking water for a number of communities in the San Marcos – Guadalupe River drainage, including the cities of San Marcos (49,000 residents) and the city of Victoria (60,000 residents). Water quality and quantity is of principle concern to communities below the San

Marcos River – Guadalupe River confluence because they are highly dependent upon the San Marcos River contribution to river flows, especially during relatively dry periods.

Texas State University and the City of San Marcos taken highly significant measures to protect the water quality of Spring Lake. The University, a public institution currently owns the land the lake sits on and acts as a steward to protect the lake's current state. The city has put in place special ordinances to ban swimming and boating in the lake to protect the endangered species habitat in the lake. Additionally, the city partners with the university to monitor water quality in the lake (fecal testing). Recently, the developer of the hotel and conference center wanted to build up above the lake. In response, the city commissioned a special environmental study. The results of the study showed many environmental concerns, which were presented to the City Council. Based on the results of the environmental report, the City negotiated with the developer to move the hotel and conference center to the highway, out of the Spring Lake watershed and out of the Edwards Aquifer recharge zone. The City has acquired and will preserve the 251 acres of land from the developer. The stormwater from this property flows directly into Spring Lake and Sink Creek just upstream of the lake. The most current plans for action include a Watershed Protection Plan that will begin in the next few years. At this time, the City of San Marcos and Texas State University are funding a half-time watershed planner position.

Spring Lake has never been monitoring by the State of Texas or the Guadalupe-Blanco River Authority. Therefore the lake has never been assessed for the Texas Water Quality Inventory and 303(d) List. Despite varied research projects conducted by faculty and students at Texas State University, no consistent data set exists with which to assess Spring Lake for the CWA 305(b). There is little quality-assured data on temporal dynamics of the lake's water quality. This is likely due to the fact that the lake presents several logistical monitoring challenges because of the multiple spring openings in the lake and the high variability in surface water flows from the Sink Creek watershed. Under a separate project, TCEQ and the River System Institute are working to develop two continuous water quality monitoring stations with which to collect data sufficient for temperature, dissolved oxygen, pH and specific conductance to assess Spring Lake in future CWA 305(b) assessments. Data collected by the proposed project will augment the TCEQ/RSI data set with nutrient data and describe contributing sources (springs, and various reaches of Sink Creek), a critical early step in developing a watershed protection plan. However, that project will not assess nonpoint source nutrient loadings to the lake, nor help to identify the sources of the pollution.

Until this proposal, there has not been an attempt to obtain high-resolution quality assured event-based data in order to target nutrient inputs to the lake or determine the influence of various sources of water on the algae and turbidity of the lake.

What is known is that, despite their high ecological, economic and cultural value, Spring Lake and the upper San Marcos River have recently experienced increased turbidity and major algal blooms following substantial rainfall events and the associated increases in surface and subsurface flows. While there is an obvious and sometimes persistent deterioration of water quality during and after periods of high surface and ground water inputs to the lake, the relative pollutant load contributions of these sources in the watershed is unknown. Thus, determination of the relative nutrient and sediment inputs to the lake from the various hydrological sources is critical for the management and preservation of the lake. In particular, determination of inputs of phosphorus (P) are of greatest concern because productivity of the lake is extremely phosphorus limited due to the low levels of immediately bioavailable phosphorus (<5 µg orthophosphate - P/L) relative to the high levels of bioavailable nitrogen (~1600 µg NO_3^{2-} - N/L).

Among the potential sources of nutrient perturbation to the lake, one of the most likely sources is Sink Creek. Currently, the Sink Creek watershed is experiencing rapid and major land use changes. Sink Creek was historically an ephemeral stream that drained ranching and agricultural areas. However, rapid urban development along the I-35 Austin-San Antonio corridor has led to a substantial increase in impervious cover and urban lands in the watershed. Most of the land within the Sink Creek watershed is privately owned; however, the city of San Marcos recently purchased approximately 250 acres within the watershed as part of a "greenbelt" and the uppermost headwaters of Sink Creek are located on Freeman Ranch, a property owned by Texas State University. Because Sink Creek discharges into the relatively shallow and productive Slough Arm of Spring Lake, incidents of high precipitation and high surface waters inflows may function as the major contributor to the deterioration of lake water quality because of the land use changes within the Sink Creek watershed.

The relative contribution of nutrients from the spring openings during periods of high discharge also remains unclear. During periods of low precipitation and surface flows (e.g., summer and early fall) groundwater dominates hydrological and nutrient inputs to the lake. However, groundwater discharges to the lake also increase with precipitation, but the relative contribution of these groundwater flows to nutrient loading during high flow periods is unknown. In addition, there are numerous spring openings in Spring Lake that vary in flow rate and groundwater sources. Some openings discharge water from largely local sources that was recently captured (e.g., within Hays county in the last 6 weeks), while other openings can discharge water from regional sources that is much older (>250 km away and >50 years old). The relative contribution of these various groundwater sources and how they vary seasonally and with local precipitation patterns is also unclear.

Another potential nutrient source to Spring Lake and the upper San Marcos River is the Texas State University Golf Course. The course lies immediately adjacent to the middle portion of the Slough Arm of Spring Lake, and maintenance practices from the course may lead to nutrient and sediment inputs to the lake. Again, the relative contribution of nutrient runoff from the golf course to algal blooms in the lake remains unknown.

Given the recent substantial water quality issues and the ecological, economic and cultural value of the Spring Lake system, understanding the relative NPS contributions of nutrients and suspended materials to Spring Lake via groundwater, the Sink Creek watershed, and the Texas State Golf Course is critical to preserve the biota and water quality of the lake.

General Project Description:
Determination of the relative NPS contributions of groundwater, the Sink Creek watershed, and the Texas State Golf Course to water quality and algal problems in Spring Lake and the upper San Marcos River will aid in the identification of various NPS and point-source contributors to Spring Lake and the upper San Marcos River. Verifying NPS contributions to Spring Lake will aid in the protection of water quality for endangered species habitat and a tremendously important economic and cultural resource for central Texas. In addition, determination of NPS contributions can aid future investigation activities.

Implementation of the NPS assessment project for Spring Lake and the Upper San Marcos River will be conducted in three main parts. The first part of the NPS program will be a Continuous Monitoring Program (CMP) which will continuously monitor basic water parameters at the major spring openings and in the Slough Arm of the lake. The CMP will be integrated with a STOrm flow Monitoring Program (STOMP) which will continuously monitor the hydrological and nutrient loading from the Sink Creek watershed into the Slough Arm of Spring Lake. The second part of the Spring Lake NPS program will be a Periodic Monitoring Program (PMP) which will regularly collect water quality and nutrient data from Spring Lake to examine spatial and temporal patterns of nutrients within the lake. The PMP data will be available to the TCEQ, RSI, and the public on the web at www.txwaterdata.org. In combination, these monitoring programs will provide the data required to calculate a nutrient budget for Spring Lake and to determine whether NPS nutrients arrive via Sink Creek, runoff from the TSU golf course, from groundwater sources (spring discharge), or a combination of these. The third part of the Spring Lake NPS program will use GIS and remote sensing platforms to analyze land use characteristics of the Spring Lake and Sink Creek watersheds. These data, along with results from the CMP, the STOMP, and the PMP, will be presented to stakeholders to inform them of potential linkages between present and future land use practices and water quality of the lake. This last part of the NPS program will identify nutrient load reduction priorities and will be employed in creation of a Nutrient Management Plan with stakeholder input for potential future management strategies for Spring Lake and the watershed.

This project takes an innovative approach to monitoring water quality and quantity from two distinct sources: ground water and surface water. The combination of tools and resources will help to provide a well-rounded description of the nutrient budget of Spring Lake and of watershed activities. These monitoring techniques will serve as an excellent example for the Central Texas Edwards Aquifer region, the state, and the nation by providing standard operating procedures for data analysis using different methods of water quantity and quality data collection.

The Project will be led by the River Systems Institute (RSI) at Texas State University (TSU) with university professors playing and integral role in the project.

Part 1 – Continuous Water Quality Monitoring Program: A continuous water quality monitoring program within Spring Lake and the Sink Creek watershed will be established to determine the relative importance of surface water and ground water inflows to the nutrient and sediment inputs to Spring Lake. Continuous Monitoring Program (CMP) sites will be established in the lake and maintained for the project duration to continuously measure and log basic water quality parameters. The CMP instruments will continuously measure and data-log temperature, dissolved oxygen (DO), specific conductance (SpC), pH, oxidation-reduction potential (ORP), and turbidity at high temporal resolution.

One CMP site will be located within the Slough Arm, where the main surface water inputs occur. These data will be coupled with discharge data from the Sink Creek gauging station (see below) to estimate the contribution of surface water inputs to changes in basic water quality parameters. Five additional CMP sites will be located at 5 major spring openings in the Spring Arm of the lake. Spring Lake CMP data will be used to monitor basic water quality of the major springs in the lake and to determine if these springs respond rapidly and/or significantly to precipitation/recharge events. Temporal patterns in CMP data from springs will be directly coupled with temporal patterns in surface water discharge to the lake and with local precipitation data collected from the Spring Lake Meteorological Station (maintained and operated by the RSI). Spring openings which show substantial variation in water quality in response to precipitation events will be targeted for high frequency nutrient grab-sampling during periods where spring water quality is likely to change (e.g., during large or extended precipitation/recharge events). High-frequency sampling will measure orthophosphate (Ortho-P), nitrate (NO_3^{2-}), ammonium (NH_4^+), and turbidity entering the Spring Arm via groundwater discharge throughout large or sustained rainfall events. This high-frequency sampling will be independent from the Periodic Monitoring Program (PMP) outlined below. If substantial amounts of nutrients are entering Spring Lake via groundwater discharge, it may be possible to determine general source regions (i.e. regions within the surface recharge zone) by utilizing existing dye-trace data.

