THE WATER QUALITY OF THE LITTLE COLORADO RIVER WATERSHED

Fiscal Year 2007

Prepared by the

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Fiscal Year 2007

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Report Cover: From left to right: EMAP team including ADEQ, AZGF, and USGS; Rainbow over the Round Valley in the White Mountains; Measuring Tape, and Clear Creek located east of Payson.

ABBREVIATIONS

Abbreviation	Name	Abbreviation	Name
ALKCACO3	Total Alkalinity	SO4-T	Sulfate Total
ALKPHEN	Phenolphthalein Alkalinity	SPCOND	Specific Conductivity
AQEQ	Arizona Department of Environmental Quality	SSC	Suspended Sediment Concentration
AS-D	Arsenic Dissolved	su	Standard pH Units
AS-T	Arsenic Total	TDS	Total Dissolved Solids
AZGF	Arizona Game and Fish Department	TEMP-AIR	Air Temperature
AZPDES	Arizona Pollutant Discharge Elimination System	TEMP-WATER	Water Temperature
BA-D	Barium Dissolved	TKN	Total Kjeldahl Nitrogen
B-T	Boron Total	TMDL	Total Maximum Daily Load
CA-T	Calcium Total	USGS	U.S. Geological Survey
CFS	Cubic Feet per Second	ZN-D	Zinc Dissolved
CO3	Carbonate	ZN-T	Zinc Total
CU-TRACE	Copper Trace Metal		
CWA	Clean Water Act		
DO-MGL	Dissolved Oxygen in mg/l		
DO-PERCENT	Dissolved Oxygen in Percent		
E. coli	Escherichia coli		
Ft	Feet		
Ft/s	Feet per second		
HARDCACO3	Total Hardness		
HCO3	Bicarbonate		
HG-T	Mercury Total		
HUC	Hydrologic unit Code		
IBI	Index of Biological integrity		
K-T	Potassium Total		
MG-T	Magnesium Total		
ml	Milliliters		
mm	Millimeters		
MN-T	Manganese Total		
MRL	Minimum Reporting Level		
MU	Monitoring Unit		
NA-T	Sodium Total		
NH3	Ammonia		
ntu	Nephelometric Turbidity Unit		
PB-D	Lead Dissolved		
PB-T	Lead Total		
P-T	Phosphorous Total		
QA	Quality Assurance		
QC	Quality Control		
RBS	Relative Bed Stability		

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CHAPTER 1 – OVERVIEW

Water is one of Arizona's most important commodities. The importance of water will only grow as Arizona's population increases. The United States Census Bureau has ranked Arizona the 2nd fastest growing state after Nevada. Arizona's population as of the 2000 census was 5,130,632. Arizona's population is expected to double by 2030 to 10,712,397. This increase will unquestionably place further demands on Arizona's water supply.

Groundwater is the primary source for Arizona's water (ADWR, 2006). Surface water, Central Arizona Project water and effluent from wastewater treatment plants, make up the remaining 45 percent of the water that Arizona uses. The majority of Arizona's water is used for agriculture with smaller allotments being used for municipal and industrial uses (Figure 1).

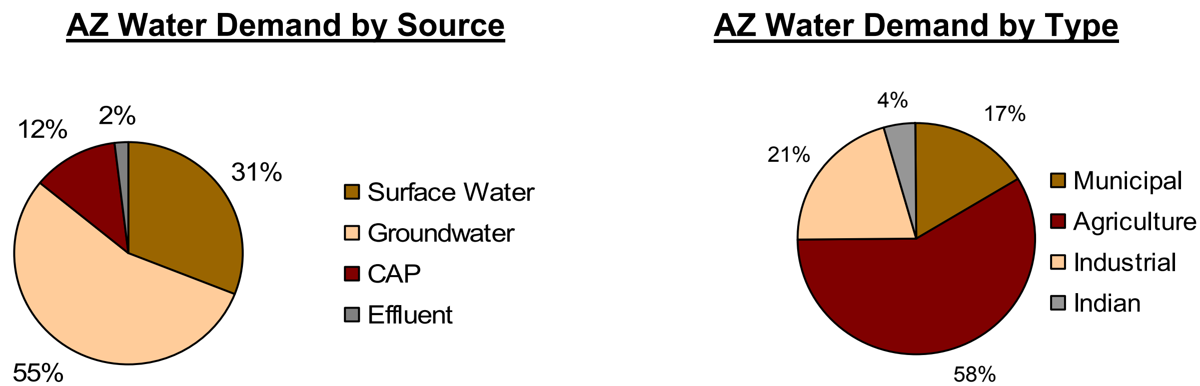


Figure 1. Arizona water usage (Department of Water Resources Water Atlas, 2006)

WHY MONITOR?

ADEQ monitors lakes, streams and groundwater throughout the state to gather information. The information is used to assess whether the water is safe to drink, safe to swim in, suitable for irrigation, and adequate to support aquatic life. The Clean Water Act (CWA) gives ADEQ the authority to conduct ambient water monitoring. Monitoring is used to meet state and federal goals of protecting human health and aquatic life.

The information that the Monitoring Unit in the Water Quality Division at ADEQ gathers is used by other government agencies such as the Environmental Protection Agency, Arizona Game and Fish, and the Arizona Department of Water Resources. The data is also used by land owners, universities, operators of drinking water systems and the public to make informed management decisions.

ADEQ uses the data to assess whether surface water quality standards are being met for human health, agriculture and aquatic and wildlife uses. Figure 2 illustrates the relationship between water quality monitoring, assessments, Total Maximum Daily Load (TMDL) development, and the implementation of water quality improvement strategies.

Water quality is monitored and the results are compared against the surface water quality standards. The results of the assessment are included in the CWA Section 305(b) report, while impaired waters are placed on the 303(d) list. TMDLs are developed for impaired surface waters on the CWA Section 303(d) list. The National Pollution Discharge Elimination System (NPDES) is a permitting program which addresses point source discharges to surface waters. Permits are written to protect water quality standards. Arizona received delegation for this program in December, 2002 and administers a program known as the Arizona Pollutant Discharge Elimination System (AZPDES) permitting program. The 319 program addresses nonpoint source programs and provides grants for projects to improve water quality, especially in water quality limited locations.

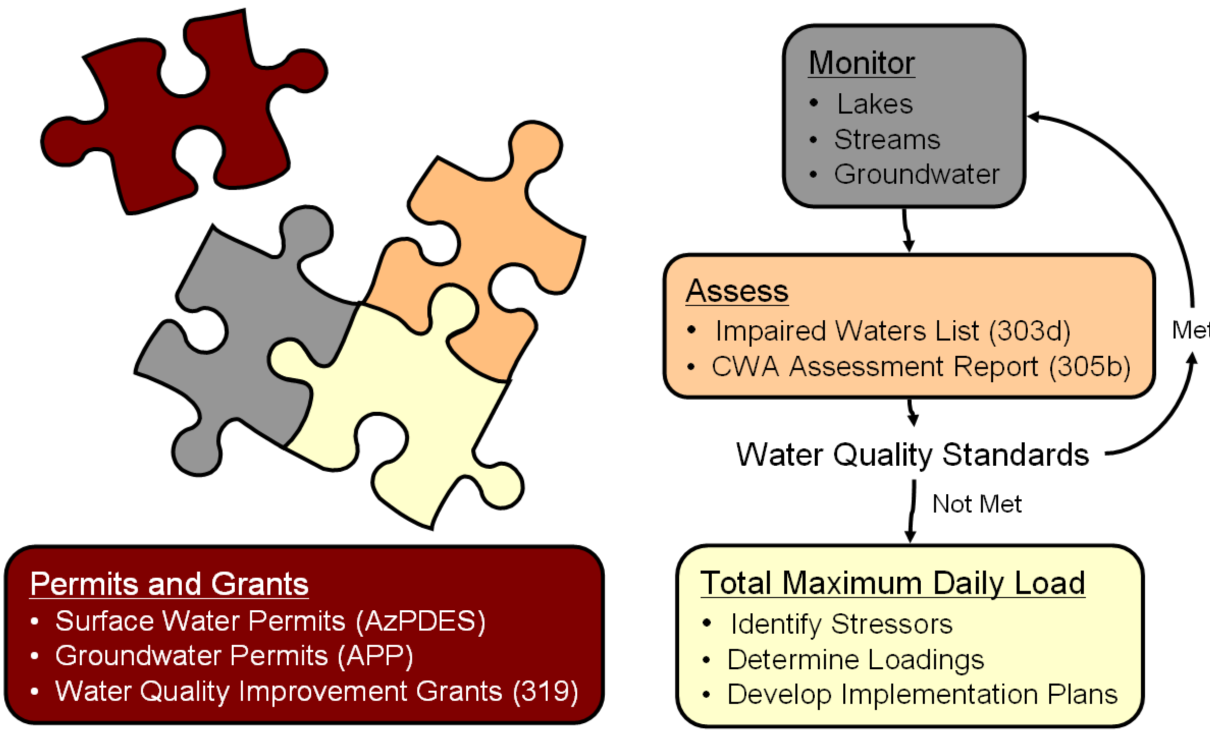


Figure 2. Water quality monitoring is integrated with the development of water quality standards, TMDLs, assessments and the implementation of water quality strategies.

This report is not associated with the assessment (305b/303d) or TMDL issues. Please consult the most recent Integrated Assessment and Listing Report to determine if a particular stream reach is impaired or is attaining.

ADEQ'S MONITORING UNIT

The Arizona Department of Environmental Quality's (ADEQ) Monitoring Unit is responsible for monitoring the water quality of all of Arizona's groundwater and surface waters.

Monitoring Unit staff collects water quality data to assess the biological, chemical, and physical integrity of Arizona's rivers and streams. The objectives of the Monitoring Unit are to:

- Conduct ongoing monitoring of the waters of the state as required by Arizona Revised Statutes (A.R.S.) §49-225;
- Characterize the baseline water quality of wadeable, perennial streams ;
- Provide credible data for surface water quality assessments, identify impaired waters, and determine compliance with water quality standards as required by §305(b) of the Clean Water Act;
- Collect bioassessment data on the regional biocriteria reference site network to determine trends in reference conditions over time and to test indexes of biological integrity; and
- Monitor the State's outstanding waters to determine whether water quality is being maintained and protected in accordance with Arizona Administrative Code (A.A.C. R18-11-112).

LITTLE COLORADO RIVER SURFACE WATER MONITORING

This report focuses on wadeable perennial streams within the Little Colorado River Watershed. Samples from 44 streams sites in the Little Colorado River Basin (LCR) were collected from July 2006 to June 2007. Three quarters of water quality monitoring data were collected for most of the sites. Water chemistry was collected for all three quarters and benthic macroinvertebrate/habitat data were collected at 30 of the 44 sites in the spring.

The purpose of this report is to summarize the water quality data collected during fiscal year 2007, which runs from July 1, 2006 to June 30, 2007. Raw data is presented in Appendix A. Photos of each site are presented in Appendix B. Appendix C includes summary statistics for water quality data.

AZPDES AND TMDL ISSUES IN THE LITTLE COLORADO RIVER BASIN

There are currently 22 Arizona Pollution Discharge Elimination System (AZPDES) point source discharge locations within the Little Colorado River watershed (Figure 3). The 22 outfalls are covered by the 18 permits in Table 1 (some permits have multiple outfalls). EPA Region IX does the permitting for the Navajo Tribal Utilities Authority.

Table 1. List of AZPDES permits by facility and permit number in the LCR watershed.

