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(final)

Quality Assurance Project Plan (QAPP)

Santa Cruz River Monitoring Project

Targeted Watersheds Grant WS-98942101



Responsible Agency:
Environmental Protection Agency Region 9

November 17, 2008

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2.2 Partners

Arizona Department of Environmental Quality
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Arizona State Parks
Friends of the Santa Cruz River, River Watch
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National Park Service, Sonoran Desert Network
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2.3 Science Advisory Committee

A Science Advisory Committee will provide technical expertise and peer review for the duration of the project. In particular, the advisory committee will work with Sonoran Institute staff to ensure that the analysis and synthesis of monitoring data for the Riparian Health Score Card and State of the Santa Cruz Report are scientifically sound and defensible. Members of the Science Advisory Committee are:

Mark Briggs, World Wildlife Fund, Big Bend Coordinator, Chihuahuan Desert Program

Gita Bodner, The Nature Conservancy, Conservation Ecologist

Doug Duncan, U.S. Fish and Wildlife Service, Fish and Wildlife Biologist

Evan Gwilliam, National Park Service, Sonoran Desert Network Program Manager

Hans Huth, Arizona Department of Environmental Quality

Marty Jakle, Friends of the Santa Cruz River

Tom Meixner, University of Arizona, Associate Professor, Hydrology and Water Resources

Brian Powell, Pima County Natural Resources, Parks and Recreation, Ecological Monitoring Coordinator

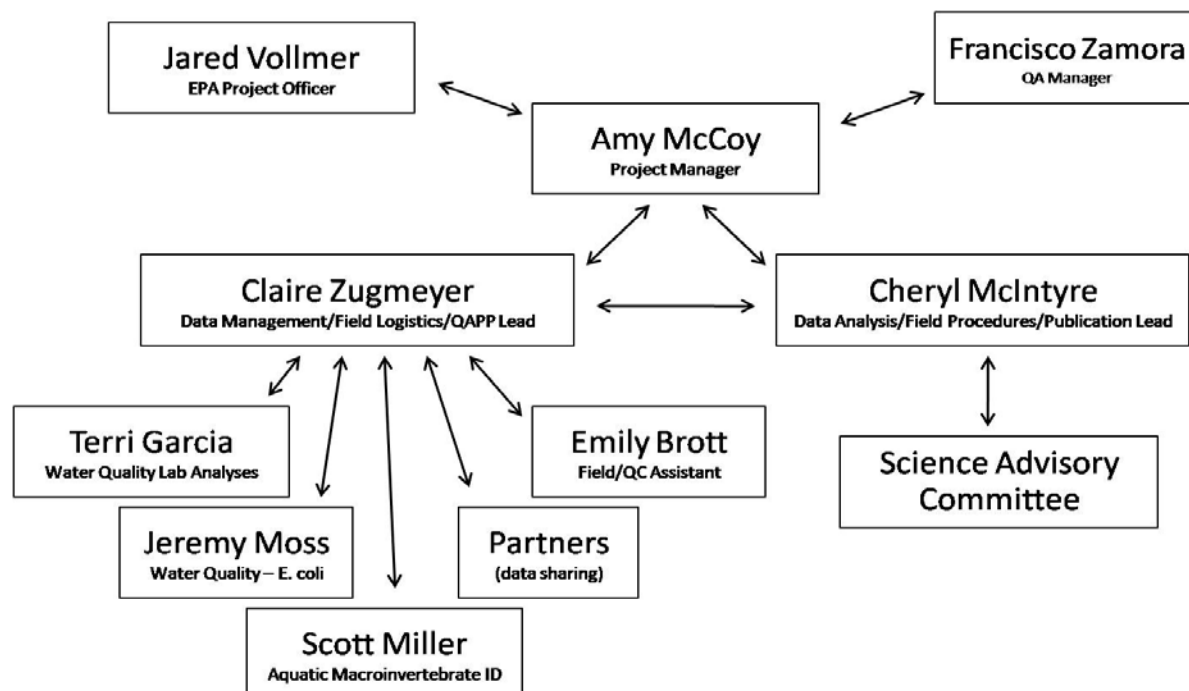
Joanne Roberts, Arizona State Parks, Resources Ecologist

Sherry Sass, Friends of the Santa Cruz River, President

M.C. Gilberto Solis Garza, Universidad de Sonora, Departamento de Investigacion Cientifica y Tecnologica

Scott Wilbor, Tucson Audubon Society, Conservation Biologist

2.4 Communication Chart



3.0 Project Description

3.1 Project Purpose and Problem Definition

As one of the most endangered ecosystems in the United States, riparian ecosystems are ecologically critical to watershed health. In the Southwest, riparian ecosystems constitute less than two percent of the land area, but support the highest density and abundance of plants and animals in the region.

The Santa Cruz River is a visible green ribbon of life that connects the U.S. and Mexico, bridges rural and urban landscapes, and joins together diverse stakeholders (Figure 1). The Santa Cruz River headwaters begin in Arizona and flow south from the U.S. into Sonora, Mexico, where the river makes a u-turn, and flows back north across the international boundary into Arizona and through Santa Cruz County, Pima County, and the City of Tucson. The river has the unique distinction as the only river to cross the U.S./Mexico border twice. The Santa Cruz River and its major tributaries sustain one of the country's largest cottonwood-willow riparian corridors and provide habitat to numerous resident and migratory species, including the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) and the Gila topminnow (*Poeciliopsis occidentalis*). The river feeds ecological processes and agriculture that contribute to local economies in Arizona and Sonora, augments municipal water supplies, sustains invaluable ecological riparian zones, and is central to the culture of the region.

In an arid region where water is scarce, the greatest challenge to conserving river systems comes from reconciling competing demands and engaging local communities in collaborative conservation actions. A variety of state, federal, and grass-roots monitoring projects are underway in the Santa Cruz River basin, but are not coordinated to produce effective and useable information that is publicly accessible and useable. The Sonoran Institute is responding to a need for ecological information by developing a watershed-wide coordinated and standardized monitoring protocol that can be applied and used throughout the upper basin.

The Sonoran Institute will compile and synthesize existing data, as well as conduct additional monitoring of a suite of ecological variables, described in this Quality Assurance Project Plan (QAPP), that complement existing monitoring efforts. This monitoring plan will be implemented at 6-10 sites, but could be applied throughout the basin if future funding is available, at which point an addendum to the original quality assurance plan will be submitted for approval to the EPA.

Data collected and acquired during this project will result in two main publications, 1) Upper Santa Cruz River Health Assessment, and 2) State of the Santa Cruz River Report (Table 1). The health assessment will be published annually and provide a means of summarizing the previous year of monitoring data for the general public, agencies, and managers. The first health assessment will rely on data from existing monitoring, while future versions will include monitoring conducted by the Sonoran Institute as described in this QAPP. These assessments will enable easy tracking of watershed health over time, as

well as identify areas of concern that may require additional investigation. While the health assessment will be written for a broad audience, a document explaining technical details of the assessment will be made available on the project website.

The State of the Santa Cruz River report will be a comprehensive summary of research findings and monitoring trends in the watershed during the past 5 years. This report will be written for a broad audience and provide references and information about research and monitoring on the main stem of the Upper Santa Cruz River as well as major tributaries.

In addition to publishing our monitoring data in our assessments and report, we will complete a Sampling Analysis Plan (SAP) with Arizona Department of Environmental Quality (ADEQ). Approval of a SAP by ADEQ will permit our data to be submitted for use in ADEQ 305b Water Quality Assessment Reports on regional water quality conditions.

Table 1. Major project activities and their anticipated starting and completion dates.