In addition to data collection from the CMP instruments in the lake, there will also be an automated STOrm flow Monitoring Program (STOMP) along Sink Creek that will sample three sites within the creek to determine NPS nutrient contributions from various portions of the watershed to Spring Lake. STOMP nutrient concentration data from the Sink Creek watershed will be coupled with surface water discharge values to calculate nutrient loading to the lake from the Sink Creek watershed. In order to determine hydrological inputs, and thus nutrient loading from the Sink Creek watershed, a gauging station must be installed in the Sink Creek watershed. The United States Geological Survey (USGS) currently operates a gauging station below the outflow of Spring Lake; however, surface water inflows to the lake via the Sink Creek watershed are unknown. Construction of a hydrological and nutrient budget for the lake to determine the relative importance of nutrient loading from the Sink Creek watershed requires that the GRANTEE install a continuously monitoring gauging station to measure hydrological inflows from Sink Creek.

In order to compare nutrient and sediment loading from the Sink Creek watershed to nutrient and sediment inputs from spring flows within the lake, flow measurements will be taken from the major spring openings in the lake. Major spring openings or groups of springs will be approximately gauged periodically (where physically possible) using an acoustic Doppler velocity meter. Flow data from individual springs will be coupled with nutrient and turbidity data from the spring to determine nutrient and sediment loading from spring flows to the lake. Discharge data from individual springs will be used in conjunction with Sink Creek and San Marcos River gauge data to estimate the relative contribution of major spring openings in the lake to the total discharge, nutrient and sediment loads. 319(h) funds will pay for the purchase, installation, operation and maintenance of the gauging station. This station is necessary to determine the flows of Sink Creek and the associated loading contributions. The combination of surface- and spring flow nutrient inputs will be used to calculate seasonal and annual nutrient loadings to Spring Lake. These data will aid in determining the relative contributions of groundwater vs. surface water NPS nutrient loading to the lake. This information will also provide a basis for determining nutrient and sediment sources to the lake and to prioritize any future plans for nutrient management for Spring Lake and the watershed.

Part 2: Periodic Water Quality Monitoring Program: A Periodic Water Quality Monitoring Program (PMP) will be established within Spring Lake itself to assess spatial and temporal patterns of nutrients and water quality in the lake. TSU personnel will collect periodic "grab samples" from sites within Spring Lake every two to three weeks from sites distributed throughout the lake. Sampling on a two to three week basis will capture reasonably high resolution spatial and temporal patterns of water quality in the lake. The periodic sampling will measure total phosphorus (TP), total nitrogen (TN), nitrate (NO_3^{2-}), Ammonium-N, Orthophosphate (OP), total suspended solids (TSS), turbidity, and *E. coli*. In addition to identification of general spatial and temporal patterns of nutrients and suspended sediments in the lake, the PMP will also provide information on the impact of the TSU golf course in the Slough Arm of the lake. For example, if nutrients and/or suspended sediment concentrations increase in the portion the Slough Arm adjacent to the golf course without other apparent nutrient loading sources, then this result would suggest that the TSU golf course is a potential water quality problem for Spring Lake.

Part 3: Spring Lake Watershed Land Use Analysis and Potential Management Measures: Upon execution of the contract, Spring Lake / Sink Creek watershed stakeholder meeting(s) will be held to inform the public of the project plan and ask for stakeholder input on known nonpoint sources of nutrients and pollution. RSI has excellent contacts and has already informed a large number of stakeholders in the upper San Marcos River and the Sink Creek watershed of this proposed plan, including the city of San Marcos, San Marcos Chamber of Commerce, San Marcos Parks and Recreation, the San Marcos River Foundation (SMRF), Texas Stream Team (formerly Texas Watch), Texas State University, Texas Parks and Wildlife Department, United States Fish and Wildlife Service (USFWS), and private citizens who own property within the Sink Creek watershed. RSI and Texas State University personnel have been in direct contact with, and will collaborate with, the city of San Marcos (the San Marcos Mayor and the Parks and Recreation Department) throughout the life of the project due to their vested interest in area land uses and the effects on water quality. Most of the stakeholders listed above enthusiastically support this proposal and will participate in future stakeholder meetings (letters of support available on request). Under this work plan, the RSI/TSU personnel will also document current land use practices within the Sink Creek watershed using remote sensing and GIS. This information, coupled with STOMP data will be used to inform stakeholders in the upper San Marcos River and the Sink Creek watershed of potential linkages between land use and water quality of the lake.

With the water and land use data, as well as stakeholder input, a Watershed Characterization and Management Recommendations Report will be created. The report will provide an assessment of the water quality and water quantity data, along with the land use data, from which potential nonpoint sources of pollution will be identified. Strategies to reduce these sources of pollution will be provided as suggestions for future management options for the watershed. Stakeholders will have opportunities to provide suggestions and comments on the plan before finalization.

A Watershed Characterization and Management Recommendations Report has been chosen as portion of the initial phase for a future watershed protection plan for the Upper San Marcos River. The TCEQ believes that a full watershed protection plan cannot be completed within the time period of one grant due to the very complicated nature of the water body and the monitoring that will be conducted on it. The City of San Marcos and Texas State University are planning the initiation of a watershed protection plan for the Upper San Marcos River in the next few years. The collection of this very important data will be very important to the watershed planning process. It is critical to first understand the nutrient inputs to the creek and lake system, due to its unique and complicated hydrology, before a full assessment of sources of these pollutants and management measures in the watershed can be prepared.

The Subgrantee, the River Systems Institute (RSI) at Texas State University (TSU) have partnered and cooperated with the TCEQ in numerous water quality monitoring programs and projects. Here, the RSI and TSU will provide operation and maintenance of the CMP sites in Spring Lake for up to 3 years based on available resources.

This project will start on the date of execution of the associated contract between TCEQ and RSI for the project. The project is scheduled to be completed not later than August 31, 2012.

TASK 1: PROJECT ADMINISTRATION

Goal: *To effectively coordinate and monitor all technical and financial activities performed under this grant, preparing regular progress reports, and maintaining project files and data.*

Task 1.1 **Project Oversight** – The RSI Project Manager (Andy Sansom) will provide fiscal oversight of the staff and/or subgrantee(s)/subcontractor(s) to ensure tasks and deliverables are on time and on budget. Dr. Weston Nowlin and Dr. Benjamin Schwartz (Texas State University) will work with Andy Sansom on the technical oversight of the project. With the TCEQ Project Lead authorization, RSI will secure services of subgrantee(s)/ subcontractor(s) as necessary for technical support, repairs and training. Project oversight status will be provided to the TCEQ with the Quarterly Progress Reports.

Task 1.2 **Progress Reports** - To be submitted to TCEQ by the 15th of the month following each state fiscal quarter for incorporation into the Grant Reporting and Tracking System (GRTS). Progress reports will contain a level of detail sufficient to document the activities that occurred during the quarter, and contain a detailed tracking of deliverable status under each objective.

Task 1.3 **Reimbursement Forms** - Reimbursement forms will be submitted to the TCEQ by the last day of the month following each state fiscal quarter.

Task 1.4 **Conference Calls** – The RSI Project Manager and collaborating scientists, will participate in monthly conference calls coordinated by Monitoring Operations staff to provide updates on the project, and will communicate status and issues to the TCEQ designated Project Lead as necessary.

Task 1.5 **Contractor Evaluation** - The River Systems Institute will participate in an annual Contractor Evaluation.

Task 1.6 **Project Fact Sheet** – The River Systems Institute will develop a one-page fact sheet of the project using the TCEQ NPS Projects Template. The fact sheet will briefly describe what the project is going to accomplish, gives background information on why the project is being conducted, the current status of the project and lists who is involved in the project. The project fact sheet will be submitted to the TCEQ within 60 days after contract initiation. The fact sheet will be updated annually and submitted with the fourth quarter progress report. The fact sheet will be updated more often, as the project status changes. The fact sheet will be published on the RSI website after approval from the TCEQ Project Manager.

Measures of Success: Adherence to the TCEQ administrative requirements; timely completion and submittal of progress reports and deliverables.

Deliverable: Quarterly Progress Reports for incorporation in the Grants Reporting and Tracking System (GRTS).

TASK 2: QUALITY ASSURANCE OF MONITORING AND DATA COLLECTION

Goal: *To collect and analyze quality assured water and land use data.*

Task 2.1 **QAPP** – The River Systems Institute will develop and submit to the TCEQ a Quality Assurance Project Plan (QAPP) with project specific data quality objectives consistent with the EPA QA/R5 format 120 days prior to the initiation of any sampling. Upon approval from the TCEQ, the QAPP will be submitted to the EPA for approval 60 days prior to sampling. Annually throughout the project period, the RSI and TSU will provide input to TCEQ 60 days prior to the end of the effective period of the QAPP, and will develop annual QAPP revisions 30 days prior to the end of the effective period of the QAPP.

Task 2.1 **Data Quality Objectives** - The data quality objective of the monitoring for this project is to determine the water quality conditions of Spring Lake and Sink Creek. The data will be used to determine pollutant sources and loads from Sink Creek and the major springs of Spring Lake in order to develop a Spring Lake nutrient management plan for nutrients and sediment.

Measure of Success: An improved QAPP with a monitoring plan that will meet the data quality objectives.