Permit #	Facility Name
AZ0020427	Flagstaff, City of - Wildcat Hill WW Plant
AZ0021610	Cameron Trading Post
AZ0023311	APS - Cholla Power Plant (S2- variance appl)
AZ0023612	Grand Canyon Natl. Pk-Desert View WWTP
AZ0023639	Flagstaff, City of - Rio de Flag Plant
AZ0023833	Winslow, City of - WW Plant
AZ0023841	Show Low, City of WWTP
AZ0024228	Navajo Tribal Utilities Authority (NTUA) - Pinon

AZ0024236	NTUA - Jeddito
AZ0024279	High Country Pines II WWTP
AZ0024287	Snowflake, Town of WWTP
AZ0024422	Sanders Unified School District #18 WWTP
AZ0024902	Estates at Pine Canyon WWTP
AZ0025224	USFS - Apache-Sitgreaves National Forest
AZ0025399	Bison Ranch WWTP (aka Bisontown LLC)
AZ0025437	Pinetop-Lakeside, City of WWTP
AZ0025542	Holbrook, City of - Painted Mesa WRF
AZ0025739	Black Canyon WWTP

There are eight impaired streams within the LCR based on the 2006 303(d) list (Table 2). HUC refers to the hydrologic unit code, which identifies specific basins within the watershed. Reach refers to a particular section of the stream.

Table 2. List of impaired streams in the LCR watershed.

Stream Name	Impaired for	HUC	Reach
Little Colorado River - Coyote Creek to Lyman Lake	Sediment/ Turbidity	15020001	005
Little Colorado River - North of Silver Creek	Sediment, E. coli	15020002	004
Nutrioso Creek - At Springerville	Sediment/ Turbidity	15020001	015
Nutrioso Creek - South of Springerville to Nelson Reservoir	Sediment/ Turbidity	15020001	017B
Little Colorado River - Water Canyon Creek to Nutrioso Creek	Sediment/ Turbidity	15020001	010
Little Colorado River - Nutrioso Creek to Carnero Creek	Sediment/ Turbidity	15020001	009
Little Colorado River - West Fork LCR to Water Canyon Creek	Sediment/ Turbidity	15020001	011
Little Colorado River - West of Holbrook	Copper, Silver, Sediment	15020008	017

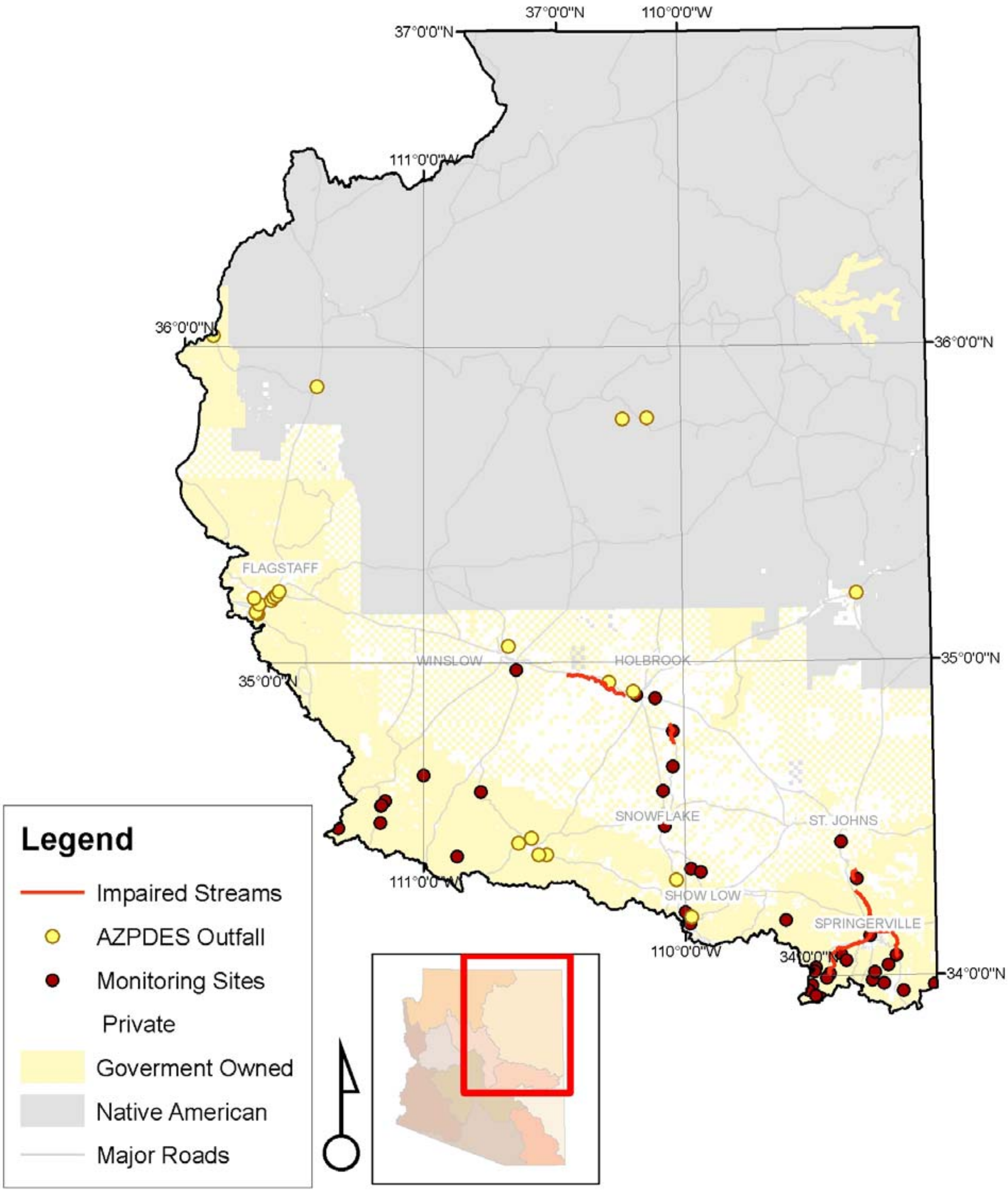


Figure 3. Impaired streams, AZPDES outfalls and LCR monitoring sites within the LCR basin.

ADDITIONAL INFORMATION REGARDING THE LCR

For a basic description of the Little Colorado River Basin region including information regarding climate, geology, topography, etc. visit The University of Arizona's NEMO watershed-based plans at http://www.srnr.arizona.edu/nemo.

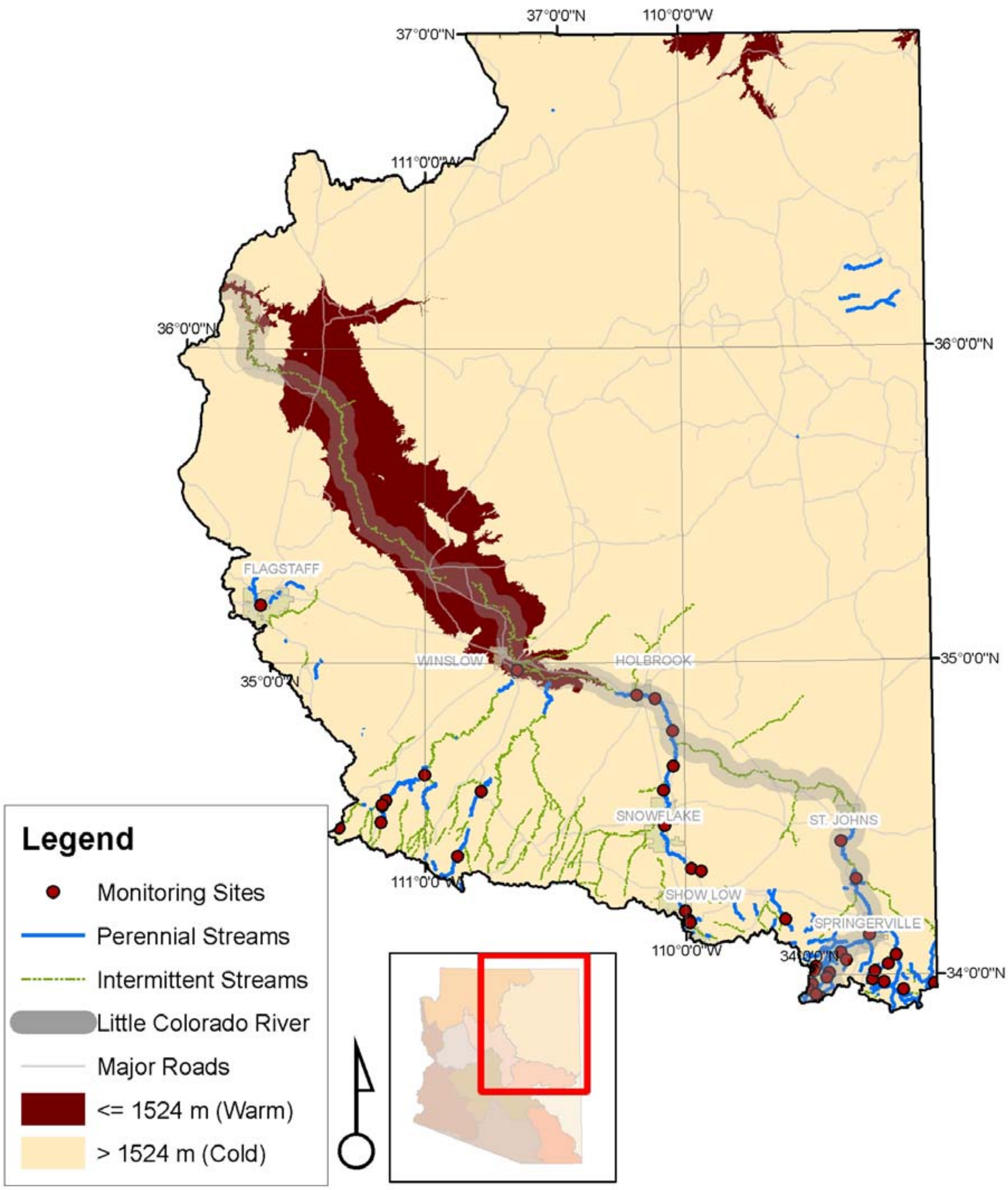


Figure 4. Perennial and intermittent reaches in the LCR Watershed.

The Little Colorado River (LCR) watershed is located in northeastern Arizona. The watershed drains a total of 79,880 square kilometers (30,800 sq. miles), almost the entire northeast quarter of the state and a small portion of northwestern New Mexico. Approximately 50% of the watershed area is on Native American Reservations. ADEQ's sample sites are in the non-tribal area within Arizona (Figure 3).

The LCR watershed includes several large mountain ranges with some of the highest peaks in Arizona. The highest elevation in the watershed is 3,850 meters (12,600 ft.) at Humphreys Peak in the San Francisco Mountains just north of Flagstaff. Much of the watershed's southern edge is defined by the 480-kilometer (298 mi.) long Mogollon Rim, a steep escarpment, with an average elevation of 2,100 meters (6,890 ft.). The Mogollon Rim transitions into the White Mountains near the New Mexico border, in which Mount Baldy and Escudilla Mountain are two prominent peaks with elevations 3,500 meters (11,500 ft.) and 3,000 meters (9,840 ft.), respectively. The lowest elevation in the basin is 820 meters (2,690 ft.) at the mouth of the LCR.

The LCR headwaters originate in the White Mountains and form the main stem of the LCR near Greer, which then flows generally north to Lyman Lake and continues northeast through Holbrook and Winslow as an intermittent river until it reaches the mainstem of the Colorado River (Figure 4). Flow alterations caused by impoundments and diversions are common throughout the watershed, causing a number of stream reaches to flow only intermittently or ephemerally. The largest tributary, Silver Creek, is fed by the largest spring in the basin, Silver Creek Spring southeast of Snowflake-Taylor with a discharge of 3,648 gpm (measured in 1990, ADWR, 2006). Most of the discharge from Silver Creek was diverted for irrigation from April to June. Perennial flows are found in the higher elevations due to winter snow, monsoon storms, and springs.

Only 30 of the 44 sites could be sampled during the spring period. The spring period was used to select sampleable sites for the probabilistic monitoring design because this is only the period that chemistry, macroinvertebrate and habitat data are sampled together. Any reference to "random sites" throughout this document will refer to the 30 sites sampled during the spring (See Chapter 2 for additional information regarding the probabilistic monitoring design).