Activity	Starting Date	Completion Date
Submit QAPP to EPA for approval	November 2008	February 2009
Health Assessment 2008 <i>(with data collected by partners during 2008)</i>	February 2009	June 2009
Start of Sonoran Institute monitoring	March 2009	ongoing
Submit SAP to ADEQ for approval and begin submitting data	April 2009	ongoing
State of the Santa Cruz River Report 2005-2009 <i>(research and monitoring data collected during the past 5 years)</i>	September 2009	December 2010
Annual Review of QAPP with EPA <i>(if necessary)</i>	January 2010	February 2010
Health Assessment 2009 <i>(with data collected by partners and Sonoran Institute during 2009)</i>	February 2010	June 2010

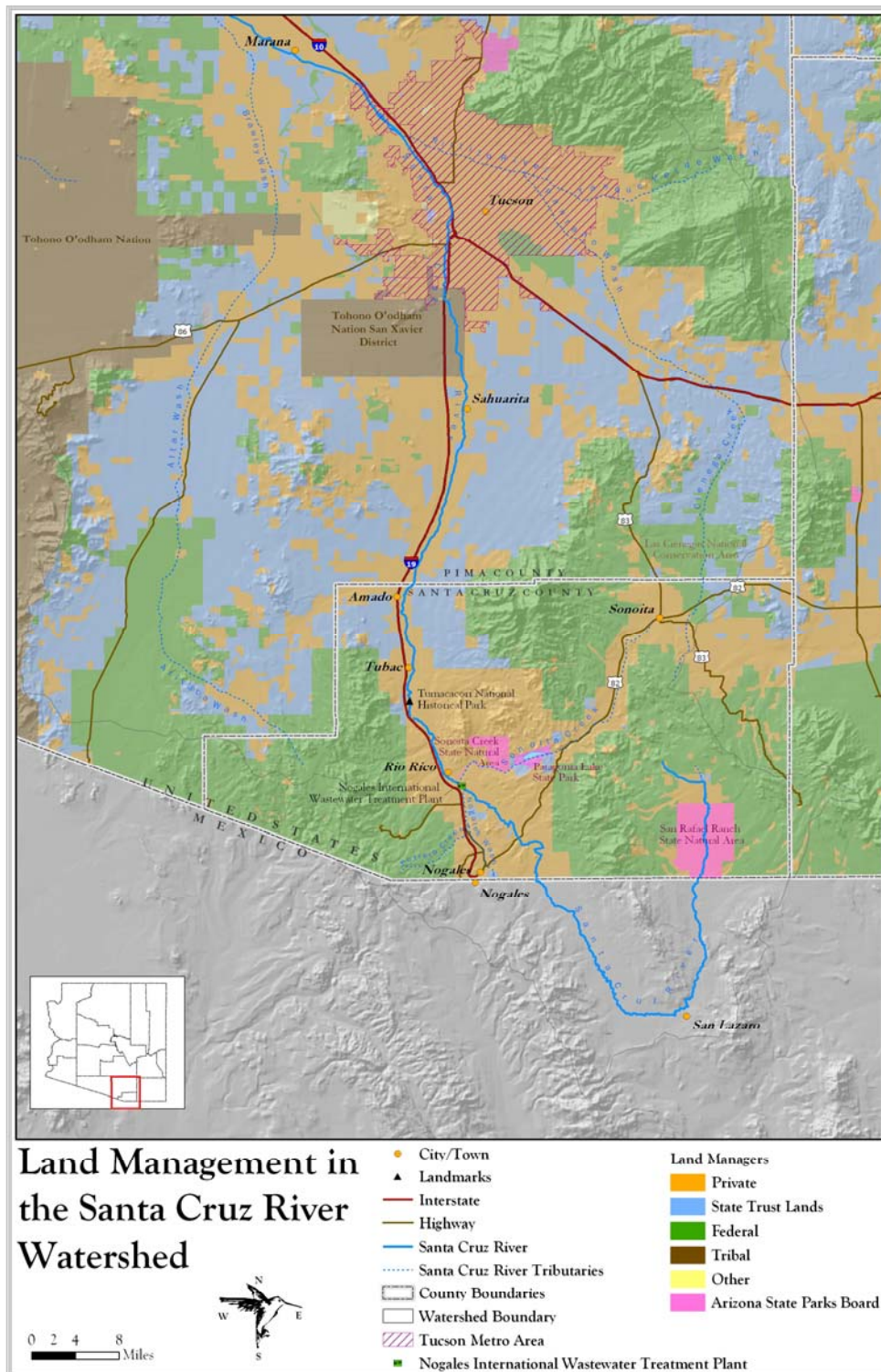


Figure 1: Map of the Santa Cruz River Watershed

3.2 Project Area Description

The Sonoran Institute's monitoring work will focus on the Upper Santa Cruz River. This river segment is the primary water resource in Santa Cruz County, supplying water to both Nogales, Arizona and Nogales, Sonora, as well as other regional communities, farmers and ranchers. On both sides of the international border, the Santa Cruz River aquifer system is generally shallow with limited storage capacity and extreme sensitivity to drought. Population pressures are significant: recent U.S. census data identified Arizona as the second-fastest growing state in the country, and the Santa Cruz River watershed draws numerous new residents every year. Increased population leads to amplified municipal water use and places a greater burden on the small aquifers that support the region.

The riparian area is particularly vulnerable to declining groundwater levels because the vegetation is completely dependent on surface flow and shallow groundwater resources. Fast-paced development, groundwater depletion, and a prolonged drought have reduced natural groundwater recharge and storage, and contributed to water quality deterioration. Water quality challenges also arise from the Nogales International Wastewater Treatment Plant (NIWTP), which discharges 15 million gallons of treated effluent each day into the river in Santa Cruz County (IBWC 2005). While this discharge creates water quality concerns for citizens, as well as local and state management agencies, the effluent also nourishes and bolsters the riparian area and recharges the aquifer.

The Sonoran Institute has identified 10 sites (see sampling design) along the Upper Santa Cruz River where the long term monitoring protocol will be implemented. The majority of the land in this region is privately owned. Access to monitoring sites will require the cooperation of landowners and may result in alternate or reduced site selection if permission is not granted.

3.3 History of Project Area and Previous Studies

In the past several years, a number of local planning and research efforts have focused on assessing the values, threats, and needs of the Upper Santa Cruz River and associated riparian habitat. In 2004, Santa Cruz County approved a Comprehensive Land-use Plan that identified the Santa Cruz River as an important regional resource and specifically stated that "the Santa Cruz River and its watershed should be conserved and managed as a 'Living Ecosystem' "(Santa Cruz County 2004). The National Park Service (NPS) has completed a vertebrate and vascular plant inventory at Tumacácori National Historical Park (NHP), which protects over 1 mile of the Santa Cruz River. The NPS Sonoran Desert Network is currently implementing a long-term inventory and monitoring program at Tumacácori NHP. In addition to agencies, a number of individual landowners and local organizations have initiated and completed restoration and monitoring programs on private land. Friends of the Santa Cruz River, through their volunteer-based program River Watch, have monitored surface water quality on a monthly basis for over a decade. They have consistently supplied data to the Arizona Department of Environmental Quality for incorporation into their regular 305b Water Quality Assessment reports. In addition, there is currently an effort underway to designate the Santa Cruz River Valley as a National Heritage Area.

4.0 Project Management

4.1 Data Quality Objectives

We will follow data quality objectives for all monitoring components by using precision, accuracy, representativeness, completeness, and comparability.

Precision – measures the degree to which two or more measurements are in agreement. For chemical parameters, sampling precision will be determined through collection of field duplicates of 1 duplicate per 10 analytical samples. Field precision will be calculated using relative percent difference of less than or equal to 10 percent. Precision in the laboratory is determined through the calculation of relative percent difference between the matrix spiked sample and the matrix spiked duplicate. The relative percent difference deemed acceptable varies with the parameter being tested (see Summary of Laboratory Analyses).

Accuracy – measures the degree of agreement between an observed and an accepted reference value. Laboratory accuracy is expressed as the percent recovery of the true value. The percent recovery and relative percent difference deemed acceptable varies with the parameter being tested (see Summary of Laboratory Analyses).

Representativeness – is the expression of the degree to which data reflect a characteristic of an environmental condition or a population. Representativeness will be satisfied by ensuring that proper sampling techniques are employed, proper analytical procedures are followed, and holding times specific to each parameter are adhered to in the laboratory.

Completeness – is expressed as the percent of data actually obtained compared to what was expected. Due to a variety of circumstances, monitoring locations may be temporarily inaccessible, samples may be lost, and instruments may fail etc. We aim to have 90% completeness of data collected for all parameters.

Comparability – expresses the confidence with which one data set can be compared to another data set. The degree to which existing and future analytical data will be comparable depends on the similarity of sampling and analytical methods.