TASK 3: WATER QUALITY DATA COLLECTION AND MONITORING

Goal: *To continuously monitor water quality parameters in Spring Lake and the Sink Creek watershed in order to identify potential nonpoint sources and causes of nutrient pollution, and to characterize groundwater vs. surface water contributions to flow in the San Marcos River. Data will be collected at (1) Continuous Monitoring Program (CMP) six sites within Spring Lake, (2) an automated STOrm water Monitoring Program (STOMP) in the Sink Creek watershed, and (3) a Periodic Monitoring Program (PMP) within Spring Lake.*

Task 3.1 **Continuous Monitoring Program (CMP) Site Locations and Installation** - The NPS program for Spring Lake and Sink Creek will utilize seven multi-parameter water quality probes. Funding to purchase four of the multi-parameter probes is requested in this work plan; Dr. Schwartz will purchase three of the multi-parameter water-quality probes with TSU start-up money as matching funds. The CMP will utilize In-Situ TROLL 9500 Professional-XP customizable probes.

The In-Situ TROLL 9500 Professional-XP will be configured to collect data on the following water quality parameters:

- Dissolved oxygen (mg/L)
- Specific conductance (µS/cm)
- Temperature (°C)
- pH/ORP (E_h)
- Depth (m)
- Turbidity – self cleaning (NTU)

Operation and maintenance includes periodic scheduled service rotation (by purchasing one more probe than will be deployed) and download of data. TSU and RSI personnel will conduct all maintenance and downloading activities.

Five TROLL 9500 Professional-XP probes will be installed in the largest spring openings in Spring Lake, and one will be installed in the Slough Arm of the lake. The seventh probe will be periodically rotated between the six CMP sites to allow repairs and routine maintenance while maintaining uninterrupted data collection. Continuous measurements will be accompanied by periodic flow measurements using a Doppler flow meter, and 'grab' samples to measure Ortho-P, NO_3^{2-}, and NH_4^+ from the spring openings in order to estimate nutrient loading from each spring opening. The periodic measurements will be taken as a part of the Periodic Monitoring Program (see Task 2.3 below).

Task 3.2 **Storm flow Monitoring Program (STOMP)** – To determine nutrient export from the various sub-catchments in the Sink Creek watershed, the RSI and TSU staff will collect storm flow samples from three locations within the Sink Creek watershed using Teledyne ISCO portable storm flow samplers outfitted with water level gauges. Data on nutrient concentrations and turbidity during high flow events will be used to identify potential sub-catchment sources of nutrients and sediment inputs to Spring Lake.

Storm water samples will be collected at each watershed site after high flow events. Samplers will be programmed to collect hourly samples over a 24-hr period when storm flows are present so that nutrient and sediment exports from each sub-catchment can be determined. This information will be used to generate flood stage/water level – nutrient concentration relationships for different portions of the watershed. Storm water samplers will be regularly inspected (every two weeks) and if any water is present at the site, a "grab" sample of stream water will be collected for analysis.

The three storm water sampling sites will be positioned within the watershed at the following locations:

- Within Sink Creek, upstream from Spring Lake at the USGS gauging station at the Lime Kiln Road Crossing (see Task 3 below)
- Within Sink Creek below near the headwaters of the Slough Arm of Spring Lake
- Within Sink Creek inside the headwaters location in Freeman Ranch

Water samples will be transported to the Edwards Aquifer Research and Data Center (EARDC) at Texas State University for analyses. EARDC has applied for NELAC lab accreditation and expects to be accredited by the project start date. Lab analyses will follow EPA approved methods. The following analyses will be conducted on the STOrm samples:

- Total phosphorus (TP) concentration
- Total nitrogen (TN) concentration
- Nitrate-N
- Ammonium-N concentration
- Orthophosphorus (Ortho-P) concentration
- Total suspended solids (TSS) and/or non-volatile suspended solids (NVSS)
- Turbidity
- *Escherichia coli* (*E. coli)*

Task 3.3 **Periodic Monitoring Program (PMP)** – In order to supplement and enhance the overall CMP data, the RSI staff and/or subgrantee(s) will collect periodic "grab samples" from sites within Spring Lake. Water samples will be collected every two to three weeks from sites within the lake. The following sites will have water samples collected:

- Within the upper Slough Arm of Spring Lake

- Within the lower Slough Arm of Spring Lake, below the Texas State University Golf Course
- Within the upper Spring Arm of Spring Lake below the outflows of the major spring sites within the lake
- Within the lower Spring Arm of Spring Lake
- Below the USGS gauging station in the San Marcos River

Water samples will be transported to the Edwards Aquifer Research and Data Center (EARDC) at Texas State University for analyses. EARDC has applied for NELAC lab accreditation and expects to be accredited by the project start date. Lab analyses will follow EPA approved methods. The following analyses will be conducted on samples:

- Total phosphorus (TP) concentration
- Total nitrogen (TN) concentration
- Nitrate-N concentration
- Ammonium-N concentration
- Orthophosphate (Ortho-P) concentration
- Total suspended solids (TSS) and/or non-volatile suspended solids (NVSS)
- Turbidity
- *E. coli*

Task 3.4 **CMP, STOMP, and PMP Training** – RSI and Texas State University will train personnel who will participate in sample collection. Only individuals who have successfully completed training may collect samples. The RSI and TSU will provide training information and status in the Quarterly Status Reports.

Task 3.5 **CMP, STOMP, and PMP Site Development -** The RSI and TSU will design and develop all CMP, STOMP and PMP sites in close coordination with the TCEQ.

Task 3.6 **CMP, STOMP, and PMP Scheduling** – CMP, STOMP, and PMP sampling and analyses will be performed by the RSI and TSU staff and/or subgrantee(s) consistent with all applicable TCEQ/EPA SOPs. Sampling will be conducted within 48 hours of the scheduled sampling date. Summaries of sampling activities will be included in the Quarterly Progress Report.

Task 3.7 **CMP, STOMP, and PMP Data Submittals** - Data and date status will be provided to the TCEQ with the Quarterly Progress Reports. Data will be stored on TCEQ and RSI/Texas State University computer systems. PMP data will also be stored in the TCEQ SWQMIS database.

Task 3.8 **CMP, STOMP, and PMP Coordination** – TSU and RSI will purchase and maintain stocks of items required to perform STOMP sampling. Information regarding coordination of activities will be included in the Quarterly Progress Reports.

Measure of Success: The capture and transfer of data from the CMP sites and collection and transfer of STOMP and PMP data to TCEQ.

TASK 4: ESTABLISH AND OPERATE SINK CREEK GAUGING STATION

Goal: *To continuously monitor hydrologic inputs to Spring Lake from the Sink Creek watershed and to determine hydrologic and nutrient loading from the Sink Creek watershed into Spring Lake, a gauging station will be established in Sink Creek watershed.*

Task 4.1 **Sink Creek Gauging Station Installation** –RSI and TXSTATE will install a gaging station at the most upstream of the two Lime Kiln Road crossings. The gaging station will be installed following USGS guidelines: USGS Water Supply Paper 2175, Volumes 1 and 2. After multiple assessments by the RSI and TXSTATE, it was determined that Lime Kiln Road site, at a large concrete box culvert, presents the most reasonable option for installation of a reliable stream gauge; this site integrates about 90% of the Sink Creek drainage area and presents limited potential for backwater formation. Gauging station installation will commence upon execution of the TCEQ-TSU and TSU-USGS contracts. TSU and RSI will provide summaries of gauging station installation progress to TCEQ in the Quarterly Progress Report.

Task 4.2 **Sink Creek Gauging Station Operation and Maintenance** - Operation and periodic scheduled maintenance will be performed by RSI/TXSTATE using SOPs in USGS Water Supply Paper 2175, Volumes 1 and 2. Subject to availability of parts and other supplies, RSI/TXSTATE will respond to and correct any equipment failures or malfunctions. Summaries of operation and maintenance activities will be included in the Quarterly Progress Report.

Task 4.3 **Sink Creek Gauging Station Data Submittal** – Flow data will be provided to and stored on RSI and TSU computers. Data status will be provided with the Quarterly Progress Reports.

Task 4.4 **Sink Creek Gauging Station Coordination** – As a part of the gauging station contract, the RSI/TXSTATE will purchase and maintain items regularly required to perform routine maintenance of the site. RSI and will provide information regarding coordination of activities in the Quarterly Progress Reports.

Measure of Success: Capture and transfer of data from the Sink Creek gauging to RSI, TSU and TCEQ.

TASK 5: IDENTIFY NUTRIENT SOURCES TO SPRING LAKE AND CREATE A WATERSHED CHARACTERIZATION

Goal: *Evaluate present land use within the Spring Lake watershed (including the San Marcos Spring watershed), and in conjunction with water quality data, inform stakeholders in the San Marcos River headwaters and the Sink Creek watershed of the potential linkages between land use and water quality. Land use data, water quality data, and information from stakeholders will then be used to generate suggestions of nutrient source management for Spring Lake and the Sink Creek watershed.*

Task 5.1 **Evaluation of Sink Creek Watershed Land Use Patterns** – Remote sensing and GIS will be used to evaluate land use patterns in the Sink Creek watershed by RSI and Texas State University staff. Land in the various sub-catchments within the Sink

Creek watershed will be categorized into specific land use groups (i.e., urban, forest, etc). Land use maps generated from remotely sensed platforms will be imported into a GIS database that would depict land use and land cover changes over time. Land use analyses will begin in September 2009.

Task 5.2 **Evaluation of NPS groundwater source regions** – Existing dye-trace and other hydrogeologic data will be used to evaluate the most likely contributing zones for spring openings which may be determined to significantly contribute to NPS nutrient loading in Spring Lake. This analysis will be performed by RSI and TSU staff. Maps generated will be imported into a GIS database that would depict the most likely source regions based on hydrogeologic data available at that time. These analyses will begin upon approval of the QAPP.