Main sources of perennial flows at 30 random sites sampled for this assessment were snow melt at 37% and springs at 27% (Figure 5). Ten percent of the sites were located downstream of reservoirs and had regulated flows. The LCR and its tributaries flow through a variety of landforms such as mountain meadows, coarse colluvial deposits, bedrock canyons, and alluvial deposits.

Rosgen (1996) devised a stream classification system, in which the Level 1 stream classification, A through G, involves characterizations of channel morphology, valley types, and landforms where stream systems are found. Figure 6 shows Level 1 stream types observed in the LCR basin and their general descriptions for the randomly sampled sites. Most dominant stream types among random sites evaluated were B streams and C streams.

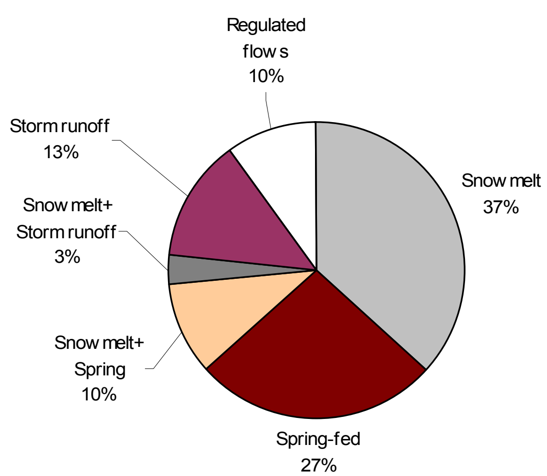


Figure 5. Main water sources contributing to perennial flows at the random sampling sites.

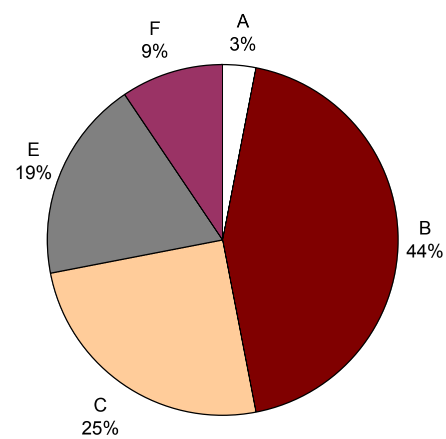


Figure 6. Rosgen stream types for random sampling sites.

Table 3. Rosgen Level 1 Stream Type General Descriptions.

Stream Type	General Description
A	Steep, entrenched, and cascading step/pool channel.
B	Riffle-dominated channel on moderate gradient in narrow valley.
C	Meandering riffle/pool channel with point bars and well defined floodplains.
E	Highly sinuous riffle/pool channel in broad valley/meadows.
F	Entrenched and meandering riffle/pool channel on low gradient
G	Entrenched “gully” step/pool channel on moderate gradient.

Omernik (1987) divided the United States into 104 Level III ecoregions. Both the EMAP West assessment (Stoddard et al., 2005) and the Arizona EMAP assessment (Robinson and Pareti, 2007) reported results within broader ecoregions aggregated from Omernik's ecoregions. Though the sample size in this study is not large enough to report results in different ecoregions, two of the Omernik Level III ecoregions occur in the study area: Arizona/New Mexico Mountains and Arizona/New Mexico Plateau (Figure 7). The Mountains region, which lies along the southern border of the watershed, accounts for about 50% of the total study area. The region is characterized by mountainous terrain with pinyon-juniper and oak woodlands at low to mid-elevations and ponderosa pine forests at high elevations. Most perennial streams identified in this study occur in the Mountains region which ranges in elevation from 1,780 to 2,920 meters (5,840 to 9,580 feet). The vast majority of the random sampling sites (29 out of the 30) were located in this ecoregion. The Plateau ecoregion, the other 50% of the study area, is characterized by desert vegetations at low elevations, grass and shrublands at mid-elevations, and pinyon-juniper woodlands at high elevations. One random site is located in this region at a land-surface elevation of 1,550 meters (5,090 ft.). All 30 sampling sites were, however, located above 5,000 feet (1,524 meters), thus categorized as "coldwater" streams for the assessment purpose (ADEQ, 2007).

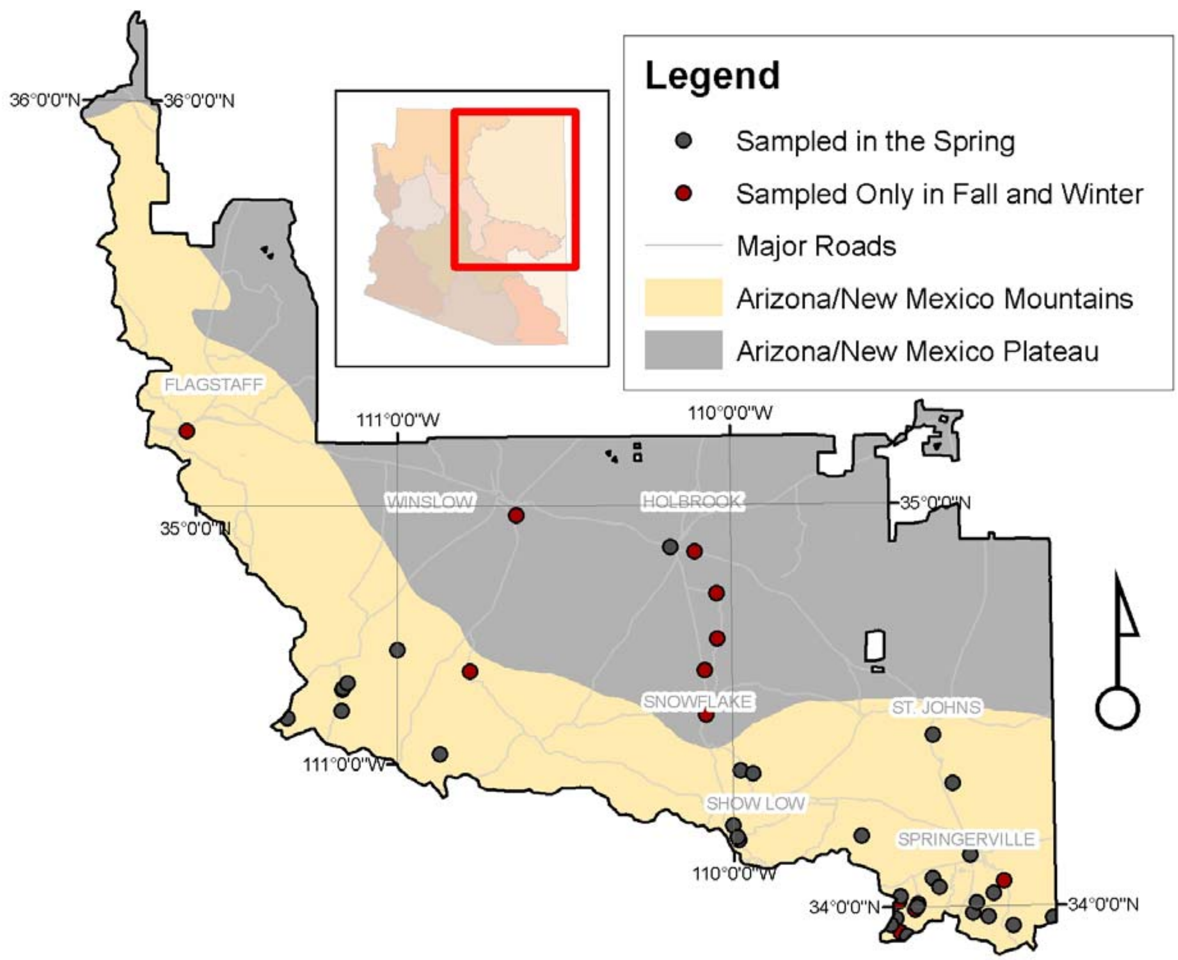


Figure 7. Ecoregions in study area.

Precipitation in the LCR basin generally increases with altitude and varies widely season to season. Precipitation is usually highest during summer months of July and August and peaks again during winter months with the driest period in April through June. Spring of 2007 was especially dry throughout Arizona with temperatures well above average across the state. Though northern Arizona had a wet winter in 2004-2005, the records indicate consistently dry and warm conditions for the LCR basin since 1999 (ADWR, 2006). Similarly, stream flows measured at select USGS gages in the LCR basin show that flows during the spring months of 2007 were considerably lower than the 30-year average monthly flows measured at the same stations.

CHAPTER 2 – MONITORING DESIGN AND METHODS

PROBABILISTIC MONITORING DESIGN

ADEQ was awarded a grant by EPA's Regional Environmental Monitoring and Assessment Program (REMAP) for FY 2006-2007. EPA is promoting the use of a probability-based monitoring design. This design will enable ADEQ to make comprehensive water quality assessments from randomly selected sample sites. A probability-based monitoring design allows statistically valid inferences to be made about the condition of all water body types in the target population of the state's waters in an efficient and cost-effective way.

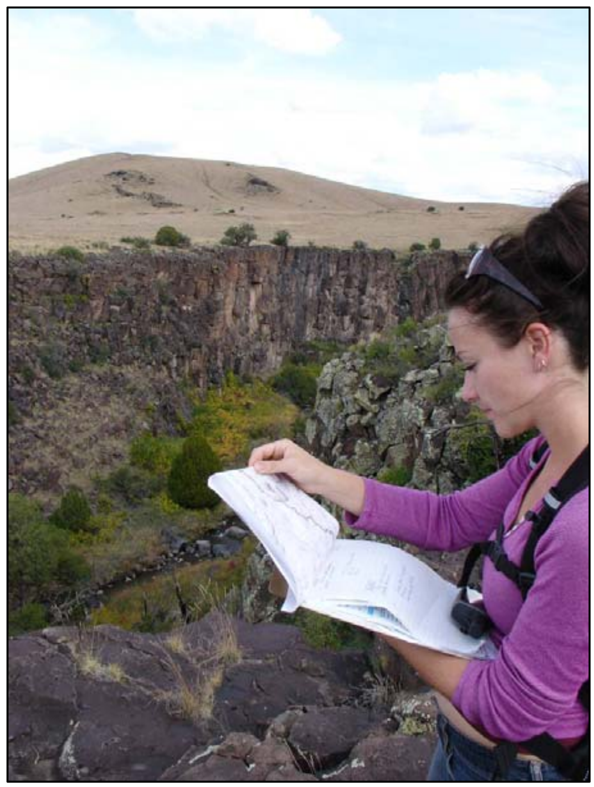


Figure 8. This site was wadeable and perennial, but inaccessible due to a steep canyon.

In order to use the probability-based monitoring plan, EPA generated a random sampling site list with specific coordinates using the R-statistical program. The coordinates were then plotted on ADEQ's perennial stream map. The map was modified in 2007 from the original version of an Arizona Game and Fish Department map from 1993. ADEQ updated the map with new "predicted perennial" reaches based on the USGS models, which used existing ADEQ flow records to predict the hydrological regime of unregulated streams in Arizona (USGS, 2008 in press). The map was also modified to exclude stream reaches that were on Native American land, lake shorelines, canals, or ditches.

Next, the random sites were further evaluated by GIS and field reconnaissance, and categorized as "target" or "non-target". GIS and reconnaissance validated the following criteria for the "target" sites:

1) Was the sample site wadeable and perennial?
2) Was the sample site accessible?
3) Was permission granted if the site was on private land?
4) Was sample site on Native American Land?

30 sites were randomly chosen to be sampled by both DEQ methods and EPA methods. Three reference and stressed sites were also used. The reference sites will be used to estimate precision while the stressed sites will be used to examine stressor gradients. Results from this comparison analysis will be included in a separate report.