4.2 Training Requirements

The Sonoran Institute has partnered with the NPS Sonoran Desert Network (SODN) on monitoring techniques for riparian ecosystems. Most of the protocols and standard operating procedures described in this QAPP have been developed with SODN. Cheryl McIntyre co-led the development of and is the lead author of the SODN stream monitoring protocol. In addition, Cheryl McIntyre led numerous field sampling efforts with SODN, trained SODN and Sonoran Institute staff on several of the field methods including physical channel dimensions and physical habitat characterization, and received multiple trainings on all other field techniques described in this QAPP. Cheryl McIntyre's education as a chemist aids in assuring quality control of water quality samples and her training with Tom Moody of Natural

Channel Design ensures high quality data for physical channel dimensions. Claire Zugmeyer has an M.S. in wildlife biology and has participated in many field excursions with SODN to learn and refine these techniques. In addition both Cheryl McIntyre and Claire Zugmeyer have extensive experience with field biology and will be the primary leaders of Sonoran Institute field work for this project. All field work will be conducted by Sonoran Institute staff listed in this QAPP, with the exception of the QA manager. Field work will be conducted by a team of 2 at a minimum. Each field crew must have a Sonoran Institute crew leader who is approved by the Field Procedures Lead. All water quality samples, including discharge, will be collected by Sonoran Institute staff. All datasheets will indicate personnel present during data collection. There are no plans to use volunteers to collect field data. However, any field assistants or volunteers will be carefully supervised and instructed. In addition, all new field assistants or volunteers will receive training in the form of a practice field visit that occurs prior to that quarter's sampling event. The training will stress hands-on practice of methods, collection of high quality data and samples, and safety. Practice field visits are not possible for riparian vegetation flights. Therefore, ground training will be conducted. Topics covered during the training vary based on the type of data being collected and are described below.

- *Longitudinal Profile/Thalweg Depth and Cross-Section Morphology.* Operation of a digital camera. Use of GeoXT and ArcPad software. Identification of channel features and habitat types (See SOPs 2.1 and 2.2).
- *Wetted Width/Depth Ratio and Physical Characterization of Stream.* Identification of flow class, erosion class, water color, and water mixing (See SOP 2.3 for categories). Proper use of convex spherical densitometer (Model B). Identification of filamentous algae, macrophytes, large and small woody debris with diameter, overhanging vegetation, undercut banks, boulders, and artificial structures. Estimating cover using cover classes. Use of measuring tapes and folding rulers. Operation of a digital camera.
- *Sediment Composition.* Identification of bankfull and embedded sediments. Identification of intermediate axis (See SOP 2.4).
- *Riparian vegetation.* Operation of a digital camera and GPS.
- *Wet/dry mapping.* Operation of GPS. Use of the 30 foot rule (See SOP 3.1)
- *Surface water quality and discharge.* Because field assistants and volunteers will only serve as data recorders during surface water quality sample collection, including discharge, training will be conceptual but not hands-on. Identification of appropriate location to collect water quality samples. Operation of Oakton PCD650 probe. Collection procedures for bottle samples. Labeling of water quality samples. Operation of current meters. Demonstration of discharge measurement with recorder role clearly identified.
- *Photo points.* Operation of a digital camera and GPS. Completion of photo identification card and photo point record datasheet.
- *Benthic macroinvertebrates.* Proper kick-net sampling techniques. Removal of sample from kick-net. Processing and preserving samples.

4.3 Data collection oversight

The QA Manager, Francisco Zamora, will review and sign the QAPP, ensure that all project activities comply with the project plan, and verify that any changes or modifications are submitted to the EPA for review. The QA manager will also provide critical review of all publications produced for this project. Francisco Zamora is the Sonoran Institute's Upper Gulf Program Director and has extensive experience working as a researcher and coordinator of the biogeographic information unit at the Monterrey Institute of Technology-Campus Guaymas. He has significant experience working with the following: Geographic Information Systems and remote sensing, natural resource and environmental economics, land use planning, and restoration project design and monitoring. He obtained his Ph.D. in Resource Geography from Oregon State University in October 2002. His dissertation title was: Impacts of Instream Flows on the Colorado River Delta, Mexico: Spatial Vegetation Change Analysis and Opportunities for Restoration.

As discussed in the previous section, all data collection will be supervised by the Sonoran Institute staff and in most cases only Sonoran Institute staff will be collecting field data. A field audit will be conducted on an annual basis. The quarter in which a field audit occurs will rotate each year. Therefore, every field technique will not be audited each year. However, should unusual or outlying data be suspected, we will request that our data and field methods be reviewed by the QA manager and/or field personnel at the NPS Sonoran Desert Network. If field methods are at fault for the unusual data, all affected data will be discarded. All problems and corrective actions will be recorded in our field log book.

4.4 Documents and Records

Data from all field sheets will be entered into computer databases within 10 working days of field sampling. All data entered into databases will comply with standard quality assurance and quality control methods. Although the primary goal of data entry is to transcribe all data from paper records into the database with 100% accuracy, this target is rarely achieved. To facilitate data-entry accuracy, we have built into the database many quality assurance/quality control (QA/QC) mechanisms to eliminate as many potential data-entry errors as possible. Data-entry forms closely match the paper datasheets, and serve as the user's portal into the database. Data verification is the process of checking the accuracy of the digital data against copies of the original paper data sheets, and it should immediately follow data entry. All data entered will be verified by checking the accuracy of the digital data against copies of the original paper datasheets. The Data Analysis leader will review and validate the data, looking for range and logic errors.

All databases will be physically located on the computer server at the Sonoran Institute's main office in Tucson, Arizona. All information on the server is backed-up daily in two week cycles at an off-site location. All data obtained during the project will be archived at the main office for a minimum of 10 years. Data reports for this project will include the most recent data recorded into our databases, results of quality control checks, any necessary changes to standard procedures and protocols outlined in the QAPP, and any problems that were encountered in the course of field and lab work. The original

datasheets for field and lab data will be archived at the main Sonoran Institute office in Tucson, Arizona and made available upon request.

4.5 Data Review and Validation

Two sources of data will be used during this project: 1) monitoring data collected by the Sonoran Institute and 2) research and monitoring data collected by other agencies and organizations that have been shared with the Sonoran Institute, found in published documents, or made publically available on the internet. All data used during this project will be collected using an approved Arizona Department of Environmental Quality Sampling and Analysis Plan, Environmental Protection Agency Quality Assurance Plan or peer-reviewed protocol.

The State of the Santa Cruz River Report will include all research and monitoring data collected by the Sonoran Institute and other entities. This document will be a consolidation of the most up to date information about the Santa Cruz River and will thus make use of all sources of data. The report will summarize findings and provide complete references of the information presented.

The Health Assessment will utilize monitoring data collected by the Sonoran Institute in addition to existing monitoring data collected near Sonoran Institute sites. Proximity to Sonoran Institute sites will vary depending on the data.

- o Friends of the Santa Cruz River (FOSCR) collect water quality data using similar methodology under an approved Sampling and Analysis Plan with Arizona Department of Environmental Quality. We will use data from 4 FOSCR sites; 1 site is identical to and 3 others are approximately 1 mile from Sonoran Institute sites. In addition, Arizona Game and Fish Department and FOSCR monitor fish at these same sites.
- o One Sonoran Institute site is within the Tumacácori National Historical Park. Therefore, the Sonoran Institute will partner with the NPS Sonoran Desert Network which has established a long term monitoring reach at this location. As described in *4.2 Training Requirements*, the Sonoran Institute developed monitoring methodology in partnership with SODN and thus will utilize data from this site.
- o Hydrology data from wells and stream gauges, that monitor levels of groundwater and stream flow, is available from Arizona Department of Water Resources and U. S. Geological Survey. Hydrology data will only be used from locations in the floodplain and within the basin of interest (see *5.1 Sampling Design*).

To ensure the use of valid data in the Health Assessment, the Data Manager and Data Analysis Leader will use the following procedures for all Sonoran Institute data. Any unusual or questionable data will be used only after thorough examination to reduce the possibility of data entry, data transcription, or equipment errors. Should no source of error be found and inclusion of data does not change analysis

results, the data will be accepted. However, should inclusion of the data drastically change analysis results, both sets of results will be presented.

To ensure the use of valid existing data, the Data Manager and Data Analysis Leader will review all existing data prior to use in any analysis, publication, or presentation. Existing data will be reviewed with a standardized review form and checklist to ensure compliance with the project's required data quality (see Appendix B, datasheet 10.1). All review forms and notes will be filed with the data set. A review form and checklist will be completed for any dataset, as well as updates and/or additions to datasets previously reviewed.