Task 5.3 **Presentation of Land Use and Water Quality Data and Feedback from Stakeholders** – Upon initiation of the Spring Lake NPS program, RSI and TSU personnel will conduct group and/or individual meetings with stakeholders in the Spring Lake watershed in order to inform them of the NPS program and to describe its goals. At this point, an effort will be made to obtain preliminary information on additional NPS sources to the lake and any concerns stakeholders might have – including any future development or preservation plans for the Sink Creek and Spring Lake watersheds. In September 2010, RSI will set up more group and individual meetings with the various stakeholders in the Spring Lake watershed. Nutrient loading data from the previous two years, as well as land use analyses, will be presented to stakeholders. Stakeholder opinions, concerns and future expectations for Spring Lake will be recorded. In addition, how the opinions and/or future development plans of stakeholders may change in response to the NPS study data will be determined.

Task 5.4 **Creation of a Watershed Characterization and Potential Management Measures Report for Spring Lake** – RSI and TSU staff and/or subgrantee(s) will recommend specific nutrient management strategies given the current and future land use and flow patterns of the Sink Creek and Spring Lake watersheds. The potential impacts of any future development and/or land preservation plans for the Sink Creek and Spring Lake watersheds will be incorporated into any management strategies. The report for Spring Lake will be presented to stakeholders, with opportunities to provide comments and suggestions, by the end of the contract. The report will be included as a part of the Final Report to TCEQ and EPA.

Measure of Success: Evaluation of land use patterns, identification of potential groundwater source regions, conducting meetings with stakeholders, and creation of a Watershed Characterization and Potential Management Measures Report for Spring Lake.

TASK 6: FINAL REPORT

Goal: *To provide TCEQ and EPA with a comprehensive Final Report on the activities conducted by the Grantee during the course of the project.*

Task 6.1 **Final Report** - Provide comprehensive, technical Final Report on the activities conducted by the Grantee to the TCEQ and EPA. The Final Report will provide analysis of all activities and deliverables within the grant. Draft reports will be provided to the TCEQ. The final version of the report will address comments provided by the TCEQ Project Manager. The Final Report will include but is not limited to the following information:

- Title
- Table of Contents
- Executive Summary
- Introduction
- Project Significance and Background
- Methods
- Results and Observations
- Discussion
- Summary
- References
- Appendices

Measure of Success: Acceptance of the Final Report by the TCEQ.

Deliverables: Final Report by August 31, 2012

PROJECT LEAD

Andrew Sansom, Executive Director
River Systems Institute at Texas State University
601 University Drive
San Marcos, Texas 78666-4616
Telephone: 512-245-9200
Fax: 512-245-7371
E-mail: as22@txstate.edu

Schedule of Deliverables

The Schedule of Deliverables is based on the contract execution date. The Schedule of Deliverables will be adjusted accordingly if the contract execution is delayed.

Task No.	Deliverable	Due Date
	Post Award Meeting & Minutes	Within 60 days of contract execution
1.1	Project oversight status	Quarterly
1.2	Quarterly Progress Reports	The 15th of the month following each state fiscal quarter
1.3	Quarterly Reimbursement Request Forms	The end of the month following each state fiscal quarter
1.4	Quarterly conference call or meeting with the TCEQ Project Manager & Minutes	The second month of each state fiscal quarter
1.5	Contractor Self-Evaluation	15 days following the end of the state fiscal year
1.6	Project Fact Sheet	Within 60 days of contract execution
1.6	Project Fact Sheet Update	15 days following the end of the state fiscal year
1.7	Project Annual Report Article (when requested)	15 days following the end of the state fiscal year or when requested
2.1	Draft PPP	Within 30 days of contract execution
	1st Stakeholder Meeting	Within 45 days of contract execution
2.1	Final PPP	45 days after the draft PPP is submitted
2	The following items will be submitted to the TCEQ Project Manager for approval prior to publishing/purchasing: o Press releases, press conference agendas o Meeting agendas o Public events /workshops/demonstrations plans, documents, o Education and outreach materials	Ongoing
2	Stakeholder Group and Public meetings/events agendas, minutes, sign in sheets, pictures and other available documentation	With QPRs

2	Final copies of all public information produced and media coverage regarding the Spring Lake will be submitted to the TCEQ Project Manager	With QPRs
2	Report on attendance at local and regional meetings to communicate and obtain input on the project	With QPRs
2	PPP Progress Reports	Biannually (2 times per year) with QPRs
3	Draft Watershed Characterization – Phase 1: Data Inventory Report	2/28/10
3	Final Watershed Characterization – Phase 1: Data Inventory Report	5/31/10
4.3	Water Quality Monitoring Plan	Within 40 days of contract execution
4.4	QAPP Planning Meeting	Within 45 days of contract execution
4.4	QAPP Planning Meeting Minutes	15 days after QAPP Planning Meeting
4.5	QAPP Draft	30 days after QAPP Planning Meeting
4.5	QAPP Final	20 days after receiving TCEQ comments on Draft QAPP
4.6	Draft QAPP Updates submitted to the TCEQ Annually	60 days prior to the end of the effective period of the QAPP
4.6	Final QAPP Updates submitted to the TCEQ Annually	45 days prior to the end of the effective period of the QAPP
4.7	Draft QAPP Amendments	75 days prior to change in sampling plan implemented
4.7	Final QAPP Amendments	45 days prior to change in sampling plan implemented
5.4	Sample collection techniques training updates	Quarterly
5.5	Status of all sampling and analyses conducted	Quarterly
5, 6	Water quality data and data summary submittals	Quarterly & one (1) month prior to use or presented to stakeholders
5, 6	Monitoring non-conformances and sampling coordination activities updates	Quarterly

5, 6	Water quality monitoring non-conformance notices	As soon as possible & with QPRs
6	Gaging station installation, operation & maintenance status updates	Quarterly
7	Draft Watershed Characterization – Phase 2: Data Collection and Analysis Report	7/31/10
7	Final Watershed Characterization – Phase 2: Data Collection and Analysis Report	8/31/10
8.1	Revised/refined watershed goals & targets	9/29/10
8.4	Watershed maps that identify the causes and sources of water quality problems	10/31/10
8	Draft Watershed Characterization - Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads Report	10/31/10
8	Final Watershed Characterization - Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads Report	11/30/10
9	Draft Management Measures Report	2/28/11
9	Final Management Measures Report	3/31/11
10	Draft Watershed Characterization and Management Measures Report	4/30/11
10	Final Watershed Characterization and Management Measures Report	7/31/11
10.2	Letter of Approval from the Stakeholder Group	8/31/11
10.3	Documentation of presentations to relevant officials and the public submitted	8/31/11

Appendix C. Data Review Checklist and Summary

NPS DATA REVIEW CHECKLIST AND SUMMARY

A completed checklist must accompany all data sets submitted to the TCEQ by the Contractor.

Data Format and Structure		**Y, N, or N/A**
A.	Are there any duplicate *Tag_Ids* in the *Events* file?	____
B.	Are all *StationIds* associated with assigned station location numbers?	____
C.	Are all dates in the correct format, MM/DD/YYYY?	____
D.	Are all times based on the 24 hour clock format, HH:MM?	____
E.	Is the *Comment* field filled in where appropriate (e.g. unusual occurrence, sampling problems)?	____
F.	Are *Submitting Entity*, *Collecting Entity*, and *Monitoring Type* codes used correctly?	
G.	Do the *Enddates* in the *Results* file match those in the *Events* file for each *Tag_Id*?	____
H.	Are all measurements represented by a valid *Parameter code* with the correct units?	____
I..	Are there any duplicate *Parameter codes* for the same *Tag_Id*?	____
J.	Are there any invalid symbols in the Greater Than/Less Than (*Gt/lt*) field?	____
K.	Are there any tag numbers in the *Result* file that are not in the *Event* file?	____
L.	Have verified outliers been identified with a "1" in the *Remark* field?	____

Data Quality Review		
A.	Are all the "less-than" values reported at or below the specified reporting limit?	____
B.	Have checks on correctness of analysis or data reasonableness performed? e.g.: Is ortho-phosphorus less than total phosphorus? Are dissolved metal concentrations less than or equal to total metals?	____ ____
C.	Have at least 10% of the data in the data set been reviewed against the field and laboratory data sheets?	____
D.	Are all *Parameter codes* in the data set listed in the QAPP?	____
E.	Are all *StationIds* in the data set listed in the QAPP?	____

Documentation Review		
A.	Are blank results acceptable as specified in the QAPP?	____
B.	Was documentation of any unusual occurrences that may affect water quality included in the *Event* table's *Comments* field?	____
C.	Were there any failures in sampling methods and/or deviations from sample design requirements that resulted in unreportable data? If yes, explain on next page.	
D.	Were there any failures in field and laboratory measurement systems that were not resolvable and resulted in unreportable data? If yes, explain on next page.	