For the LCR basin 237 sites were evaluated, of which only 41 sites were determined "target." Of the target sites, however, 11 could not be sampled due to landowner denial or the presence of a physical barrier (Figure 8). The remaining 30 sites were determined to be target sites for probabilistic stream monitoring, which represented approximately 268 km (167 miles) or 13% of the 2,121-km (1,320 miles.) total perennial stream length in the LCR basin (Figure 9 and Table 4). The 2007 site evaluation results were added as new attributes to the perennial stream map for future reference and to further improve the accuracy of selecting "target" monitoring sites. While the 82% non-target sites are discouraging, almost half were on Native American land and many were water body errors which were determined by desktop evaluation.

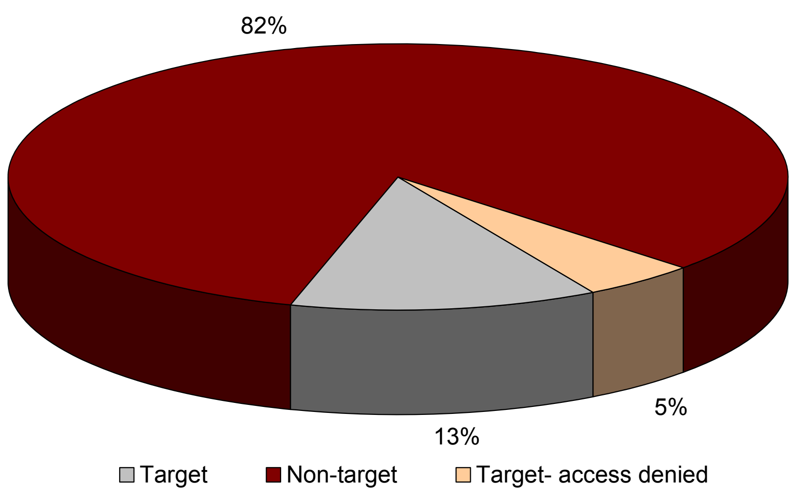


Figure 9. Reconnaissance success rate. Out of 237 sites 82% were non-target sites, 13% were target sites and 5% were target sites but access was denied.

TARGETED MONITORING DESIGN

A targeted monitoring design was used in conjunction with the probabilistic design. Targeted sites are selected to address data gaps for reaches identified on the 2004 §305(b) Planning List, to monitor Arizona's Outstanding Waters and to investigate complaints. Table 4 lists all the targeted sites in this study.

Data Gaps

Section 305(b) of the Clean Water Act requires ADEQ to conduct a water quality assessment of Arizona's surface waters every two years. Current EPA guidance states that each surface water assessed should be placed in one of five assessment categories that describes its level of attainment. The five categories are as follows:

1) Surface waters where all designated uses are attaining;
2) Surface waters that are attaining some designated uses but there is insufficient data to assess the remaining uses;
3) Surface waters with insufficient data to assess any designated use;
4) Surface waters that are not attaining one or more designated uses, but a Total Maximum Daily Load (TMDL) analysis is not required; and
5) Surface waters that are impaired for one or more designated uses and a TMDL is required.

Surface waters with insufficient data to determine whether a surface water is attaining designated uses or is impaired are identified in categories 2 and 3 on the assessment list. Surface waters in these categories are included on a planning list and targeted for water quality monitoring to fill existing data gaps. In some cases, data sets for some sample sites were incomplete and did not include all core parameters required for §305(b) water quality assessment. In other cases, there were an insufficient number of sampling events to make an assessment.

Outstanding Arizona Waters

Monitoring Unit staff collects surface water quality data to characterize existing water quality and to determine whether water quality is being maintained and protected in Arizona's outstanding waters (previously identified as unique waters). Currently, there are 22 Outstanding Arizona Waters listed in Arizona's Administrative Code R18-11-112. The primary purpose of monitoring outstanding waters is to collect surface water quality data to characterize baseline water quality. A long-term goal of this program is to acquire enough water quality data over time to determine water quality trends in Arizona's outstanding waters and to determine whether state antidegradation requirements are being met (i.e. water quality improving, maintained, or degrading). MU staff conducted quarterly monitoring at sites located on the outstanding waters.

Outstanding waters in the Little Colorado River Basin include only one stream, the West Fork of the Little Colorado, above Government Springs. Quarterly chemistry and annual invertebrate samples were collected here.

Biocriteria

Monitoring Unit staff conducts bioassessments and habitat assessments at biocriteria reference sites, basin sites, and outstanding water sites to develop Arizona's regional reference site network statewide and to monitor trends in reference conditions over time. Another purpose of the biocriteria monitoring effort is to test existing indices of biological integrity for warm and cold water streams over a range of impairment conditions and sources of stressors. A minimum of 10 biocriteria reference sites in each basin each water year are selected. Benthic macroinvertebrate samples are collected in wadeable, perennial streams with suitable riffle habitats during the spring index period (April, May, or June of 2007). Some of the random sites were also used as reference sites for the FY 07 macroinvertebrate collection.

SITE LOCATION

Table 4 summarizes where the sites were sampled and indicates which monitoring objective was addressed. Figure 3 shows the aerial location of all the LCR monitoring sites.

ADEQ gives each sample site a unique identification code. The first two letters correspond to the watershed code. For example, LCBEN002.57, LC corresponds to the Little Colorado Basin. Using certain rules, the next three letters are chosen to correspond to the stream name. Using our example LCBEN002.57, BEN represents Benton Creek. Lastly, the values at the end of the identification code relate to the river miles that pinpoint the sample site on the stream (measured in river miles from the mouth of the stream to the site location). The site ID LCBEN002.57 represents the specific sampling point 2.57 river miles from the mouth of Benton Creek located in the Little Colorado River watershed.

Table 4. Site list.

Site ID	Stream Name	Designated Uses	Latitude	Longitude	Type
LCBEN002.57	Benton Creek	A&Wc, FBC, FC	335907.38	1091727.51	RANDOM
LCBRB000.27	Barbershop Canyon	A&Wc, FBC,FC, AgL	343250.50	1110942.50	CHEMISTRY ONLY
LCBRB006.74	Barbershop Canyon	A&Wc, FBC,FC, AgL	342939.90	1110954.73	REFERENCE & RANDOM
LCCHC060.61	Chevelon Canyon	A&Wc, FBC,FC, AgI, AgL	343533.10	1104652.00	CHEMISTRY ONLY
LCCHC081.26	Chevelon Canyon	A&Wc, FBC,FC, AgI, AgL	342314.50	1105217.40	RANDOM
LCCLE000.69	Clear Creek	A&Wc, FBC, DWS, FC,AgI, AgL	345839.80	1103827.50	CHEMISTRY ONLY
LCCLE063.52	Clear Creek	A&Wc, FBC,DWS, FC,AgI, AgL	343841.00	1105957.00	RANDOM
LCCOY000.71	Coyote Creek	A&Wc, FBC,FC, AgI, AgL	341822.95	1092045.46	STRESSED & RANDOM
LCECL018.17	East Clear Creek	A&Wc, FBC,FC, AgI, AgL	343351.10	1110848.80	RANDOM
LCECL021.13	East Clear Creek	A&Wc, FBC,FC, AgI, AgL	343302.82	1110939.22	RANDOM
LCECL040.69	East Clear Creek	A&Wc, FBC,FC, AgI, AgL	342837.02	1111933.82	RANDOM
LCELR000.13	East Fork of the LCR	A&Wc, FBC,FC, AgL	340007.14	1092723.66	RANDOM
LCELR007.19	East Fork of the LCR	A&Wc, FBC,FC, AgL	335547.23	1092919.15	REFERENCE &RANDOM
LCHAL004.59	Hall Creek	A&Wc, FBC,FC, AgI, AgL	340140.00	1093022.00	RANDOM
LCHAL005.62	Hall Creek	A&Wc, FBC,FC, AgI, AgL	340054.72	1093041.56	RANDOM
LCHAL008.83	Hall Creek	A&Wc, FBC,FC, AgI, AgL	335821.00	1093117.20	CHEMISTRY ONLY
LCHAL010.20	Hall Creek	A&Wc, FBC,FC, AgI, AgL	335725.00	1093209.00	RANDOM
LCLCR211.73	Little Colorado River @ Holbrook	A&Wc, FBC,FC, AgI, AgL	345348.50	1101050.20	STRESSED & RANDOM
LCLCR216.67	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	345309.30	1100634.10	CHEMISTRY ONLY
LCLCR226.31	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	344656.50	1100235.50	CHEMISTRY ONLY
LCLCR311.31	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	342533.63	1092408.16	RANDOM
LCLCR340.02	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	340906.20	1091738.00	STRESSED

Site ID	Stream Name	Designated Uses	Latitude	Longitude	Type
LCLCR342.03	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	340740.35	1091754.67	RANDOM
LCLCR360.06	Little Colorado River	A&Wc, FBC,FC, AgI, AgL	340028.90	1092713.66	RANDOM
LCLVL001.32	Lee Valley Creek	A&Wc, FBC, FC, AgL	335622.00	1093029.00	CHEMISTRY ONLY
LCMIN018.05	Mineral Creek	A&Wc, FBC,FC, AgI, AgL	341047.72	1093705.56	RANDOM
LCMLK001.18	Milk Creek	A&Wc, FBC, FC, AgL	335706.57	1091023.46	RANDOM
LCMRS043.17	Morrison Creek	A&Wc, FBC, FC, AgI, AgL	335812.48	1090318.02	RANDOM
LCNUT012.99	Nutrioso Creek	A&Wc, FBC,FC, AgI, AgL	340347.80	1091152.80	CHEMISTRY ONLY
LCRDF015.45	Rio De Flag	AWEDW, PBC	351104.00	1113756.00	CHEMISTRY ONLY
LCRIG004.87	Riggs Creek	A&Wc, FBC, FC	335833.53	1091449.57	RANDOM
LCRUD003.45	Rudd Creek	A&Wc, FBC,FC, AgL	340200.07	1091346.49	RANDOM
LCRUD007.23	Rudd Creek	A&Wc, FBC,FC, AgL	340039.50	1091651.50	RANDOM
LCSHL026.50	Show Low Creek	A&Wc, FBC,FC, AgI, AgL	341230.00	1100002.00	RANDOM
LCSHL029.75	Show Low Creek	A&Wc, FBC,FC, AgI, AgL	341046.00	1095916.00	RANDOM
LCSHL031.05	Show Low Creek	A&Wc, FBC,FC, AgI, AgL	341017.96	1095857.51	RANDOM
LCSIL006.13	Silver Creek	A&Wc, FBC,FC, AgI, AgL	344013.60	1100237.97	CHEMISTRY ONLY
LCSIL013.53	Silver Creek	A&Wc, FBC,FC, AgI, AgL	343536.20	1100452.90	CHEMISTRY ONLY
LCSIL024.83	Silver Creek	A&Wc, FBC,FC, AgI, AgL	342854.40	1100436.75	CHEMISTRY ONLY
LCSIL041.04	Silver Creek	A&Wc, FBC,FC, AgI, AgL	342039.30	1095836.19	RANDOM
LCSIL043.84	Silver Creek	A&Wc, FBC,FC, AgI, AgL	342009.14	342009.14	RANDOM
LCSLR001.42	South Fork Little Colorado River	A&Wc, FBC,FC, AgL	340414.53	1092434.63	REFERENCE & RANDOM
LCSLR003.72	South Fork Little Colorado River	A&Wc, FBC,FC, AgL	340256.00	1092323.00	RANDOM
LCWLR000.92	West Fork Little Colorado River	A&Wc, FBC,FC, AgL	335937.30	1092752.20	OUTSTANDING WATER

A&Wc = Aquatic and wildlife cold
AWEDW= Aquatic and wildlife (effluent dependant water)
FBC = Full body contact
FC = Fish consumption
AgI = Agriculture irrigation
AgL = Agriculture livestock

SAMPLE METHODS

The ADEQ A Manual of Procedures for the Sampling of Surface Waters (Lawson, 2005) describes the sample collection methods used for water chemistry, macroinvertebrate and habitat data.

CHAPTER 3 – SUMMARY OF DATA / ANALYSIS

QUARTERLY COMPARISONS

ADEQ collects quarterly water quality samples to account for seasonal variation and to obtain enough data for the 305(b) assessment report. Due to staffing shortages the first quarter was not sampled, however assessments can still be conducted with three quarters of data. See Appendix A for a detailed list of all quarterly data.