4.6 Reports to Management

Quarterly progress reports will be sent to the EPA project officer summarizing progress on project activities. In addition, reports will summarize any problems with quality assurance and how they were resolved. A final report will be submitted at the end of the funded project.

5.0 Field Design and Measurements

The following sections summarize the monitoring protocol the Sonoran Institute will implement (for detailed standard operating procedures (SOPs), see Appendix A).

5.1 Sampling Design

The Upper Santa Cruz River was divided into ten strata (Figure 2). The headwaters of the Santa Cruz River and the stretch of river that flows through San Lazaro, Mexico were designated as strata based on expert knowledge on the extent of perennial flow. After the Santa Cruz returns to the United States, strata were based on 4 micro- and 3 sub-area basins immediately bordering and underlying the stream channel. These micro- and sub-area basins have low storage capacity and range in depth from 40-150 feet (Arizona Department of Water Resources 1999). Due to the basin-fill material, water easily moves through basins. During flood events, micro and sub-area basins rapidly re-fill causing water to cascade into adjacent downstream basins. Micro-basins have been clearly defined (Erwin 2007) and sub-area basins are roughly defined according to well-logs and geophysical data (Nelson 2007). The tight connection between the groundwater in micro- and sub-area basins and the riparian area led to stratification based on micro- and sub-area basins. The last stratum was a small portion of Nogales Wash with perennial water that occasionally flows directly into the Upper Santa Cruz River, just south of the NIWTP.

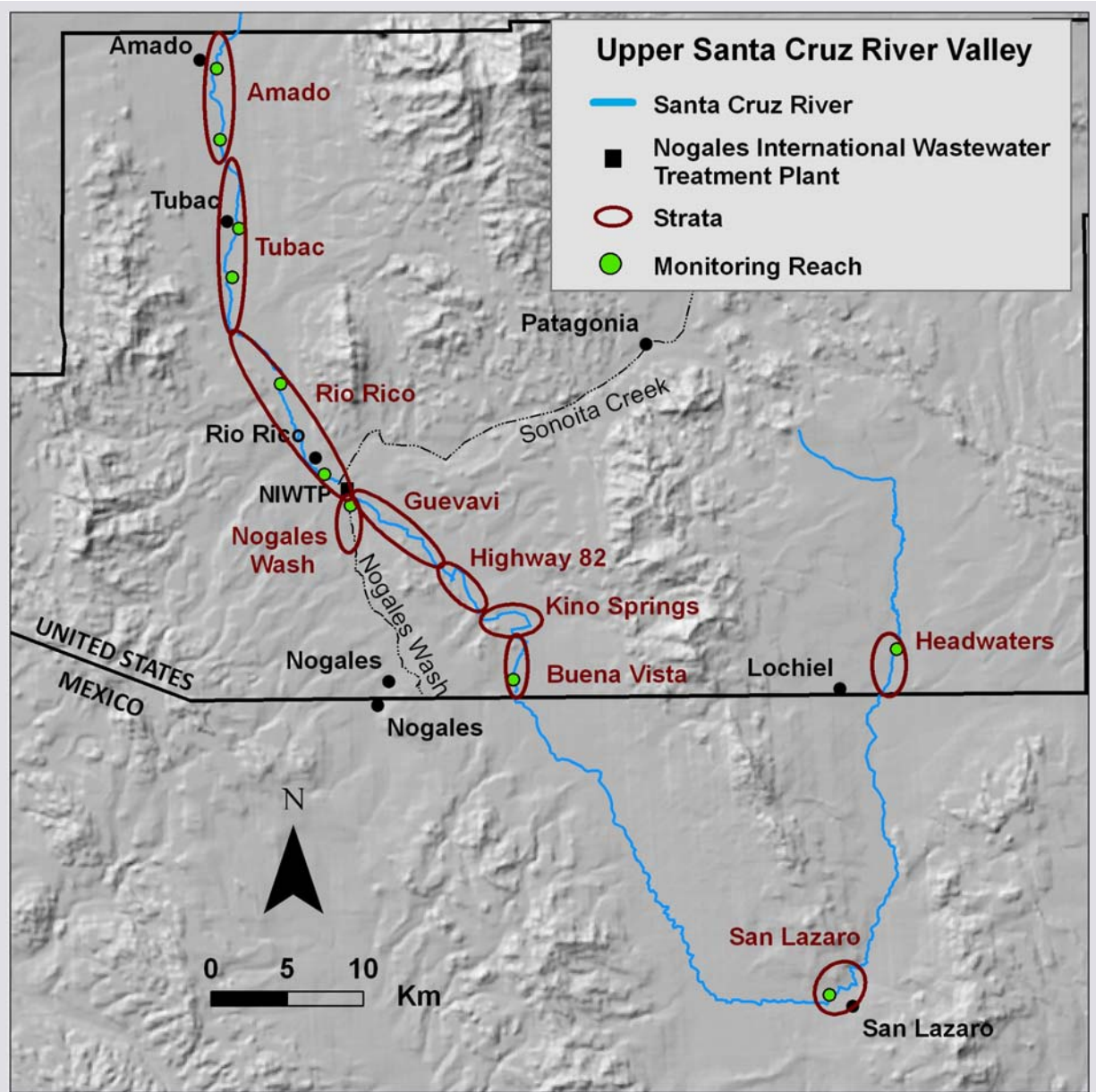


Figure 2. Map of project area focusing on Upper Santa Cruz River

The sampling design for stream monitoring on the Santa Cruz River employs permanent sampling locations (reaches). Sampling reaches were allocated using a Generalized Random Tessellation Stratified (GRTS) spatially balanced design (Stevens and Olsen 2004) with stratification based on the 10 strata described above. GRTS provides the advantages of a probabilistic design (Stehman 1999) but ensures spatial balance regardless of the overall sample size. GRTS also facilitates adding or removing sampling reaches in a spatially balanced manner if statistical power, financial considerations, or additional

monitoring objectives warrant adjusting the sample size. We restricted stream monitoring to perennial segments of the main-stem of the Santa Cruz River and a portion of Nogales wash. Thus, the sampling frame consists of all perennial stream segments within each stratum.

We acquired spatial data for the Santa Cruz River and Nogales wash (Arizona Land Resource Information System) and spatial data representing the micro- (Arizona Department of Water Resources) and sub-area basins (created using information in Nelson 2007). The stream layers were intersected with the micro- and sub-area basin layer to generate strata. Within each stratum, five sampling points were allocated with equal selection probabilities using GRTS. The GRTS point represents the center point for the sampling reach; the endpoints of the reach are then located 20 times the distance of the wetted width both up and downstream of this point (Peck et al. 2003). This method was employed for all strata except the Buena Vista microbasin. Because of the short stretch of perennial flow within the Buena Vista microbasin, the permanent reach was co-located with FOSCR's Johnson's Ranch site. The length and number of sampling reaches varies among strata, but monitoring of all parameters takes place within sampling reaches.

5.2 Survey Design

Streams are complex and dynamic systems that comprise interacting and interdependent biological and physical components. To support a comprehensive understanding of stream condition, we employ a holistic approach to monitoring that integrates geomorphological, hydrological, and biological indicators (Table 2). Almost all parameters of the indicators addressed in this plan are monitored within each sampling reach (i.e., their monitoring is co-located), but the specific sampling locations vary among parameters. Each sampling reach is divided into 10 equally spaced segments resulting in 11 equally spaced sampling locations. A brief introduction to the spatial configuration of sampling locations is provided below (Figure 3). Parameters that may not be monitored within the same sampling reach are those related to hydrology (surface flow extent and groundwater depth) and native fish presence, which are conducted within or near the sampling reaches as appropriate (*see 4.5 Data Review and Validation*).

- *Stream channel dimensions.* Channel morphology is monitored at three cross-sections located at the top of the riffle (if possible) nearest to the top, middle, and bottom of the sampling reach. Because riffles are relatively stable, changes will not be confused with the natural variability of streams. Active channel dimensions (wetted width and depth) are monitored at each of the 11 sampling locations and at 10 additional locations within the reach. The longitudinal profile and thalweg depth, or deepest point in the stream, are measured along the entire reach.
- *Riparian vegetation.* Local vegetation patterns will be monitored with photo points within the reach. Regional vegetation patterns will be monitored with aerial photography of the reach and other sites.
- *Surface water quality.* Within each reach, field personnel choose an area with smooth laminate flow within a well defined channel that is free of obstructions and large cobbles or boulders and collect discharge measurements and water quality samples.