Describe any data reporting inconsistencies with performance specifications. Explain failures in sampling methods and field and laboratory measurement systems that resulted in data that could not be reported to the TCEQ. (attach another page if necessary):
Date Submitted to TCEQ: ______________________________

TAG Series: ______________________________

Date Range: ______________________________

Data Source: ______________________________

Comments (attach file if necessary):

____

____

____

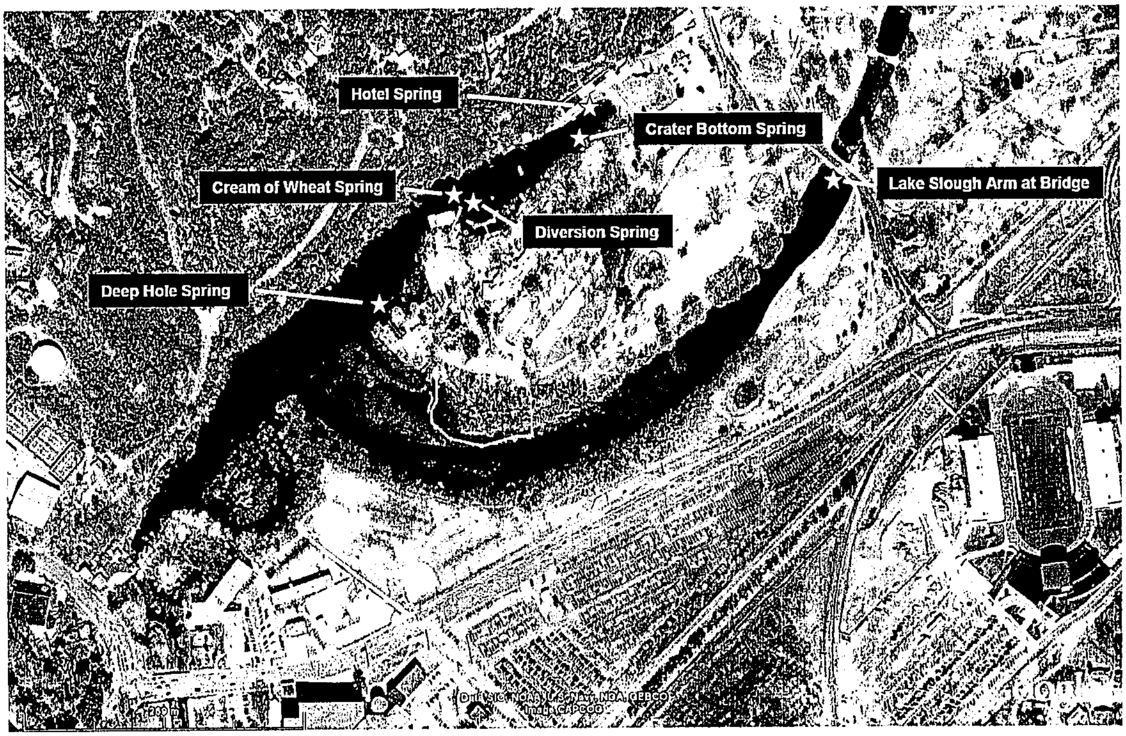
____

____

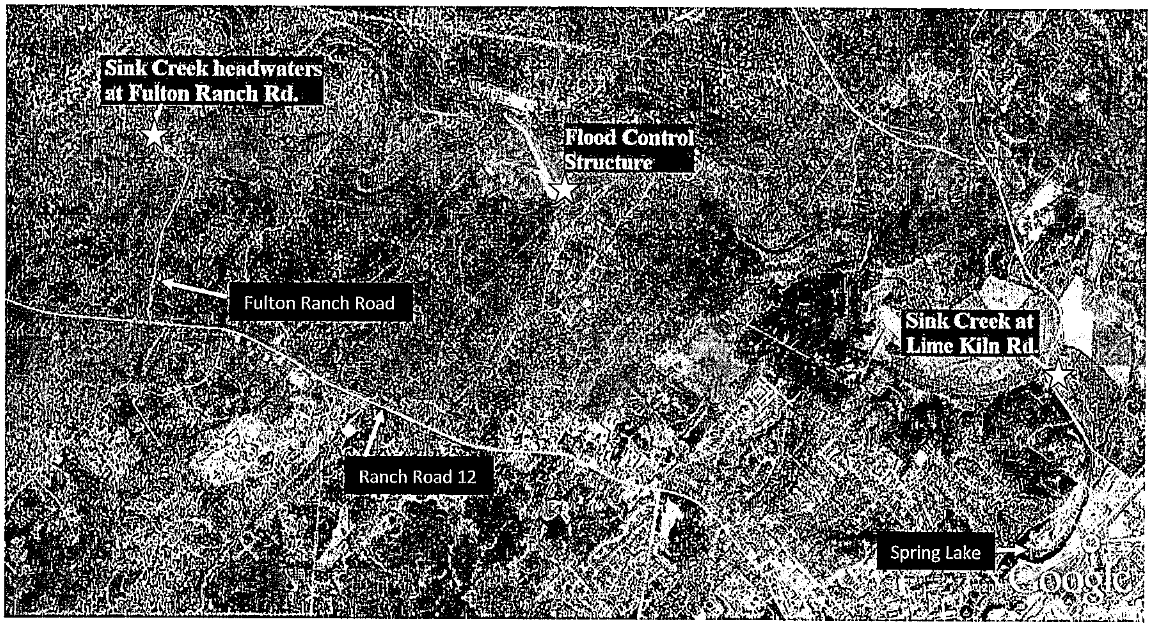
Contractor's Signature: ______________________________

Date: ______________________________

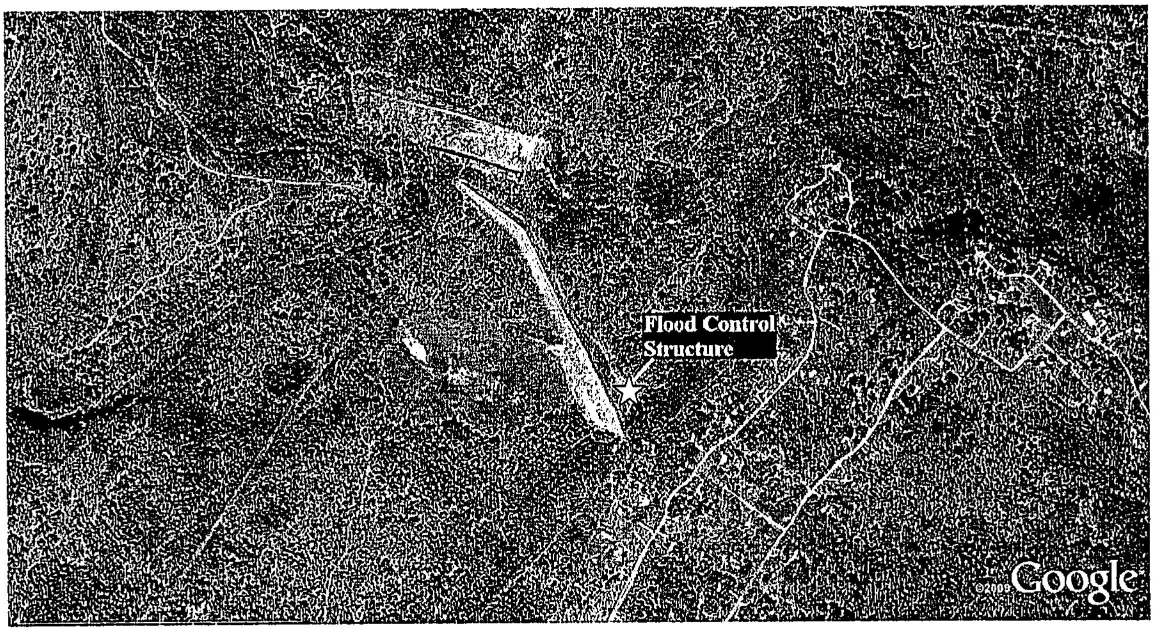
Appendix D. Detailed Site Location Maps



Appendix D1. Detailed satellite image of sites within in Spring Lake for the Continuous Monitoring Program. Sites are indicated by stars.

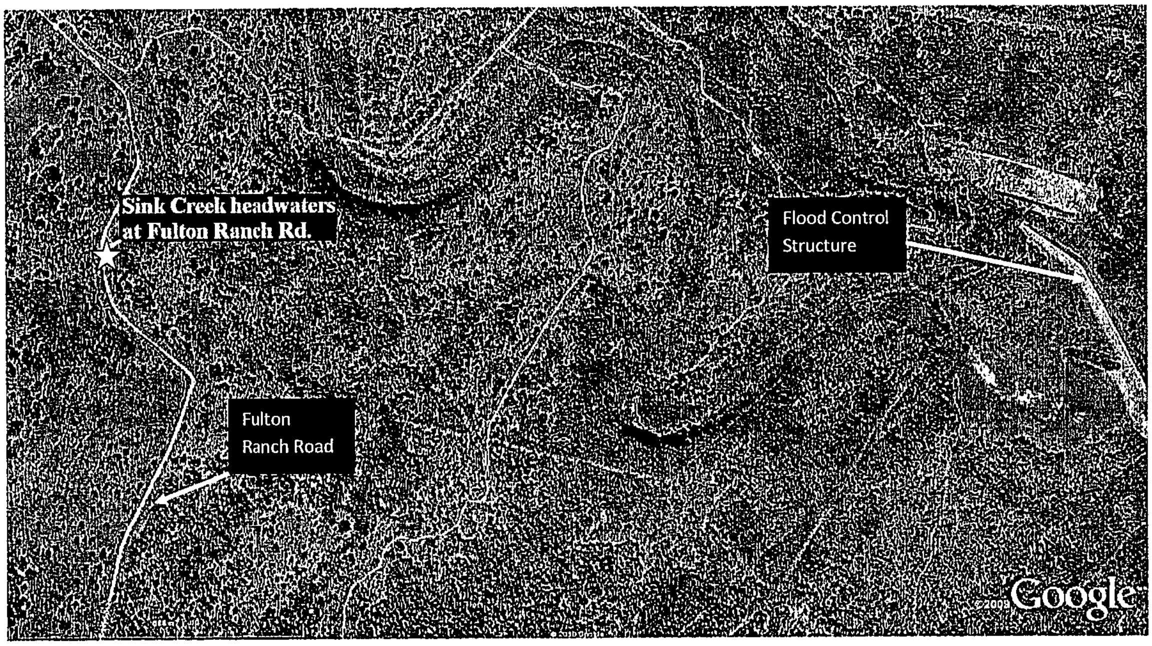


Appendix D2. Detailed satellite image of sites in the Sink Creek watershed used for the Storm Flow Monitoring Program. Sites are indicated by stars.