In general, parameters for most sites did not vary much by quarter. However, temperature, discharge, and *E. coli* all vary considerably between quarters. The following sites did show variation among certain parameters. Irrigation usage and precipitation could play a major role in the variation at these seven sites.

- **LCCLE000.69** Clear Creek below the Clear Creek Reservoir. Sodium concentrations were 10 times higher on November, 16, 2006 than May 1, 2007 at a concentration of 390 mg/L versus 32 mg/L respectively. Sodium and to a lesser extent calcium concentrations also inflated hardness values by almost three times (230.0 mg/L versus 83.0 mg/L). Discharge in November was only 0.090 cfs while in May it was 3.1 cfs.

- **LCLCR211.73** Little Colorado River at Holbrook. Hardness, cations, anions and conductivity all increased while discharge and dissolved oxygen decreased from November 2006 to May 2007. Dissolved oxygen (DO) decreased from 9.25 mg/L on November 28, 2006 to 5.44 on April 24, 2007.

- **LCLCR340.02** Little Colorado River below Springerville Waste Water Treatment Plant. Hardness, cations and anions, and conductivity decreased from November to May 2007. Discharged varied over the three quarters. The second quarter (October to December) had a discharge of 2.6 cfs and the third and fourth quarters had discharges of 15.0 and 2.5 cfs, respectively.

- **LCLCR342.03** Little Colorado River above Airport Road. Discharge and conductivity show the opposite response for this site compared to the LCLCR211.73 and LCCLE000.69. Hardness decreased in the Little Colorado River (LCLCR342.03) from 160 mg/l $CaCO_3$ in November to 130 mg/l in March to 64 mg/l in April. This decrease corresponded with an increase in discharge (2.8 cfs in November, 4.0 cfs in March, and 15 cfs in April).

- **LCMRS043.17** Morrison Creek 0.8 Miles below Confluence with Coyote Creek. Hardness, total dissolved solids, and conductivity were all roughly twice as high on November 14, 2006 and May 23, 2007 compared to March 28, 2007. The May sampling event had the highest concentrations of cations and anions and the lowest concentration of dissolved oxygen.

- **LCNUT012.99** Nutrioso Creek Downstream From Old USGS Gaging Station. Nutrioso Creek had the largest pH change of any of the 44 sites over the three quarters (Table 5). The fall quarter pH value was 7.71 indicating a neutral pH. However, the winter quarter pH value dropped to 5.71, which could have been from an increase in precipitation (rain and snow) during the winter quarter. The spring quarter had an exceptionally high pH value of 9.3. This could be due to the release of water from the upstream reservoir (Figure 10).

Table 5. pH for Nutrioso Creek.

Quarter	Season	pH value
2	Fall	7.71
3	Winter	5.71
4	Spring	9.3

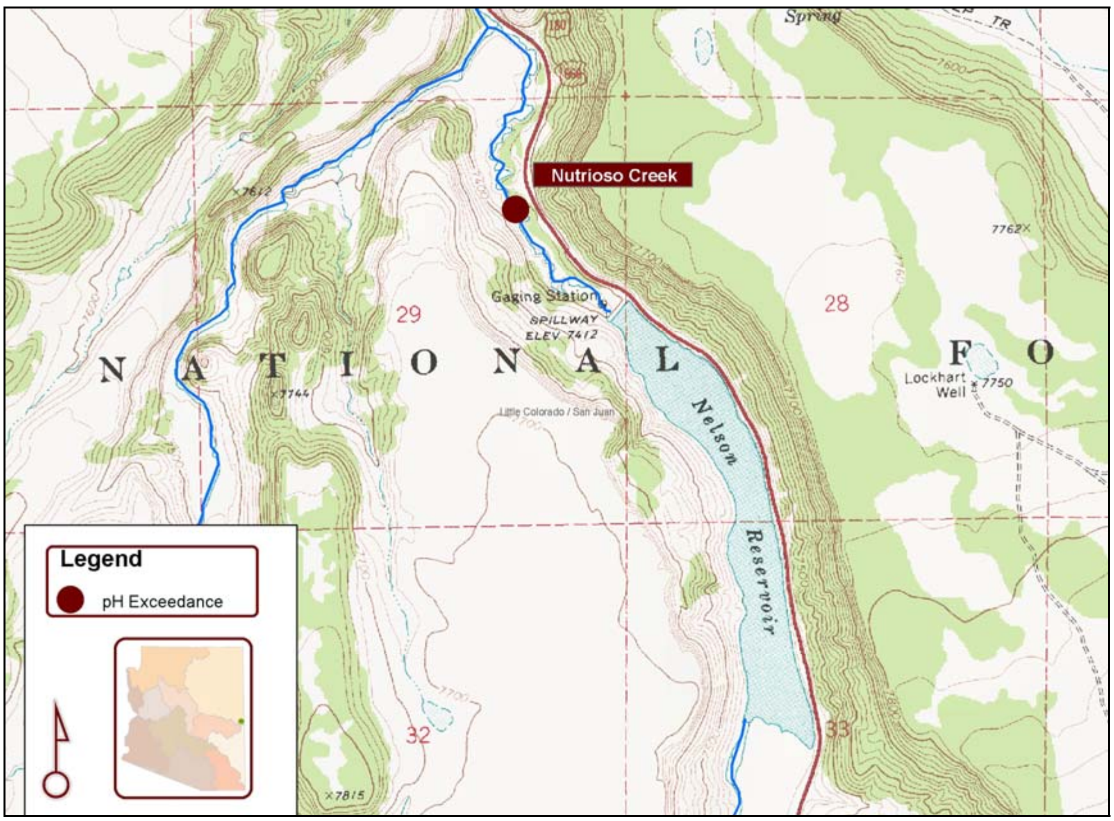


Figure 10. Monitoring Site on Nutrioso Creek.

- **LCSIL024.83** Silver Creek at Flake Property. Hardness, total dissolved solids, and conductivity were all roughly twice as high on November 15, 2006 compared to March 6, 2007 and April 23, 2007. The April sampling event had the highest concentrations of cations and anions and the lowest concentration of dissolved oxygen. E. coli also was highest on April 23, 2007 at 156 cfu compared to 21 cfu on November 15, 2006.

Figure 11 shows the coefficients of variance (CV) for each quarter by using all data points available. As expected, E. coli showed a high amount of variability. E. coli results vary due to constantly changing parameters including grazing, runoff and temperature among other factors. Discharge also shows a high variability because all types of streams (small and large) were included in the data set. In contrast, DO showed a low amount of variability because this parameter is fairly constant regardless of stream type or size. Hardness, TKN, and SSC showed a large amount of variation; however this was considerably less than the variation seen in E. coli and discharge.

Because data is available for only one sampling year, quarterly comparisons could not be done on a site by site basis. Future reports will consider historical data to make quarterly comparisons of parameters at each sampling location.

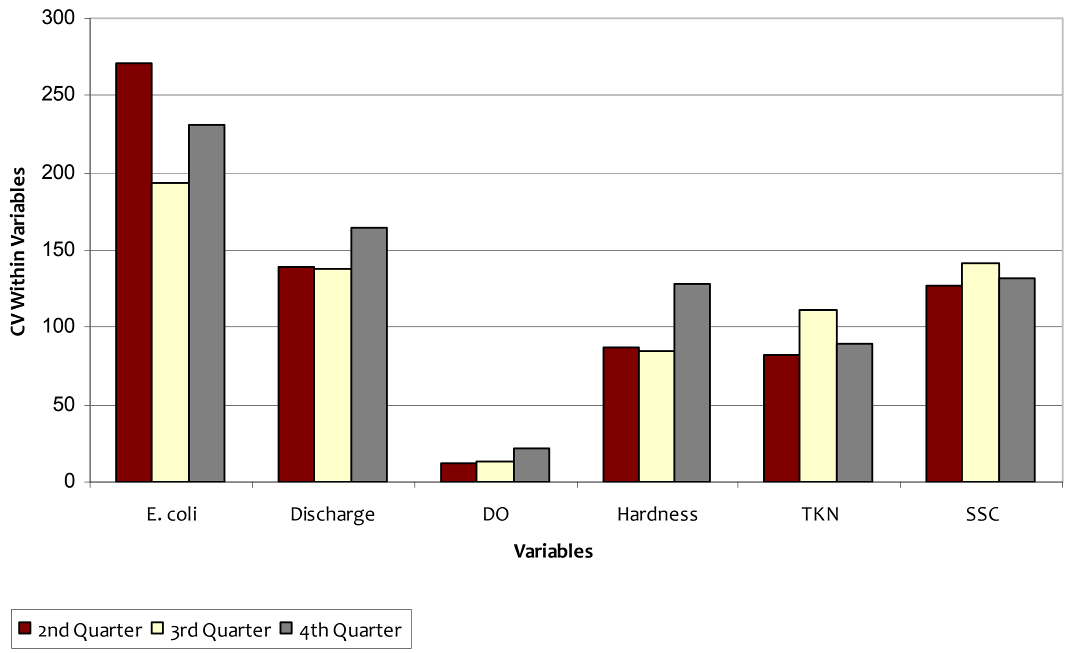


Figure 11. Coefficient of Variance (CV) (100(σ/ |μ|)%) Among Sample Groups.

REGIONAL VARIATIONS IN WATER QUALITY PARAMETERS (SITE BY SITE COMPARISONS)

Parameters can vary greatly by location. Figure 12 indicates how parameters, such as discharge, vary from one site to another. This figure is not intended to provide pinpoint measurements for each site. It is meant to summarize the range and aerial distribution of a particular parameter. Use Appendix A for specific results. Each site represents an average of all three quarters. Averaging the data allows the comparison of many sites and parameters at the same time. It should be noted, however that seasonal fluctuations are lost by averaging the data.

Ranges for each parameter (i.e. the size of each circle and the corresponding range) were chosen based on the distribution of the results and preexisting criteria such as water quality standards. Each parameter is discussed briefly below.

Discharge. The Little Colorado River had the highest discharges in the LCR watershed. Silver Creek also had relatively high discharge (7-9 cfs). The majority of the streams were low order streams with discharges between 0 and 2 cfs.

Dissolved Oxygen (DO). Mineral Creek (LCMIN018.05) had the lowest average DO for all sites (6.24 mg/L). All of the Hall Creek sites had relatively high DO concentrations in the 10 to 12 mg/L range.

Specific Conductivity (SpCond). Conductivity was high in the lower reaches of the Little Colorado River at LCLCR311.31, LCLCR216.67 and LCLCR211.73 (661 - 2974 uS/cm). LCLCR226.31 had slightly lower concentrations (388 - 660 uS/cm). The lowest conductivity values were located at Hall Creek and at the headwaters of the LCR at LCLCR360.06.

pH. Most sites had a pH averaging at 8 Standard Units (SU). Silver Creek (LCSIL043.84) and Show Low Creek (LCSHL026.50 and LCSHL029.75) had pH's around 9 SU. The lowest pHs were located at LCR340.02 and HAL010.20 with pH's around 7 SU.

Habitat Score. Habitat scores provide a qualitative way to assess riffle habitat quality, riffle extent, riffle embeddedness, sediment deposition and bank stability. It is used in conjunction with macroinvertebrate sampling to describe the riffle habitat condition in which the macroinvertebrates were sampled. A score of 0-7 indicates the habitat is very distressed; 8-14 means distressed, and above 15 is good condition. LCLCR211.73, LCR311.31, and NUT012.99 all had very poor habitat scores. The majority of the sites had scores in the "good" range.

E. Coli. Average *E. coli* was the highest at Rudd Creek LCRUD007.23. This site was only visited once and had a colony count of 223 cfu. The remainder of the sites had averages below 91 cfu.