- *Benthic macroinvertebrates*. Macroinvertebrates are sampled at all 11 sampling locations within the reach and samples are combined into a single composite sample for the reach.

5.3 Sampling Timing, Frequency, and Replication

Sampling frequency and timing is a function of the biogeochemical, geomorphological, and hydrological phenomena of interest, as well as the pragmatic constraints (time and money) of the sampling effort. Sampling frequency may be adjusted in the future due to the high cost of data collection and processing. As each of these factors varies over the suite of indicators monitored, we employ three nested sampling frequencies:

- *Quarterly*: Photo points will be taken quarterly at each site. Core water quality (including discharge), nutrients and *Escherichia coli* (*E. coli*) levels will be sampled quarterly as recommended by the Arizona Department of Environmental Quality (ADEQ) (Marsh 2007). Each of these parameters is expected to respond relatively rapidly to changes in water condition; therefore, the additional cost of quarterly sampling is warranted. See SOP 4.1, 4.2, and 5.1.
- *Annually*: Benthic macroinvertebrates, semi-quantitative descriptions of stream habitat, and aerial photographs will be collected in April or May; water measurements (width/depth and wet/dry mapping) will be made in the late summer (pre-monsoon); fish will be sampled in the fall. See SOP 2.2, 2.3, 2.4, 3.1, and 5.2.
- *Five-years*: Large-scale channel dimensions respond to routine maintenance flows and infrequent but extreme flooding events. Surveying every five years should document important morphological changes, based on the previous research and monitoring efforts in the arid southwest (Moody 2003). See SOP 2.1.

Table 2. Summary of monitoring to be conducted by Sonoran Institute (SI) and data available from Friends of the Santa Cruz River (F), National Park Service (NPS), U. S. Geological Survey (USGS), and Arizona Department of Water Quality (ADWR). Frequency of monitoring is indicated as annual (a), quarterly (q), and every 5 years (5).

	Water Quantity			Water quality						Biotic		Vegetation		Channel Dimensions			
	Wet/Dry (map/distance)	Flow (stream gauges)	Ground water Level (nearby wells)	Core Parameters (DO, pH,, conductivity, discharge, temp)	Specific Conductivity Total Dissolved Solids	Nutrients (ammonia, nitrite/nitrate, phosphorus)	Metals (arsenic, cadmium, copper, lead, selenium, zinc)	<i>E. coli</i>	Chlorine (free/total)	Bethic Macroinvertebrates	Fish	Photo Points	Aerial Photos	Wetted Width/Depth Ratio	Longitudinal Profile/Thalweg Depth	Sediment Composition	Cross-section Morphology
Frequency	a	q	q	q	q	q	F: q NPS: a	q	q	a	a	q	a	a	a	a	5
Monitoring Sites	Headwaters	SI		ADWR	SI	SI		SI	SI	SI		SI	SI	SI	SI	SI	SI
	San Laz�ro	SI			SI				SI			SI	SI	SI	SI	SI	SI
	Buena Vista	SI	USGS	ADWR	SI	SI	F	F	F	SI	F	SI	SI	SI	SI	SI	SI
	Nogales Wash			ADWR	SI	SI		F	SI	SI	F	SI	SI	SI	SI	SI	SI
	Rio Rico 1			ADWR	SI	SI	F	F	F	SI	F	SI	SI	SI	SI	SI	SI
	Rio Rico 2			ADWR	SI	SI	SI					SI	SI	SI	SI	SI	SI
	Tubac 1			ADWR	NPS	NPS	NPS	NPS	NPS	NPS	F	SI	SI	NPS	NPS	NPS	NPS
	Tubac 2		USGS	ADWR	SI	SI	SI					SI	SI	SI	SI	SI	SI
	Amado 1	SI		ADWR	SI	SI	SI	F	SI	SI	F	SI	SI	SI	SI	SI	SI
	Amado 2	SI	USGS	ADWR	SI	SI	SI					SI	SI	SI	SI	SI	SI

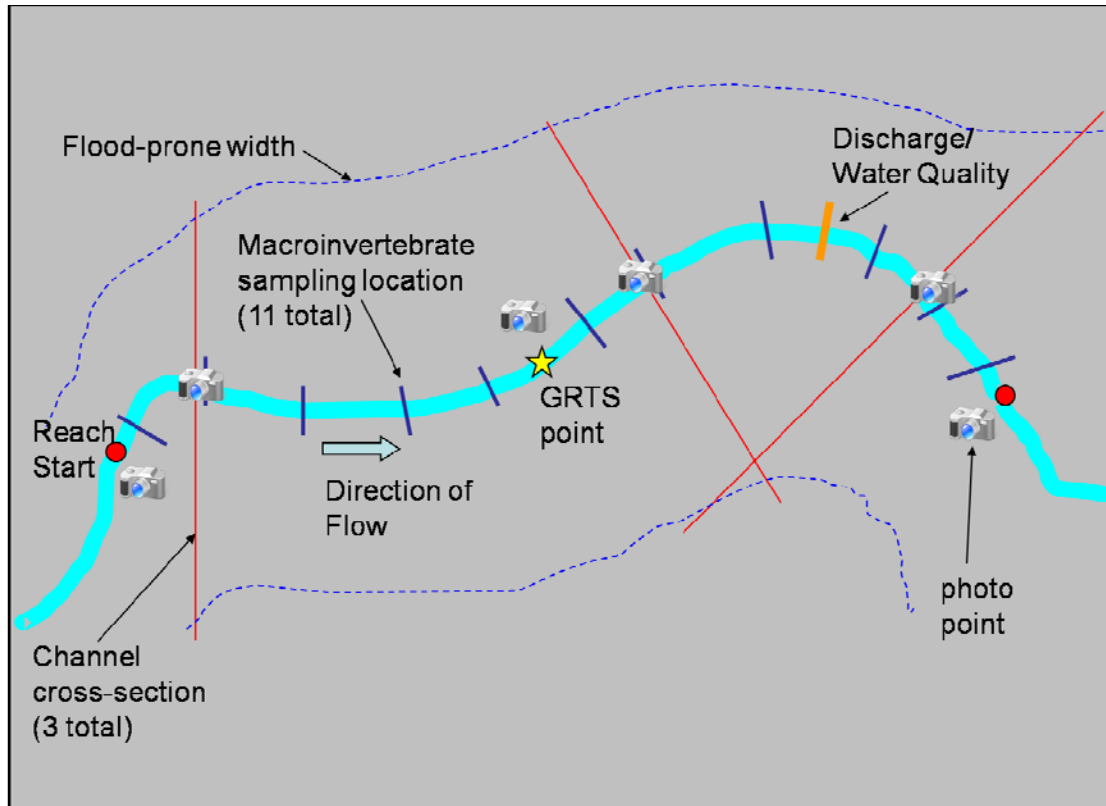


Figure 3. Spatial configuration of sampling locations within a given reach

5.4 Physical Characteristics:

5.4.1 Stream Channel Dimensions

The primary ecological functions of stream channels are to dissipate the energy associated with overland flow and to transport sediment, water, and nutrients within and from the watershed (Dunne and Leopold 1978). As a result, stream channels are constantly adjusting to watershed conditions. Geomorphic characteristics of stream channels, such as channel shape, interact with biological components, most notably vegetation, to determine the type, extent, and configuration of riparian ecosystems. Monitoring channel dimensions of the Santa Cruz River provides an important indicator of watershed condition and integrates ecological and geomorphological processes, including soil erosion, nutrient cycling, discharge characteristics, and the occurrence and magnitude of disturbance events, as well as surface and groundwater quantity and quality.

Large scale channel dimensions will be monitored at three cross-sections located at the top of the riffle nearest to the top, middle, and bottom of the sampling reach that span the estimated flood-prone area,

an area expected to be inundated with water approximately once every 50 years. Cross-sections will be traversed and elevation determined at a minimum every 25 m, as well as at any significant topographic variation. We will measure all points using a GPS (Trimble GeoXT) with high accuracy. See SOP 2.1 in Appendix A for field procedures.