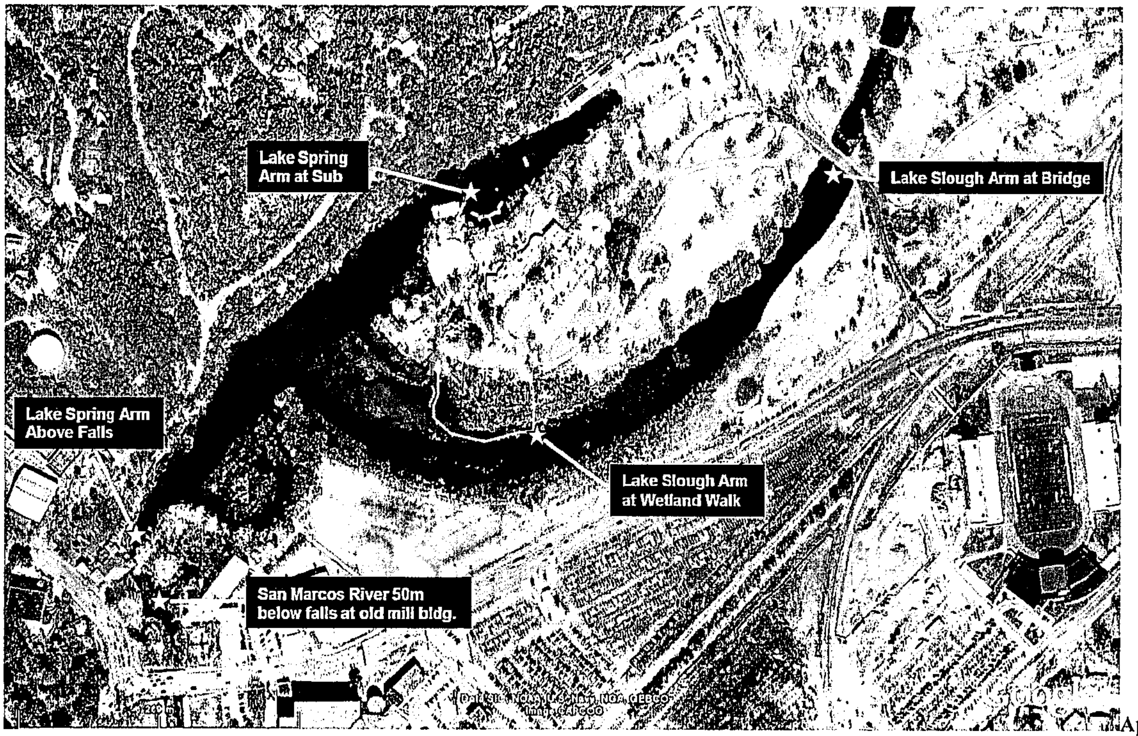


Appendix D3. Detailed satellite image of the flood control structure site in the Sink Creek watershed used for the Storm Flow Monitoring Program. The location of the site is indicated by a star.

Appendix D4. Detailed satellite image of the Sink Creek Crossing at Lime Kiln Road site in the Sink Creek watershed used for the Storm Flow Monitoring Program and the Sink Creek gauging station. The location of the site is indicated by a star.



Appendix D5. Detailed satellite image of the Sink Creek Crossing at Fulton Ranch Road site in the Sink Creek watershed used for the Storm Flow Monitoring Program. The location of the site is indicated by a star.



Appendix D6. Detailed satellite image of the sites within Spring Lake and the upper San Marcos River used for the Routine Water Quality Monitoring Program. The location of sites is indicated by stars.

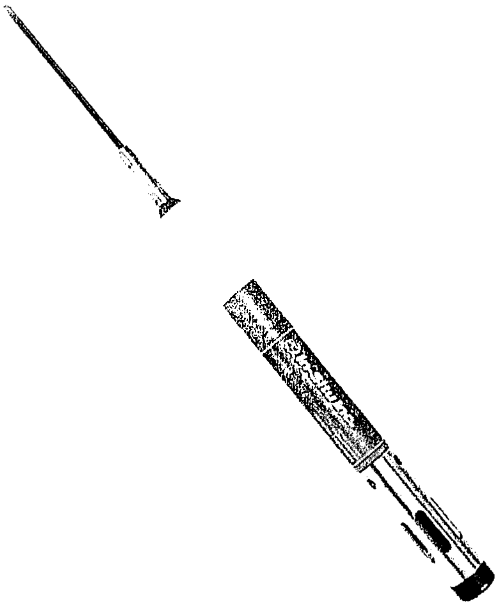
Appendix E. Manufacturer's Operator Manuals

In-Situ Inc.

Multi-Parameter
Water Quality **TROLL**®

Multi-Parameter **TROLL** *9500*

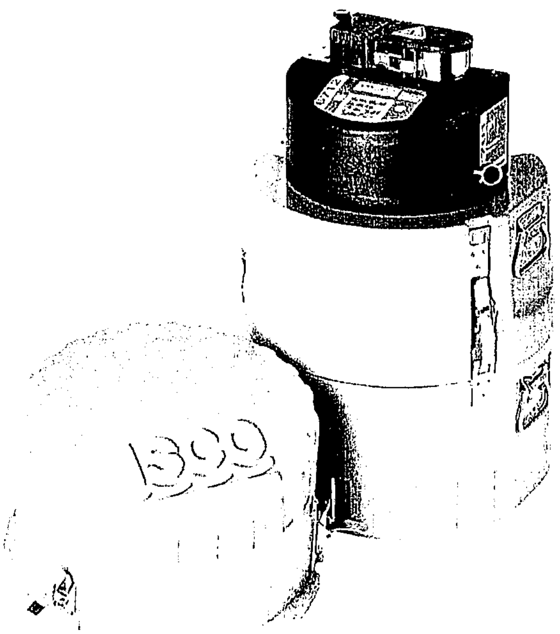
OPERATOR'S MANUAL



January 2009

6712 Portable Samplers

Installation and Operation Guide



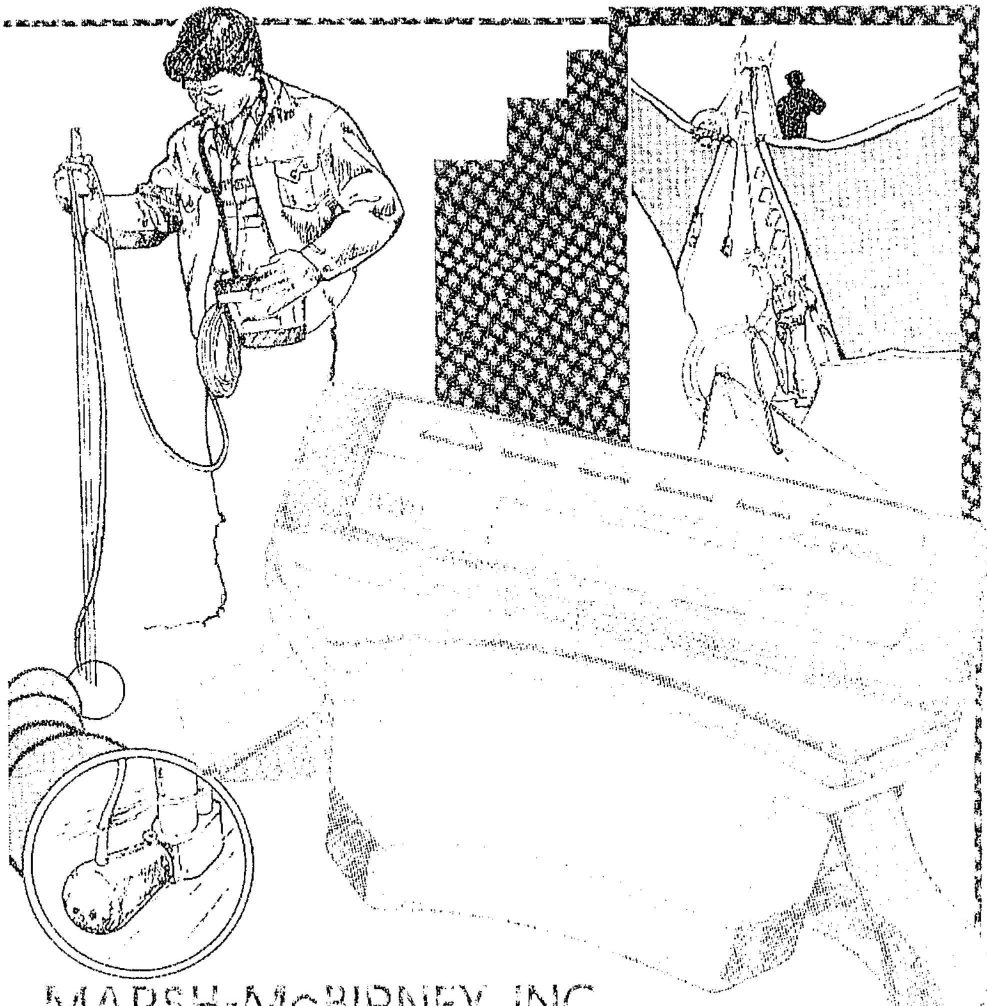
TELEDYNE ISCO
A Teledyne Technologies Company

Part #69-9003-588 of Assembly #60-9004-334

Revision AA, May 14, 2010

Schlumberger
WATER SERVICES

Mini-Diver
Micro-Diver
Cera-Diver
Baro-Diver
CTD-Diver



MARSH-McBIRNEY, INC.