Percent Fines. Percent fines is the amount of sediment < 2 mm in size on the streambed. For cold water streams percent fines is measured within riffle habitats by measuring a minimum of 100 particles. A result above 30 percent fines is considered to be detrimental to aquatic life in cold water streams. Four sites (LCR211.73, MRS043.17, RIG004.87, and LVL001.32 all had percent fines above 32 percent and have poor substrate quality. On the other hand, five sites (BRB000.27, BRB006.74, CHC081.26, HAL005.59, and LCR 360.06) had percent fines at or below 1 percent with good substrate quality.

IBI. Seven metrics were used to calculate a macroinvertebrate index of biological integrity (IBI) for cold water streams: total taxa, Diptera taxa, intolerant taxa, Hilsenhoff Biotic Index, percent Plecoptera, percent scrapers, and scraper taxa. A score below 46 is considered to have a very poor macroinvertebrate community. The majority of the sites had poor macroinvertebrate communities. The best bug communities were found at the East, West and South Forks of the Little Colorado River, Hall Creek (LCHAL010.20), Mineral Creek (LCMIN018.05), Rudd Creek (LCRUD007.23), Benton Creek (LCBEN002.57), Barbershop Canyon (LCBRB006.74), the headwaters of the LCR (LCLCR360.06), and Lee Valley Creek (LCLVL001.32). All of these sites had IBI scores above 52.

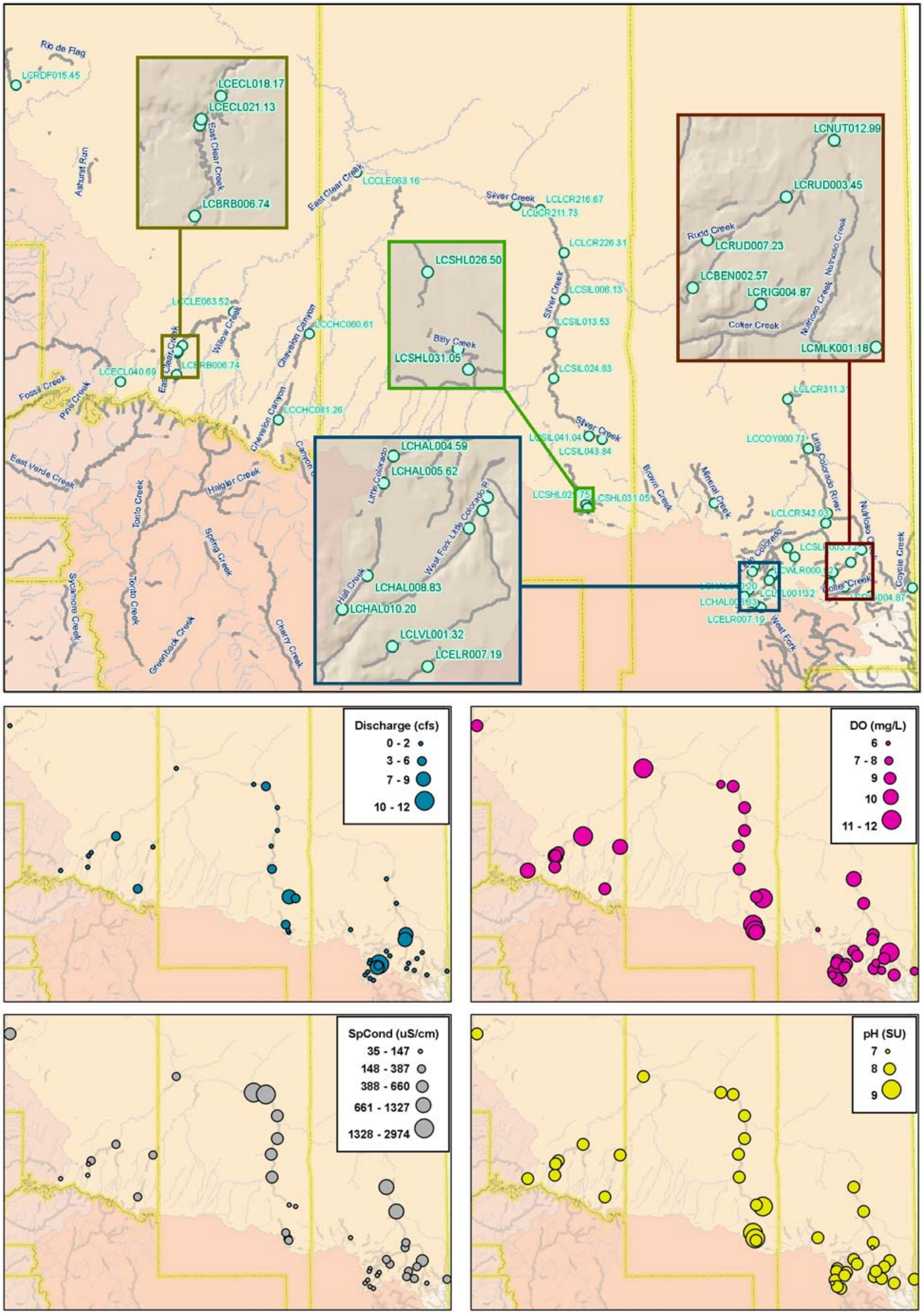


Figure 12. Top image shows sample location and site id's for all LCR sample sites. Use the top image to locate a particular site. Use the bottom images to view range and distribution of each parameter.

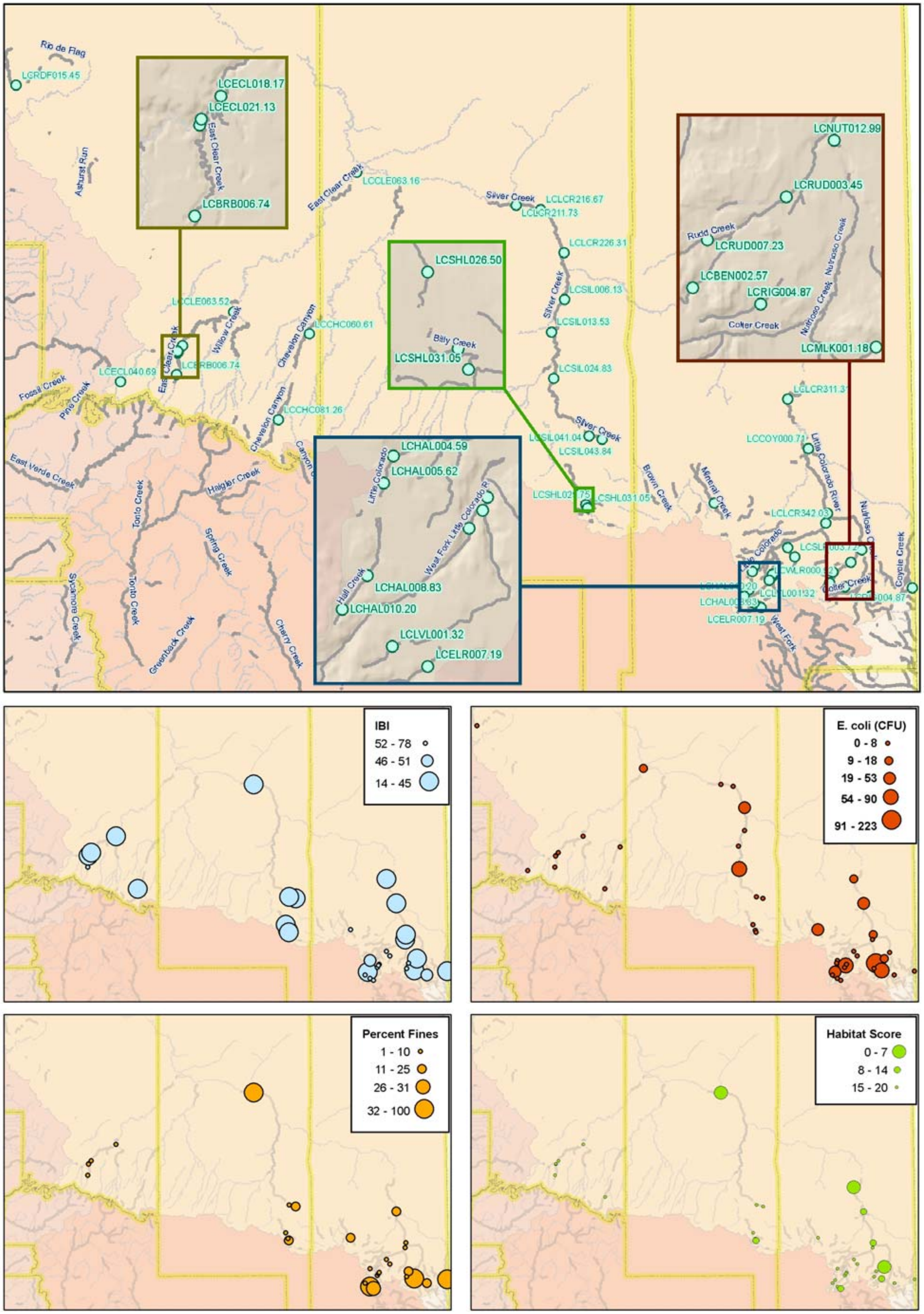


Figure 12 (Continued). Top image shows sample location and site id's for all LCR sample sites. Use the top image to locate a particular site. Use the bottom images to view range and distribution of each parameter.

GEOMORPHOLOGY RESULTS REGARDING STREAM STABILITY

Relevance of Sedimentation to Water Quality and Stream Stability

Arizona's 2008 Non-Point Source Annual Report lists sediments, metals and nutrients as the most common sources of pollution for Arizona streams. Non-point sources (such as grazing and agriculture) are the primary cause of stream impairment by these three pollutants. Arizona streams are especially vulnerable to sedimentation due to climatic conditions, recent forest fires, as well as past and current unsuitable land management practices which reduced vegetative cover. When sediment supply and sediment storage capacity are not in balance with the transport capacity the channel becomes morphologically unstable. Morphologically unstable streams affect the physical, biological and chemical integrity of the system.

Consequences of unstable streams include abnormal flooding of agricultural and urban lands, the alteration of channel structure, incision of the streambed, the lowering of the groundwater table, and in severe situations the alteration of base and peak stream flows (which may transform a system from perennial to intermittent or ephemeral). Morphological alterations to the aquatic habitat affect the entire spectrum of the aquatic biota and the riparian ecosystem. The morphological and biological alterations produce adjustments in water chemistry. Excessive sediment from unstable streams can fill irrigation ditches, clog drainage pipes, decrease reservoir storage capacity, impair navigation, and contribute to recreational-use and aesthetic impairment.

Stream Type

The stream type was determined by ADEQ field personnel using Rosgens classification of natural rivers. For example stream type **B4a** can be broken down to mean the following. Capitalized letters, as in **B,** refer to the stream type (see Table 3). In this case stream type B is a riffle dominated channel on a moderate gradient in a narrow valley. The numerical value refers to the channel substrate. The number **4** indicates a substrate consisting of gravel (1 = bedrock, 2 = boulders, 3 = cobble, 4 = gravel, 5 = sand, 6 = silt/clay). Lower case letters (**a**) refer to the slope of the stream. A stream type of **B4a** would have a slope between .04 and .099. See Rosgens classification of Natural rivers for other stream types description (Rosgen, 1996).

Measuring Stream Stability

Ten Little Colorado River Basin sample sites were investigated for channel stability. Three measures were used for the assessment: relative bed stability, slope analysis and an incision ratio (Table 6).

Relative Bed Stability

Relative Bed Stability (RBS) is an index of substrate mobility with respect to the physical characteristics of the waterbody. Substrates are expected to move a calculable degree for each natural hydrologic and geomorphic condition. Human influences are likely when the observed substrate mobility is considerably different than the predicted mobility. Stream stability can be evaluated by comparing the actual particle sizes observed from a streambed pebble count with the sizes of particles that can be mobilized at bankfull.