Stream bed profile, longitudinally along the stream, is an effective index of overall habitat structure and complexity. High channel depth variation provides greater complexity of aquatic habitat and is increased with instream and sidestream elements that resist erosion energies of the stream. We will monitor and generate a thalweg depth profile for each site (Peck et al. 2003). Thalweg depth, or deepest point in the stream, will be measured at 21 equally spaced sampling points when measuring stream width. In addition, we will traverse the stream channel every five years conducting a longitudinal profile and measuring thalweg and water depth at major habitat changes using a Trimble GeoXT. This will provide objective information on channel gradient and habitat diversity, including pool frequency and quality. See SOP 2.2 in Appendix A for field procedures.

Water width is easy to measure precisely. This measure is influenced by changes in vegetation and seasonal and climatic patterns of stream flow. Water width will be measured perpendicular to the channel at 21 equally spaced sampling points (Peck et al. 2003). See SOP 2.3 in Appendix A for field procedures.

A modified Wolman pebble count quantitatively describes the substrate composition of the reach (Harrelson et al. 1994) and involves the measurement of a minimum of 200 particles. The pebble count is measured along the sampling reach within the active channel (both in the bed and on the banks). Particles are measured along their intermediate axis (neither the shortest nor the longest measurement). Embedded and large particles are measured in place (Harrelson et al. 1994). See SOP 2.4 in Appendix A for field procedures.

5.4.2 Hydrology

Presence of surface water and shallow ground water are vital components of a thriving riparian ecosystem. Therefore, understanding quantity and spatial location of both surface and ground water are vital to monitoring the status of the riparian ecosystem along the Santa Cruz River.

The Sonoran Institute will utilize data collected by Arizona Department of Water Resources and U. S. Geological Survey on ground water level and surface flow. Data obtained from ground wells and stream gauges near monitoring sites will be utilized to monitor local ground water and surface water conditions. Additional data will be utilized when monitoring regional water conditions.

In order to monitor the spatial location of surface water, the Sonoran Institute will conduct wet/dry mapping to track the areas of the Upper Santa Cruz with perennial surface water. In recent history, segments of the Upper Santa Cruz have been ephemeral, wet only during floods, and primarily dry. Thus mapping will occur primarily near reaches at the end of common perennial stretches of the river (Amado

sites 1 and 2, San Laz ro, Headwaters). Field personnel will walk up- and downstream with a GPS and record the locations where surface water begins and ends. Wet/dry mapping will occur in late June, just prior to the start of the monsoon season, in order to capture the minimum amount of surface flow. See SOP 3.1 in Appendix A for field procedures.

5.4.3 Water Quality

Water quality is a critical measure of the chemical and biological properties of aquatic systems. Aquatic ecosystems depend on the maintenance of particular water quality conditions in order to sustain life-supporting biochemical processes in plant and animal communities. Aquatic ecosystems are influenced by inputs of metals, nutrients, toxins, soil erosion, fire ash, sewage effluent, and biomass. Core water quality parameters reflect the function of the physical and biological environment with which water interacts. Core parameters—temperature, specific conductivity, turbidity, pH, dissolved oxygen, and discharge—are easily measured and constitute a means of characterizing potential stressors to the health of aquatic systems.

The Sonoran Institute will partner with the Friends of the Santa Cruz River (FOSCR), Arizona Department of Environmental Quality (ADEQ), and the NPS Sonoran Desert Network to obtain measures of water quality along the Santa Cruz River. All recent FOSCR data has been collected following an ADEQ approved Sampling and Analysis Plan and the NPS Sonoran Desert Network recently completed an ADEQ Sampling and Analysis Plan. The Sonoran Institute will utilize FOSCR/ADEQ data when located near the sampling reach and collect data at all remaining sites. Surface water quality parameters will be measured quarterly (Table 3). A multiprobe meter (Oakton PCD650) will be used to measure 4 core parameters in the field (Table 4). The probe measures conductivity, temperature, dissolved oxygen, and pH. The probe will be placed in the middle of the water column to record data. The probe will be tested, calibrated, inspected, and maintained according to manufacturer recommendations. A portable colorimeter (Hach Chlorine Pocket Colorimeter II) will be used to measure free and total chlorine quarterly at each site (Table 4). See SOP 4.1 in Appendix A for field procedures.

All other water quality measurements (primary nutrients, specific conductivity, and total dissolved solids) will be analyzed by a laboratory from bottle samples collected concurrently with core parameter measurements (see Field Sample Collection for Off-site Analyses). The Sonoran Institute will partner with the NPS to quantify *E. coli*. The NPS at Tumac cori NHP monitors *E. coli* weekly and has equipment on site to estimate *E. coli* concentrations using the most probable number (MPN) method. *E. coli* estimates at Tumac cori NHP are conducted under an ADEQ approved Sampling and Analysis Plan and NPS at Tumac cori NHP has agreed to measure samples from Sonoran Institute monitoring sites (see section 7.3 for field procedures).

Discharge will be measured quarterly within each reach in conjunction with water quality (see SOP 4.2 in Appendix A for field procedures). The discharge measurement will be conducted by wading while using a

pygmy or Price AA meter (depending on water depth and flow) and top setting wading rod (Rantz 1982). Flow will be measured at each monitoring reach at a location meeting the following criteria:

- single well-defined channel
- smooth laminar flow consistent in direction and perpendicularity to cross section
- all water moves throughout the cross section (no slack water pools at edges)

Table 3. Water quality parameters to be measured quarterly at sites along the Upper Santa Cruz River.

Parameter	Units	Measurement
		Location
Ammonia	mg/L	Lab
Conductivity	μS	Field
Conductivity (specific @25 °C)	μS/cm	Lab
Discharge (flow)	cfs	Field
Dissolved Oxygen	mg/L	Field
<i>E. coli</i>	MPN	NPS Lab
Free/Total Chlorine	mg/L	Field
Nitrogen (Nitrate + Nitrite)	mg/L	Lab
Nitrogen (total Kjeldahl)	mg/L	Lab
pH		Field
Phosphorus	mg/L	Lab
Temperature	°C	Field
Total Dissolved Solids	mg/L	Lab

Table 4. Water quality parameters measured in the field and the equipment used to measure them. Accuracy and range of the measuring equipment is given when applicable.

Field Measurements	Field Equipment	Accuracy	Range	Standards*
Chlorine (Free/Total)	Hach Chlorine Pocket Colorimeter II	±0.01 <i>or</i> 0.1 mg/L	0.02-2 <i>or</i> 0.1-8 mg/L	11 µg/L acute A&W; 5 µg/L chronic A&W
Discharge (flow)	Pygmy Meter (WaterMark® Models 6200 or 6205)	-	0.1 to 25 FPS <i>or</i> 0.1 to 4.9 FPS	No standard
Dissolved Oxygen (mg/L)	Oakton PCD 650	±0.2 mg/L	0.0 to 90.0 mg/L	6.0 mg/L A&Ww; 3.0 mg/L (3 hrs after sunrise), 1.0 mg/L (sunset) A&Wedw
Dissovled Oxygen (% Saturation)	Oakton PCD 650	± 2%	0-600%	Dissolved oxygen is <u>not</u> violated if at least 90% saturation.
E. coli (MPN) ¹	Colilert Quanti-tray	-	down to 1 cfu/100ml	235 cfu/100ml PBC; 575 cfu/100ml FBC
pH	Oakton PCD 650	± 0.002	-2 to 19.9	6.5 - 9.0 A&W, FBC, PBC
Conductivity	Oakton PCD 650	± 1% full scale	0 to 500 µS	No standard
Temperature	Oakton PCD 650	± 0.5 °C	-10°C to 110 °C	3 °C increase due to discharge A&Ww,edw

*A&W = aquatic and wildlife; A&Ww = aquatic and wildlife warm water; A&Wedw = aquatic and wildlife, effluent dependent water; FBC = full body contact; PBC = partial body contact

¹ E. coli will not be measured in the field, but at an NPS facility at Tumacácori National Historical Park; in proposed changes to Arizona water quality standards, ADEQ considers MPN and CFU to be equivalent measures of quantity of e. coli (Arizona Administrative Register, 2008).