FLO-MATE™

MODEL 2000 PORTABLE FLOWMETER
INSTRUCTION MANUAL

Appendix F. United States Geological Survey Methods for Discharge and Stream Flow

Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge

By S. E. RANTZ *and others*

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2175

USGS
science for a changing world

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1982

Measurement and Computation of Streamflow: Volume 2. Computation of Discharge

By S. E. RANTZ *and others*

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2175

USGS
science for a changing world

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON 1982

Appendix G. Field Data Reporting Forms

Spring Lake Watershed Project
Field Data Reporting Form
Storm Flow Monitoring Program Form

Storm Flow Event Data

Station ID ________
Location ________
Sampling Date(s) ________
Sampling Time ________
Samplers Name ________
ISCO Serial Number ________

Specific Sample Information

Number of Sample Bottles ________
Sampling Duration of Event ________
Sampling Interval ________
Preservatives added to samples ________

Detailed Observations

Water Still Flowing at Site (Y/N)? ________
Flow Severity ________
Water Appearance ________

ISCO Sampler Bottle Number	Date/Time	Submit to Lab	ISCO Sampler Bottle Number	Date/Time	Submit to Lab
Bottle #1			Bottle #13		
Bottle #2			Bottle #14		
Bottle #3			Bottle #15		
Bottle #4			Bottle #16		
Bottle #5			Bottle #17		
Bottle #6			Bottle #18		
Bottle #7			Bottle #19		
Bottle #8			Bottle #20		
Bottle #9			Bottle #21		
Bottle #10			Bottle #22		
Bottle #11			Bottle #23		
Bottle #12			Bottle #24		

Spring Lake Watershed Project
Field Data Reporting Form
Routine Monitoring Reporting Form

Routine Sampling Data

Station ID ________
Location ________
Sampling Date(s) ________
Sampling Time ________
Sampler's Name ________

Specific Sample Information

Number of Sample Bottles ________
Preservatives added to samples ________

Detailed Observations

Evidence of Recent Flow Event (Y/N)? ________
Water Appearance ________

Sample Bottle ID	Date/Time	Split?/What Sample?	Submit to Lab
Bottle #1			
Bottle #2			
Bottle #3			
Bottle #4			
Bottle #5			
Bottle #6			

Spring Lake Watershed Project
Field Data Reporting Form
Continuous Monitoring Reporting Form

Sonde Retrieval Information

Station ID ____________
Location ____________
Retrieval Date ____________
Retrieval Time ____________
Sampler's Name ____________
Sonde Serial Number ____________

Detailed Observations

Evidence of Recent Flow Event (Y/N)? ____________
Water Appearance ____________

In Lab and Redloyment Information

Sonde Calibrated? ____________
If calibrated, what parameters? ____________
Sonde Redeployed? ____________
Redeploy Date ____________
Redeploy Time ____________
Sampler's Name ____________

Appendix H. EARDC Chain-of-Custody Form

Texas State University | SAN MARCOS
Laboratory
Edwards Aquifer Research and Data Center
248 Freeman Bldg   San Marcos, Texas 78666-4616

Telephone: 512/245-2329
FAX: 512/245-2669
E-mail: jg13@txstate.edu

CHAIN-OF-CUSTODY & ANALYSIS REQUEST

Client/Project Name:				Sampler (signature)			
Field Sample ID	Start Date/Time	End Date/Time	Sample Type	Sample Description	Analysis, Containers and Sample Preservation	Sample Condition	Lab ID#

Relinquished by: (print & sign)	Date	Received by: (print & sign)	Date	Time
Relinquished by: (print & sign)	Date	Received by: (print & sign)	Date	Time
Relinquished by: (print & sign)	Date	Received by: (print & sign)	Date	Time
Relinquished by: (print & sign)	Date	Received for EARDC Laboratory (print & sign)	Date	Time
Sample Disposal Method	Disposed of by: (signature)		Date	Time

CODES	Client Address and Phone #:	Number of ice chests	General Comments:
P-Plastic L-Liter G-Glass ml-Milliliters H_2SO_4-Sulfuric Acid HNO_3-Nitric Acid HCl-Hydrochloric Acid		Chest #____ ____ °C Chest #____ ____ °C Chest #____ ____ °C	Sample to be subcontracted ☐ Yes ☐ No

FORM: 001COC REV 2004

Appendix I. ISCO Sampler SOP and Set-Up Information

Spring Lake Watershed Project

Texas State University
ISCO 6712 Auto Sampler SOP and Set Up

Sampler Setup

1. Remove sampler from box, sampler distributor arm and discharge tube is already in the correct position directly out of the box. There is no need for adjustment.
2. Attach battery to machine with power cords that are provided. Connect to outlet on back of the machine that has a picture of a battery.
3. Attach pump (opaque) line and suction (transparent) line together with steel connector, with the big head portion of the connector into the pump line and the thinner end into the suction line.
4. Attach strainer (long metal filter) to the end of the suction line.
5. Install the actuator plug into the outlet that is on the far right on the back of the machine. It's also the only outlet that is male.
6. Attach Velcro that is provided to the back of actuator box by peeling of the covering on the sticky part of the Velcro and attaching one end to the actuator and the other end to the left side of the programming box on the machine(under the pump lines).

Program Sampler

1. Make sure the actuator switch is in the toggle/reset position.
2. Hit the power button.
3. From the home screen type in 6712.2 and enter to go into extended programming
4. Once program is flashing hit enter
5. Hit up arrow button to make site description flash and hit enter. Type in site name and scroll done and hit enter. Hit down arrow to continue to next screen.
6. Units selected should be in feet. . Hit down arrow to continue to next screen.
7. Data interval 1minute. Hit down arrow to continue to next screen.
8. Number of bottles should be 24. Bottle volume should be 1000mL. Set suction line length to required length from the sampler to the sampling source, it will then generate pump tables. Next auto suction head should be selected. Rinses and time should be set to 0. Hit down arrow to continue to next screen.
9. Set to one part program. Hit down arrow to continue to next screen.
10. Choose non-uniform timing, intervals in minutes, and then set the sampler method you desire. (Ex: 6 bottles every 5min., 6 bottles every 15min., 6 bottles every 30min., and 6 on every hour.) Hit down arrow to continue to next screen.
11. Distribution: 1 bottle per sampling event, switch bottle every 1 sampler, Not continuous. Hit down arrow to continue to next screen.
12. Sample Volume: 1000mL. Hit down arrow to continue to next screen.
13. Enable: None. Hit down arrow to continue to next screen.
14. Once enabled stay enable: Yes, Sample at enable: No. Hit down arrow to continue to next screen.
15. 1 minute delay to start of sampling. Hit down arrow to continue to next screen.
16. 0 Pauses and Resumes: Done. Hit down arrow to continue to next screen.
17. No delay to start. . Hit down arrow to continue to next screen.
18. Programming complete run this program now: Yes
19. Now should say on screen: Program disabled
20. Your programming now complete.

Setting up ISCO in field

1. Set ISCO on level ground, run actuator line and suction vertically down from machine to sampling source. Use pvc or some other piping to cover and protect lines. Use anchor brackets and bolts to anchor done piping. Cut extra suction line off if needed, make sure it's a clean cut and reinstall strainer at end of suction line.
2. Chain and lock the sampler and battery.

Appendix J. In-Situ TROLL 9500-XP Calibration Procedures

Spring Lake Watershed Characterization Project
In Situ TROLL 9500 Professional-XP Calibration Procedures
Texas State University

In-Situ Inc. Multi-Paramter Troll 9500 sondes are used to collect continuous data on temperature, pH, conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity. Probes measuring DO, conductivity, pH, and ORP require scheduled calibrations which occur at frequencies recommended by In-Situ, Inc. (see Table 1 below). If any drift is observed in data for any of the measured parameters, calibration will be conducted more frequently. Calibrations are performed in the following order in accordance with manufacturer's recommendations: conductivity, pH, ORP, DO, and turbidity. During calibration of each parameter, the probes and calibration cup are rinsed using the appropriate calibration standard prior to the actual calibration. This rinse is subsequently discarded and clean calibration standard is used for the actual calibration. This procedure ensures the removal of residual solution from storage or previous calibrations which could contaminate the calibration standard and result in an inaccurate calibration.

To assess precision and bias, calibration verification standards will be run monthly (see QAPP Sections D1 and A7). Samples not bracketed by a successful calibration and successful CVS will not be submitted for entry into SWQMIS.

Before calibration, probes are visually inspected for signs of damage, mineral precipitation, or bio-fouling. These conditions could result in inaccurate measurements. If any precipitates or bio-fouling is apparent on a probe, then the probe will be appropriately cleaned using the MOM recommendations. Furthermore, gaskets sealing the battery housing and communication ports are visually inspected for signs of wear or damage which could cause leakage and subsequent damage.

Table 1: Calibration frequencies for probes on Troll 9500 sondes used for continuous water-quality monitoring.

Probe	Calibration Frequency
Dissolved oxygen	Yearly
Conductivity	As needed
pH	Monthly
Oxidation reduction potential	Monthly
Turbidity	As needed

For conductivity, a one point calibration is conducted using Ricca Chemical Company conductivity standard (NaCl solution) with a conductivity of 445µS/cm at 25°C. Conductivity of this standard is near expected conductivity values expected at monitoring sites, and calibration is conducted at temperatures approaching those expected at monitoring sites. These measures increase the accuracy of field measurements. During calibration, conductivity measured in Siemens (1/ohms) between two electrodes are repeatedly measured by the probe. When these measurements stabilize over time, a valid calibration point is selected by the instrument and a cell constant is calculated that allows the measured conductivity to be expressed in the standard form (Siemens/cm) so that data are comparable among different conductance cells. Allowing the conductivity measurements to fully stabilize (versus unstable or nominally stable readings) and checking that the calculated cell constant is within an acceptable range (0.32-0l.39) ensures that the conductivity probe is functioning properly and that accurate measurements are being obtained.