RBS is calculated by:
RBS = D50 / τc

D50 - observed median particle size from surface streambed pebble count, feet
τc - critical shear stress = 62.4 Rbf Sw

Where:
62.4 = specific weight of water, lbs/ft3
Rbf = hydraulic radius at bankfull = cross-sectional area/wetted perimeter, ft
Sw = water surface slope, ft/ft

τc is proportional to the estimated shear stress (τ) at bankfull flow. τ is the competency of the stream to move a particular size particle while τc is a measure of the force required to mobilize and transport a given size particle resting on the channel bed. Stream competency can then be considered as the ability of a bankfull flow to move the largest particle on the streambed.

The range of RBS values are from zero to infinity. Streams with RBS values < 1 indicate that the bed is unstable because the bed particles are mobilized at less than sub-bankfull flows. These channels have a high sediment supply and aggrade. With few exceptions, the occurrence of extremely unstable beds i.e., those with RBS much < 1.0 (e.g., 0.0001 – 0.01) do not occur, unless there is a large amount of anthropogenic disturbance causing considerable fine sediment input to the stream. If RBS is greater than 1.0, the bed is presumed to be fully mobilized only for events larger than bankfull and the channel is stable. Reference sites generally have RBS values approximately equal to 1.0. RBS values greater than 2 indicate a high transport capacity and incision may be occurring if it has not already done so. RBS values >3 are high energy streams (steep gradient) with limited sediment supply which usually indicate that the channel and banks are greatly armored.

Slope analysis

A slope analysis of the study reach can indicate the aggradation/degradation potential of the channel condition. It is a comparison of the measured gradient with a predicted gradient, which is hydrologically the most efficient slope to move sediment at bankfull discharge.

The predicted slope is calculated by:

$S^* = (\tau c \times Vs \times Di)/Dbkf$

where: S* = predicted slope, ft/ft
Tc = critical dimensionless shear stress
Vs = 1.65, the ratio of weight of sediment to weight of water
Di = largest particle from bar or sub-pavement, ft
Dbkf = bankfull mean depth, ft

If the measured slope is greater than the predicted slope it may indicate a sediment deficit (a condition often found on regulated streams), channel degradation, a decrease in sinuosity (e.g. a cutoff shoot, channel straightening), or a recent increase in discharge (e.g. watershed disturbance). Conversely, if the measured slope is less than the predicted slope it may indicate either a sediment surplus (e.g. channel widening, watershed disturbance) or a recent decrease in discharge (e.g. water diversion or extended drought). Where the measured slope and the predicted slope are nearly equal, it indicates that the sediment supply and the transport capacity are approximately in balance. Slope analysis in the form of a ratio of the measured slope to the predicted slope provides three classification ratios:

- ~1.0 = In equilibrium
- <1.0 = potential to degrade
- >1.0 = potential to aggrade

Incision Ratios:
Incision ratios (IR) can indicate streambed degradation and are sensitive to recent bed incision. The IR is the ratio of the vertical height of the floodplain or the recently abandoned floodplain to the bankfull maximum depth (Kline, et al 2007). IRs greater than one may indicate recent downcutting; higher ratios indicate a more severe bed degradation process.

Table 6. Hydrologic Stability Evaluation of ten Little Colorado River Basin study reaches.
Purple shading = controlled flows; blue shading = high alpine meadow stream; white shading = narrow mountain stream; tan = wide valley stream.

Stream Name	ADEQ ID	Stream Type	RBS Score/ Stability	RBS transport/ Sediment Dynamics Evaluation	RBS Slope Ratio/ Potential	RBS Incision Ratio/ Status	RBS Reach Characterization	Stability Evaluation	Description
Benton Creek	LCBEN002.57	B4a	1.3 Stable	In equilibrium	0.4 Degrade	4.0 Greatly Incised	Geologically confined, bed 5% fines & gravel-cobble dominated, few pools, riffle dominated, shallow, some high steep eroding banks but most banks well armored, no BKF indicators, low base flow	Stable stream	Moderately entrenched with potential to degrade. Narrow canyon
Coyote Creek	LCCOY000.71	B5c	0.1 Unstable	High sediment supply greater than the transport capacity, potential to aggrade	17.5 Aggrade	2.7 Moderately Incised	Upper 2/3rd reach incising, narrow & deep pool, steep eroded banks, island bar, no riparian, no BKF indicators, low baseflow. Lower 1/3rd aggrading, wide shallow, no riparian, side bars	Unstable stream	Recent incision in upper reach, but slope ratio indicates potential to aggrade. Broad valley
Hall Creek	LCHAL004.59	B3a	0.9 Stable	Transport capacity & sediment supply near equilibrium	1.0 Equilibrium	1.0 Minimally Incised	Geologically confined, abundant cover, variety of habitat, eroding banks absent, stable banks, bed 34% fines & cobble dominated, 1 small mid-channel bar at base, good riparian, riffle-pool system, BKF indicators	Stable stream	Minimally incised. "V" shaped canyon
Little Colorado River	LCLCR342.03	C4	1.2 Stable	In equilibrium	0.4 Degrade	2.0 Moderately Incised	Upstream diversions, a pasture stream, some high steep & eroding banks on outcurves, lower banks stable, minimal riparian, riffles, deep pools, runs present, riffles embedded, moderate habitat variety, 1 small mid-channel bar, headcuts absent, BKF indicators, bed 25% fines & gravel dominated	Stable stream	Moderately incised with potential to degrade. Broad valley
Little Colorado River	LCLCR360.06	B4c	4.1 Stable	High energy, limited sediment supply, armored	0.2 Degrade	1.0 Minimally Incised	Meadow stream, upstream reservoirs, consistent flow, some bank slumping but majority stable and protected, no headcuts, wide & shallow, good habitat, mix of riffles (not embedded) , pools & runs, portions of good cover & riparian present, bed 9% fines & coarse gravel dominant, BKF indicators	Stable stream	Small potential to degrade, normally incised, small valley

Stream Name	ADEQ ID	Stream Type	RBS Score/ Stability	RBS transport/ Sediment Dynamics Evaluation	RBS Slope Ratio/ Potential	RBS Incision Ratio/ Status	RBS Reach Characterization	Stability Evaluation	Description
Rudd Creek	LCRUD003.45	C6	0.001 Extremely Unstable	Fine sediment supply	263 Aggrade	1.4 Minimally Incised	Meadow stream, formally pasture, fine alluvial fill, some headcuts, incision mid- & lower, upper some aggradation & widening, bed 96% fines & silt dominated, no bars, no riffles, mostly pools (deep) & some runs, banks – some undercutting & erosion at outcurves but mostly stable, fair to poor habitat, no riparian, shading is from banks	Transitional stream	Unstable stream due to fine sediment supply, but slope ratio implies aggradation, appears that the stream is in a transitional stage. Small valley
Show Low Creek	LCSHL026.96	C4	1.8 Stable	In equilibrium	0.3 Degrade	1.4 Minimally Incised	Upstream reservoir controlling flow, upper ¼ reach riffle & run, remainder 1 long deep pool, banks stable, bed 14% fines & gravel-cobble dominated	Stable stream	Stable channel with well armored banks, but the slope ratio of the lower reach indicates potential degradation
Show Low Creek	LCSHL031.05	B4c	3.3 Stable	High energy, limited sediment supply, armored	0.1 Degrade	1.2 Minimally Incised	Downstream of Rainbow Lake, a controlled flow, meadow stream with fine alluvial fill, unstable sloughing & undercut banks, side and mid-channel bars, reach mostly wide and shallow, fine gravel dominated bed	Stable Stream	Upper quarter or reach incised and slope ratio indicated potential for degradation
Silver Creek	LCSIL041.04	B3c	2.4 Stable	High transport capacity, incised	0.2 Degrade	1.0 Minimally Incised	Spring fed constant flow, banks stable & well vegetated, riffle-run-pool system, abundant habitat, riffles not embedded, some deep pools, no bars or excessive sediment present	Stable stream	Normal incision, but steep could degrade the streambed in future
South Fork of Little Colorado River	LCSLR001.42	B3	0.5 Unstable	High sediment supply greater than the transport capacity, potential to aggrade	1.0 Equilibrium	3.8 Greatly Incised	Deeply entrenched & geologically confined, no bars, no excessive sediment but riffles 50-75% embedded, stable banks, excellent habitat, riffle-run-step pool system, pools shallow, large gravel-cobble dominated	Stable stream	Historic entrenchment observed, slope ratio indicates stability, but RBS value indicates moderate unstability. “U” shaped canyon

PARAMETER COMPARISON

Relative Bed Stability and Arizona Index of Biological Integrity

Paired macroinvertebrate sets were collected from sample sites using two collection methods. One set used EMAP methods and the other set used ADEQ methods. Figure 13 reveals similar scores among methods; however, all EMAP IBI scores at Group A sites were higher than ADEQ IBI scores.

ADEQ will publish a separate report that covers the comparison between ADEQ and EMAP results in more detail.

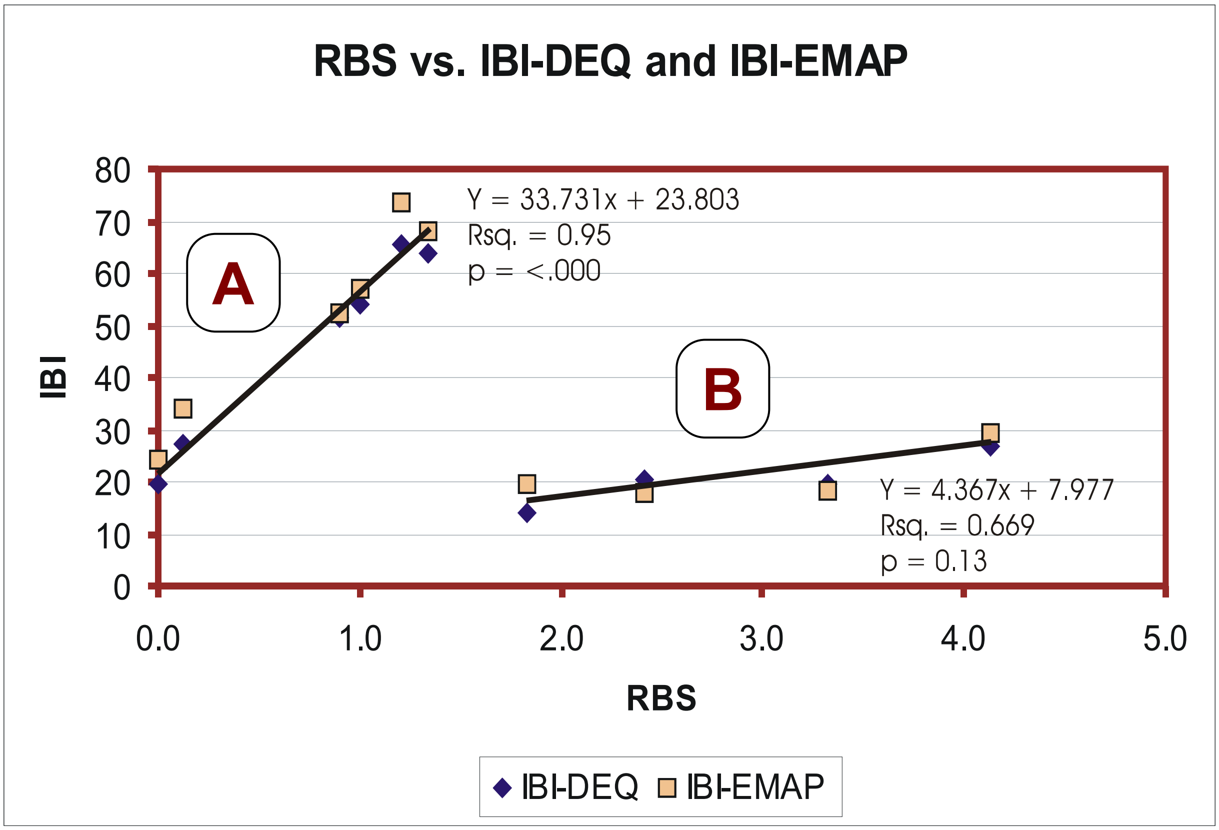


Figure 13. Comparison of RBS and IBI Scores.