5.5 Biological Characteristics:

5.5.1 Vegetation

Many consider riparian vegetation to be the most important functional component of riparian ecosystems. Near-stream vegetation stabilizes stream-banks and provides nutrients, organic matter and habitat to numerous aquatic and terrestrial organisms. Sensitive to hydrologic change, riparian communities are also influenced by natural disturbances and human activities. Patterns of riparian vegetation will be monitored using repeat photography.

Photo point monitoring will be conducted at all sites using methodology from Hall (2002). Photo points will be used to determine patterns such as tree mortality and recovery. In addition, changes in vegetation formation, such as a forest becoming herbaceous, can be ascertained using photo point monitoring. See SOP 5.1 in Appendix A for field procedures.

Aerial photos, not orthophotos, will be used to monitor regional vegetation patterns. Aerial photos will be taken annually in the months of April or May. Photos will be taken of monitoring sites and other sites in the region to enable the determination of large scale vegetation patterns, such as cottonwood mortality. We will work with Lighthawk (www.lighthawk.org) to obtain overflights at approximately 1000 feet altitude on sunny days with good visibility. All photos will be taken from inside the cockpit, with a high resolution digital camera (minimum 8 megapixels).

5.5.2 Aquatic Macroinvertebrates

Benthic macroinvertebrates are an important biological component in streams. They contribute to nutrient cycling and organic decomposition and are an important prey for fish and other aquatic vertebrates. Living on the bottom substrates or in the sediment of streams, benthic macroinvertebrate communities respond differently to a variety of stressors. Thus, the type of stress on a stream can be determined by analyzing species distribution for the macroinvertebrate community (Peck et al. 2003). Benthic macroinvertebrates can provide a useful biological indicator of water quality and local conditions (Rosenberg and Resh 1993). They have been used extensively to assess stream condition because they are sensitive to pollutants and have high species richness. They also live in contact with sediment where pollutants tend to concentrate, and taxa and lifeform response to pollutants are relatively well established (Reice and Wohlenberg 1993).

Samples for benthic macroinvertebrates are collected from each of the 11 sampling locations within a reach and combined into a composite sample. Collection begins at the bottom of the reach and proceeds upstream. A timed kick-net sample is collected within 1 m downstream of each of the 11 sampling locations. Several parameters of physical habitat will also be collected to help interpret the resulting data. See SOP 5.2 in Appendix A for field procedures.

5.5.3 Fish

Fish assemblages can serve as effective indicators of ecological conditions; fish are long-lived and mobile, forage at different trophic levels, integrate ecosystem conditions at higher and lower trophic levels, and are reasonably easy to identify in the field. Fish also respond to higher-order processes that are captured in the other elements, particularly stream channel morphology, riparian vegetation, and water quantity (for physical habitat); water quality (for health), and macroinvertebrates (for food).

The Sonoran Institute will utilize fish survey data collected by Arizona Department of Game and Fish and Friends of the Santa Cruz River (FOSCR). Fish surveys are conducted annually in the fall according to the Standard Fish Sampling Protocol for State of Arizona Waters (AZGFD 2004) at sites where FOSCR collects water quality data.

Electrofishing equipment, seines, and dip nets are used to conduct spot check surveys for fish and determine the presence and absence of native and exotic fish species as well as species composition at each site. All fish habitats present are sampled, including pools, riffles, runs, backwaters, and areas with overhanging vegetation along banks. Sampling effort is measured as number of seines, number of dipnets, time spent sampling, and approximate length of stream sampled. The following are noted for all captured fish: species, age (adult or juvenile), capture method (electrofisher, seine, dipnet), and habitat. Fish are not weighed or measured for total length. (see Appendix C for field data sheets and general sampling protocol used by AZGFD)

6.0 Field Preparation and Documentation

6.1 Field Preparation

Before conducting field work the Sonoran Institute will comply with the following when appropriate:

- Obtain required permissions and/or permits necessary to access a project area
- Collect and review relevant background information, such as: published maps, air photos and other imagery, GIS maps, published literature and reports on the project area
- Review the protocol(s) and standard operating procedures (SOPs) and identify all needed equipment for field measurement and observation.
- Coordinate field equipment and materials that may include: field data sheets, safety gear, maps, clipboard, camera, field forms/logbooks, GPS, laptop, and reference materials
- Calibrate and maintain field equipment
- Review field health and safety plan and emergency contact numbers

6.1.1 Instrument Calibration and Frequency

Calibration of all equipment and analytical instruments will be calibrated following procedures using the manufacturer's recommendations detailed in the User's Manual for each piece of equipment or instrument. Calibrations and maintenance of equipment will be done prior to analysis or use in the field. All calibrations will be recorded in a logbook. Current meters will be thoroughly cleaned after each use, spin tests conducted before, during, and after field trips, and routine maintenance conducted when necessary (see Appendix C for instructions on current meter maintenance). Calibration of the multiprobe meter (Oakton PCD650) will occur before the first use, prior to each sampling session, and after the replacement of any probe. During a sampling session, calibration will occur every five days, with the exception of pH, dissolved oxygen, and conductivity which will be calibrated each day field measurements are taken (see Appendix C for calibration section of multiprobe meter user manual). The manual for the chlorine meter recommends using the factory calibration, though manual calibration is possible (see Appendix C for calibrations section).

6.1.2 Field Logbooks

Record of all field activities conducted will be made in a field logbook. The following is a partial list of items that would be recorded in the field logbook.

- Team members and their responsibilities
- Time of arrival/entry on site and time of departure
- Other personnel on site
- Summary of any meetings/discussions with land owners, agency personnel, contractors etc.
- Deviations or variances from sampling plans, site safety plans, and QAPP procedures
- Any field note or observation *NOT* recorded on a formal datasheet or form

6.1.3 Field Data Sheets and Forms

All field data will be recorded on datasheets and forms. See Appendix B for example datasheets.

6.2 Field Photographs

Photographs will help document changes in vegetation and stream condition at each site. Photographs will be taken at observation locations, sampling locations and at other areas of interest on site or in the sampling area. For each photograph taken, the following information will be recorded on the appropriate data sheet:

- Time, date, location, bearing
- Description of the subject photographed

- Name of person taking the photograph
- Number of photograph

6.3 Documentation of Sample Collections

Any sample collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory and office post field work. Samples will be labeled with the following information: sample ID, sample location (with GPS reading if possible), date of collection, type of sample, and sampler's name. Sample ID will be a unique number adhering to the following format: SiteID_SampleNumber_YYYYMMDD (ex. 341_1_20090131).

7.0 Samples Collected for Off-site Analysis

7.1 Benthic Macroinvertebrates

7.1.1 Field Equipment

When collecting benthic macroinvertebrate samples, the following field equipment will be needed: kick-net (D frame), sample bottles, 2 five-gallon buckets, filtering sieve (500µm mesh), tweezers, 95% ethanol, 10% formalin, water proof paper, and sample collection datasheet.

7.1.2 Laboratory Details

The Bureau of Land Management and Utah State University, National Aquatic Monitoring Center: The Bug Lab, will analyze all benthic macroinvertebrate samples. Samples will be sent to:

The Bug Lab
Department of Aquatic, Watershed, and Earth Resources (AWER)
Utah State University
Logan, UT 84322-5210

7.1.3 Sample Preparation

All samples will be prepared according to the following:

1. **Samples will be fixed with 95% ethanol.** Samples containing large amounts of organic matter will be fixed 10% formalin, to be replaced with 70-95% ethanol within 10 days of shipping.
2. **Samples will be labeled inside and outside.** Pencil on waterproof paper works well for inside labels and paper on masking tape works well for outside labels. Labels will include information on the location of the sample and the date of sampling. Consecutive sample numbers will be placed on the lid of each jar, samples requiring more than one jar will be labeled as 1a, 1b, 1c, etc. A list all the samples with the location and date of sampling will be included.

3. **Information on where, when and how samples were collected will be provided.** See example in Appendix C.
4. **Sample bottles will be carefully packaged.** Lids will be wrapped with duct tape. All samples will be placed in a plastic bag and surrounded with packing material. Information sheets will be placed in a separate zip-lock bag.

7.1.4 Sample QC

All samples will be processed according to the lab's standard procedures (see Appendix C for attached lab procedures and QC or the lab website <http://www1.usu.edu/buglab/process>). All samples will be sorted to lowest taxonomic level feasible. Most specimens are identified to genus, though some to species or family, and others to the lowest taxonomic level feasible without slide-mounting.