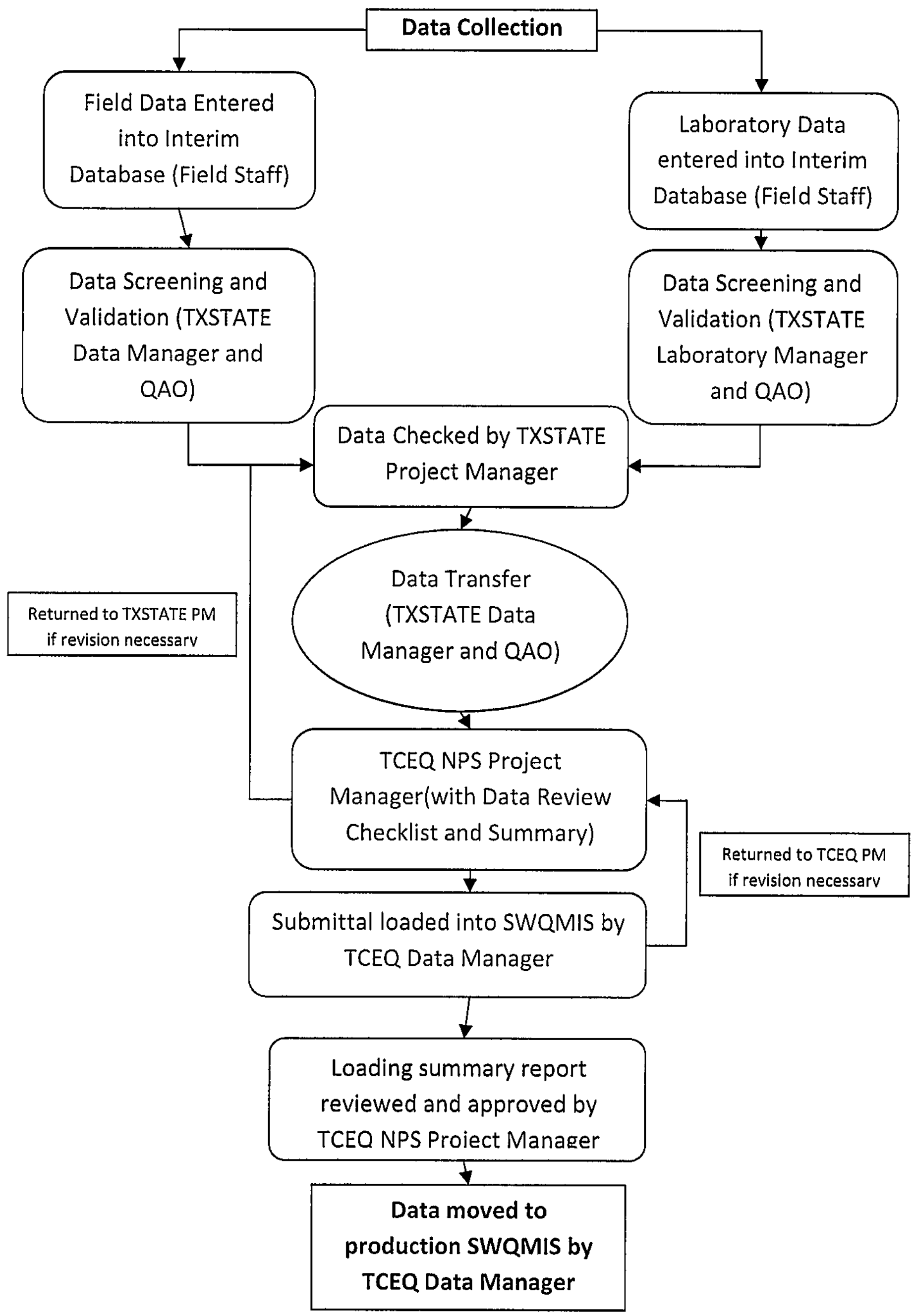
For pH, a three point calibration is conducted using pH standards with pH of 4.01, 7.00, and 10.01. Standards are made at Texas State University using Hach® powder pillows. During calibration, the pH probe is placed in the pH 4.01 solution and voltage is repeatedly measured from both a pH sensitive glass and a reference electrode. When these measurements stabilize over time, a valid calibration point is selected by the instrument. Allowing the voltage measurements to fully stabilize (versus unstable or nominally stable readings) ensures an accurate calibration point. This procedure is then repeated with the ph 7.00 and finally, the ph 10.01 solution. After all three calibrations, two linear relationships between voltage and pH (one for pH between 4.01 and 7.00 and another for pH between 7.00 and 10.01) are calculated to allow for extrapolation of pH value from a wide range of voltages. Checking that the slope and offset for these relationships are within an acceptable range (-66 to -50mV/pH and 390 to 450mV, respectively) ensures that the pH probe is functioning properly and that accurate measurements are being obtained.

For ORP, Ricca Chemical Company Zobell's Solution (ORP = 200mV) is used. This solution is the most widely used ORP standard used. Zobell's Solution is stored at 4°C, but is allowed to equilibrate with room temperature (approximately 22°C) in a sealed container before calibration. During calibration, the ORP probe is placed in the Zobell's solution and voltage is repeatedly measured from both the ORP electrode (acting as either an electron acceptor or electron donor depending on the ORP of the solution) and a reference electrode. When these measurements stabilize over time, a valid calibration point is selected by the instrument. Allowing the voltage measurements to fully stabilize (versus unstable or nominally stable readings) ensures an accurate calibration point. A voltage offset is calculated which adjusts the measured ORP electrode voltage to match the actual ORP of the standard solution. Checking that this offset is within an acceptable range (0mV ± 20mV) ensures that the ORP probe is functioning properly and that accurate measurements are being obtained.

For the calibration of DO, a measurement of atmospheric pressure is required as this variable affects the amount of oxygen that can be dissolved in solution Atmospheric pressure at the location of calibration is measured on site at the time of calibration using a Nova™ mercury barometer. For DO, a two point calibration (100% DO saturation and 0% saturation) is conducted. For 100% DO saturation, a calibration cup containing de-ionized water is allowed to equilibrate with room temperature (approximately 22°C) an is saturated with DO using a battery operated aerator which supplies a stream of bubbles to the bottom of the cup. The aerator is run for a minimum of 30 minutes prior to calibration to ensure that DO saturation is attained. The DO probe is place in the DO saturated solution, and as dissolved oxygen diffuse through a gas-permeable membrane embedded with lumiphores (molecules that fluoresce when excited by light of a given wavelength), it acts to quench the light emitted from the excited lumiphores. A photodetector measures the degree of light (wavelength) reduction to calculate DO. When these measurements stabilize over time, a valid calibration point is selected by the instrument. Allowing the measurements to fully stabilize (versus unstable or nominally stable readings) ensures an accurate calibration point. A deviation is calculated between the measured and theoretical light reduction. Checking that this offset is within an acceptable range (100% ± 10%) ensures that the DO probe is functioning properly and that accurate measurements are being obtained. This procedure is then repeated for the 0% DO saturation. The optical DO sensor does not use a filling solutioin or flow past the sensor, and consequently displays little drift over time. For these reasons, it does not require calibration as frequently as traditional polarographic DO sensors.

If calibration of turbidity is required, then a standard Formazin solution will be used for a 1 point to 4 point calibration procedure in the MOM. This in-house procedure is specifically *not* recommended by the manufacturer. If there is evidence of drift or inaccurate turbidity measurements, then the sonde will most likely be sent to the manufacturer so that it can be properly calibrated.

Appendix K. Data Management Process Flow Chart


Data Collection
Field Data Entered into Interim Database (Field Staff)
Laboratory Data entered into Interim Database (Field Staff)
Data Screening and Validation (TXSTATE Data Manager and QAO)
Data Screening and Validation (TXSTATE Laboratory Manager and QAO)
Data Checked by TXSTATE Project Manager
Returned to TXSTATE PM if revision necessary
Data Transfer (TXSTATE Data Manager and QAO)
TCEQ NPS Project Manager(with Data Review Checklist and Summary)
Returned to TCEQ PM if revision necessary
Submittal loaded into SWQMIS by TCEQ Data Manager
Loading summary report reviewed and approved by TCEQ NPS Project Manager
Data moved to production SWQMIS by TCEQ Data Manager

Appendix L: Corrective Action Status Table

Appendix L - Corrective Action Status Table

Corrective Action #	Date Issued	Description of Deficiency	Action Taken	Date Closed

Appendix M. Corrective Action Plan Form

Appendix M - Corrective Action Plan Form

Corrective Action Plan
Issued by:_________________ Date Issued_________________ Report No.____________________
Description of deficiency
Root Cause of deficiency
Programmatic Impact of deficiency
Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it?
Corrective Action to address the deficiency and prevent its recurrence
Proposed Completion Date for Each Action
Individual(s) Responsible for Each Action
Method of Verification
Date Corrective Action Plan Closed?

ATTACHMENT 1

Example Letter to Document Adherence to the QAPP

TO: (name)
(organization)

FROM: (name)
(organization)

RE: River Systems Institute, Texas State University, **Spring Lake Watershed Characterization and Management Recommendations Report**

Please sign and return this form by (date) to:

(address)

I acknowledge receipt of the "**Spring Lake Watershed Characterization and Management Recommendations Report**, Revision Date". I understand that the document describes quality assurance, quality control, data management and reporting, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria.

My signature on this document signifies that I have read and approved the document contents. Furthermore, I will ensure that all staff members participating in activities covered under this QAPP will be required to familiarize themselves with the document contents and adhere to the contents as well.

Signature Date

Copies of the signed forms should be sent by the Contractor to the TCEQ NPS Project Manager within 60 days of TCEQ approval of the QAPP.