7.2 Water Quality

7.2.1 Field Equipment

When collecting water samples that will be analyzed at a laboratory, the following field equipment will be needed: prepared sample bottles provided by the laboratory, cooler filled with ice, clean collection bottle, gloves, fine point pen, and watch.

7.2.2 Site Selection

A site will be selected according to criteria detailed by the Arizona Department of Environmental Quality (ADEQ 2005) and summarized here. The selected sampling site will exhibit a high degree of cross-sectional homogeneity. Since mixing is principally governed by turbulence and water velocity, a site immediately downstream of a riffle area will ensure good vertical mixing. Horizontal mixing occurs in constrictions in the channel. In the absence of turbulent areas, a site that is clear of immediate point sources, such as industrial effluents, will be preferred for the collection of ambient water samples.

To minimize contamination from trace metals in the atmosphere, ambient water samples will be collected from sites that are as far as possible (e.g., at least several hundred feet) from any metal supports, bridges, wires or poles. Similarly, samples will be collected as far as possible from regularly or heavily traveled roads. If water samples must be collected near roadways, sampling events will be planned during lowest traffic flow.

7.2.3 Sampling

All water samples will be collected upstream of any activity that has occurred within the sample reach during field work. Samples will be collected at the end of the field visit in order to minimize time between collection and drop-off at the laboratory. A wide mouthed collection bottle will be used to fill lab preserved sample bottles. Field personnel will decontaminate the collection bottle prior to use at a given site. Lab preserved bottles will be kept in zip-type plastic bags and handled only while wearing

gloves to prevent contamination. Water quality samples to be analyzed off-site at a laboratory will be collected using the grab sample method (ADEQ 2005). Samples will be filtered at the lab, thus field filtration will not be necessary.

1. All field personnel participating in the collection of water samples will wear gloves to prevent contamination of the samples.
2. All water samples will be labeled using permanent markers with date, time of collection, sample identification code, sample location, and name of collector.
3. While facing upstream, the collection bottle will be rinsed with stream water several times to flush out any contaminants that might be present. If a stream is in flood, a spot will be located along the edge of the stream bank where samples can be safely collected.
4. One sample bottle will be removed from the plastic bag and filled at a time. Each sample bottle will be filled completely, quickly capped, and returned to the plastic bag. Sample bottles containing preservatives will be handled carefully to avoid overfilling.
5. Upon completion of sample collection, water samples will be preserved immediately on ice, in an ice chest, and transported to a laboratory for analysis.

7.2.4 Quality Control

The laboratory provides bottles with sufficient volume to permit matrix spikes and duplicates to be conducted for all samples. Additional field duplicates will be collected to assure that sample and measurement precision is of adequate quality for intended uses. During each sampling event, one duplicate sample will be collected for each parameter measured to ensure quality control samples for approximately 10% of the samples collected. Random site selection will determine where duplicate samples will be taken. Field duplicates will be submitted blind to the laboratory. Results of duplicate samples will be indicated in the database when lab data are entered. During the first year of sampling, field blanks will be conducted for each parameter during the first two sample periods to ensure no field contamination is occurring. If samples are not contaminated, routine field blanks will be reduced to an annual basis. Should contamination of field blanks occur, sequential field blanks will be used until the contamination source has been eliminated. Random site selection will determine where field blanks will be conducted.

7.2.5 Summary of Laboratory Analyses

Table 5 below summarizes the seven parameters that will be monitored with laboratory analyses. Included in the table are the test method, method detection limit (MDL), the laboratory reporting limit, preservative, holding time, and the current water quality standard when available. Table 6 summarizes the accepted levels of precision and accuracy for the parameters being tested.

7.2.6 Laboratory Details

The following laboratory will be conducting all analyses of water quality:

Turner Laboratories, Inc
 2445 North Coyote Drive, Suite 104
 Tucson, Arizona 85745
 Phone: 520-882-5880
 Fax: 520-882-9788
 www.turnerlabs.com

Prepared sample bottles will be obtained prior to field work. Samples will be transported back to the laboratory packed in a cooler with ice. Appendix C provides examples of chain of custody forms and seals used by the lab.

Table 5. Summary of methodology, reporting limits, holding times, and available standards for all parameters that will be tested by Turner Laboratory.

Parameter	Units	Method	Reporting Limit	Preservative	Holding Time	Standard
Ammonia	mg/L	E350.1 ^a	1.00	H ₂ SO ₄	28 days	Depends on ph/Temp
Conductivity (specific @25 °C)	µS/cm	M2510B ^c	0.1	Cool	28 days	none
Nitrogen (Total Kjeldahl)	mg/L	E351.1 ^a	0.5	H ₂ SO ₄	28 days	none (0.106 ⁴)
Nitrogen (Nitrate)	mg/L	E300 ^b	1	Cool	48 hours	10.0 ¹ ; 2,240 ²
Nitrogen (Nitrite)	mg/L	E300 ^b	0.1	Cool	48 hours	1.0 ¹ ; 140 ²
Phosphorus	mg/L	H8190 ^d	0.1	H ₂ SO ₄ , Cool	28 days	none (0.01 ⁴)
Total Dissolved Solids	mg/L	M2540C ^c	20	Cool	7 days	500 ³

Methodology Sources: ^aEPA, 1993; ^bEPA, 1983; ^cAPHA-AWWA-WPCF, 1998; ^dHACH, 1997.

¹ADEQ – drinking water/domestic water source;

²ADEQ – full/partial body contact

³EPA – drinking water

⁴EPA – Region III, Ecoregion 79 streams reference level (25th percentile of historical data)

Table 6. Summary of Turner Laboratory's accepted levels of accuracy and precision for parameters being tested. Laboratory control samples reflect accuracy while matrix spike samples reflect precision.

Parameter	Method	LCS/LCSD % REC	% RPD	MS/MSD % REC	% RPD	DUP %RPD
Nitrate	E300 ^b	10	20	15	10	---
Nitrite	E300 ^b	10	20	15	10	---
Ammonia	E350.1 ^a	10	10	30	20	---
Total Kjeldahl						
Nitrogen	E351.1 ^a	30	30	30	30	---
Phosphorous	H8190 ^d	10	10	30	15	---
Conductivity	M2510B ^c	---	---	---	---	10
Total Dissolved Solids	M2540C ^c	---	---	---	---	10

%REC = Percent recovery, %RPD = relative percent difference, DUP = duplicate sample

LCS = Laboratory Control Sample , LCSD = Laboratory Control Sample Duplicate,

MS = Matrix Spike Sample, MSD = Matrix Spike Sample Duplicate

Methodology Sources: ^aEPA, 1993; ^bEPA, 1983; ^cAPHA-AWWA-WPCF, 1998; ^dHACH, 1997.

7.3 *E. coli* samples

7.3.1 Field Equipment

When collecting water samples that will be analyzed for *E. coli* at the NPS facility at Tumacácori National Historical Park, the following field equipment will be needed: sterilized sample bottles, cooler filled with ice, clean collection bottle, gloves, fine point pen, and watch.

7.3.2 Site Selection

E. coli will be sampled from the same site as all other water quality measures, see 7.2.2 *Site Selection*.

7.3.3 Sampling

All water samples will be collected in the same manner as described in section 7.2.3 *Sampling*, however samples will be collected in a sterilized bottle and transported to the NPS facility rather than the Turner Laboratory.

7.3.4 Quality Control

During each sampling event, one duplicate sample will be collected to ensure quality control samples for approximately 10% of the samples collected. Random site selection will determine where duplicate samples will be taken. If duplicate samples record statistically different quantities of *E. coli*, both the sample data and duplicated data are excluded from analysis.

7.3.5 Laboratory Details

All E. coli water samples will be processed at the following facility under supervision of Jeremy Moss:

National Park Service
Tumacacori National Historical Park
1891 E Frontage Rd
Tumacacori, AZ 85640
(520)398-2341 ext 64

All E. coli samples will be processed and paperwork completed by 3:30 pm the day samples are collected. Only approved individuals given permission by NPS will be permitted to access the facility to drop off samples. Processing of samples includes mixing the colilert reagent with the water, pouring water samples into trays, sealing trays, and placing trays into the incubator overnight. An NPS employee will examine the trays the following day to determine results of the test.

8.0 References

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