Data from ten sample sites indicate two distinct groupings when Relative Bed Stability (RBS) and Arizona Index of Biological Integrity (IBI) data are plotted. Group A sites share similar physical characteristics which are dissimilar from Group B sites.

Group A sites typically have narrow and deep channels with high gradients, higher percent canopy cover, an average shear stress twice that of Group B sites, a considerably higher sediment transport rate, higher stream power and discharge at bankfull, and somewhat lower Pfankuch scores. Group B sites have a predicted gradient greater than the actual gradient required to move the largest particle on the bar or sub-pavement, indicating that Group B sites are storing sediment within the stream channel. The most distinguishing characteristic of Group B sites is their relatively constant discharge throughout the year. This consistency in flow and low gradients are reflected in their bed stability. Although these sites are more stable, their IBI scores are significantly lower than the higher gradient sites found within Group A. This may indicate either of two possibilities: 1) channel habitat in Group B sites is less diverse than in Group A sites or 2) predator/prey relationships (i.e. crayfish/macroinvertebrates) are more severe at Group B sites. The four sites in Group B and the site with the lowest RBS and IBI score in Group A had elevated populations of crayfish.

Table 7. Site names and site codes for Groups A and B.

Group A Sites		Group B Sites	
Site Name	**Site Code**	**Site Name**	**Site Code**
Benton Creek near Pat Knoll Cabin	LCBEN002.57	Little Colorado R. above Airport Rd.	LCLCR342.03
Coyote Cr. at Richville Valley	LCCOY000.71	Show Low Cr. above Morgan Wash	LCSHL026.50
Hall Cr. east of Geneva Reservoir	LCHAL004.59	Show Low Cr. below Porter Cr. and Billy Cr. confluence	LCSHL031.05
Little Colorado R. ¼ mile east of Greer Post Office	LCLCR360.06	Silver Cr. at end of Queen Cr. Place	LCSIL044.04
Rudd Cr. at Sipe Wildlife Area	LCRUD003.45		
So. Fk. Little Colorado R. above South Fork Campground	LCSLR001.42		

Multivariate Stressor Analysis

58 percent (19 of the 33 macroinvertebrate samples) had poor IBI scores (below 46), which indicates that the macroinvertebrate communities at these sites were suboptimal. A discriminate function analysis (DFA) was performed to determine the relative importance of all environmental stressors on the macroinvertebrate IBI score. There were 26 initial environmental stressor variables. The number of stressor variables was reduced through an autocorrelation test and by removing categorical variables. Pearson correlation coefficients were computed among all variables to look for autocorrelations and the data set was reduced by 11 parameters to reduce the number of redundant parameters.

Four categorical variables (eg. macrophyte and filamentous algae cover, diatom cover, and flow status) were also removed from this analysis. Since crayfish are known to be a biological stressor in the Little Colorado River basin, a categorical variable was developed to combine EMAP and ADEQ observations on crayfish abundance. EMAP methods made a quantitative count of crayfish abundance and ADEQ methods made qualitative estimates of abundance. These abundances were combined as follows: category 1 = EMAP count of 0 or ADEQ category absent; category 2 = EMAP count of

<100 or ADEQ category rare, category 3 = EMAP count of >100 count or ADEQ category common. The resulting 13 chemical, physical/habitat, and biological parameters were selected for this analysis to evaluate influence on bioassessment (ranges of IBI scores) standard attainment categories. The 13 environmental stressor variables included:

- Crayfish abundance category
- Reachwide % fines (ADEQ method)
- Canopy percent cover
- Pool, percent of reach
- Riffle, percent of reach
- Habitat index score
- Total nitrogen concentration
- Total phosphorus concentration
- Lab specific conductance
- Field pH
- Dissolved oxygen, percent
- Temperature water
- Hardness concentration

The three IBI categories were:

- Passing or attaining the reference IBI score of 52 for coldwater streams
- Inconclusive, with IBI score 46-51
- Failing or not meeting the minimum IBI score of 45 for coldwater streams

The DFA used a backward stepwise selection method to remove variables of least importance and ultimately selected 5 parameters to include in the model for the first discriminate function (in order of importance): crayfish abundance, reach percent fines, total phosphorus, percent canopy cover, and total nitrogen. This model accounted for 86% of the dispersion among the parameters in multivariate space ($p<0.01$).

Figure 14 plots the first and second canonical discriminate functions according to the canonical scores for each site/sample. The scatter plot displays the significant difference among the three IBI category groups (passing, inconclusive, failing) in the spread of scores across the first discriminate function on the x-axis; there is less significant spread along the second discriminate function on the y-axis. The clusters of points are well separated indicating an accurate discriminate function model.

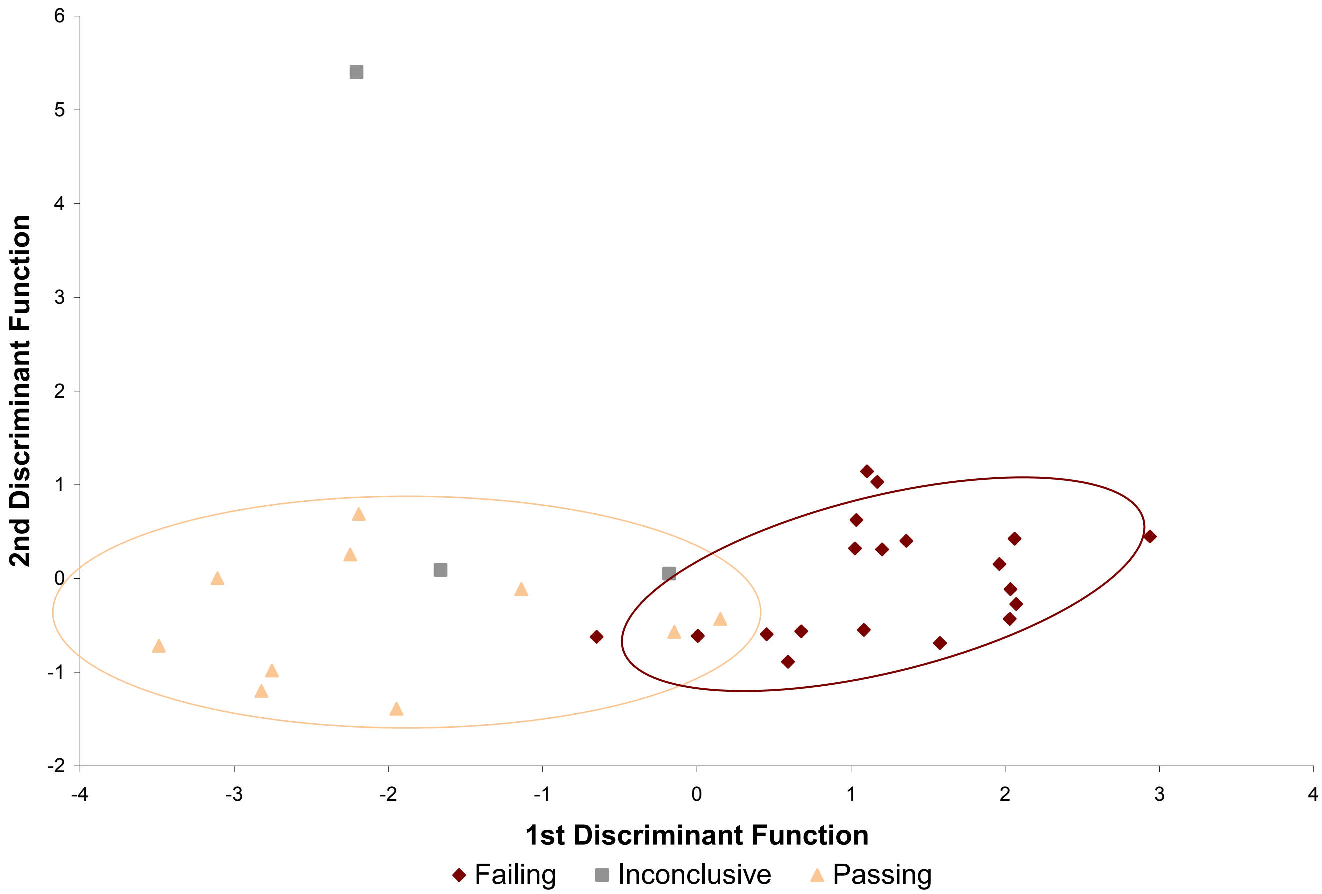


Figure 14. Distribution of IBI scores in assessment categories using discriminate function analysis for 30 macroinvertebrate samples collected in the Little Colorado River basin in 2007

Several statistics provide a significance test for this model: the jackknife procedure, rerunning the model with different parameter sets, the F-statistic and the Wilks' lambda statistic. The jackknifed procedure indicates the accuracy of the model by removing samples one at a time and rerunning the model. The jackknifed procedure obtained a percent correct classification of samples of 79% compared with 85% in the original classification matrix. This method cross-validates the model, since the percent correct classification is similar between the two classification methods. Several DFA models were run with different parameter sets to develop the best model to describe the environmental variables responsible for the IBI scores. Crayfish abundance and reach percent fines were the top 2 parameters in two other models as well (6 variables and 26 variables), providing further verification that these stressors are influencing IBI scores. The F-statistic is a significance test which compares between-group variance to within-group variances and showed a significant difference between IBI groups ($F=6.2$, $p<0.01$). Wilks' lambda is another significance test which indicates the proportion of generalized variance in the dependent variables accounted for by the predictor variables. This multivariate significance test also indicated that the discriminate model was accurate with a significance value of 0.2.

By placing all relevant, non-redundant stressor variables into a DFA multivariate analysis, we can examine the relative importance of all stressors on the IBI scoring categories and by inference on the macroinvertebrate community. Approximately 67% of macroinvertebrate samples from the Little Colorado River basin, collected during spring of 2007 violated the proposed new biocriteria standard for coldwater streams (IBI≤45). This analysis evaluated several potential chemical, physical and biological stressors on the macroinvertebrate community and discovered that crayfish abundance and streambed sediment (percent fines, reach-wide) were most responsible for separation of samples into reference and stressed groups of samples. IBI scores and macroinvertebrate community health were greatest when crayfish and bottom deposits of sediment were low in abundance in the Little Colorado River basin.

CHAPTER 4 – EXCEEDANCES

Out of the 44 sites that were sampled, six sites showed a water quality standard exceedance at the time of sampling. Dissolved oxygen exceeded standards at four sites during the summer sampling period. One site had an exceedance of pH during the spring and summer sampling periods. And one site had an exceedance of E. coli. Out of the 33 sites that had macroinvertebrate samples, 19 exceeded the Arizona Index of Biological Integrity score (see Appendix A). Out of the 30 sites that had bottom deposits analyzed, four sites were in exceedance of more than 30% fines in the stream.

Table 8. Exceedances for the FY2007 not including Macroinvertebrate and bottom deposit exceedances.

Site ID	Date	Parameter	Designated Use	Standard	Result
LCMIN018.05	6/26/2007	Dissolved Oxygen	A&Wc	7 mg/L	6.24 mg/L
LCLCR211.73	4/24/2007	Dissolved Oxygen	A&Wc	7 mg/L	5.44
LCELR000.13	6/12/2007	E. coli	FBC	235 cfu	263 cfu
LCMRS043.17	5/23/2007	Dissolved Oxygen	A&Wc	7 mg/L	5.46 mg/l
LCNUT012.99	3/5/2007	pH	A&Wc,FC, AgI, AgL	Max 9; Min 6.5	5.71
LCNUT012.99	5/21/2007	pH	A&Wc,FC, AgI, AgL	Max 9; Min 6.5	9.3
LCRIG004.87	5/10/2007	Dissolved Oxygen	A&Wc	7 mg/L	6.71 mg/L

A&Wc = Aquatic and wildlife cold
FBC = Full body contact
FC = Fish consumption
AgI = Agriculture irrigation
AgL = Agriculture livestock

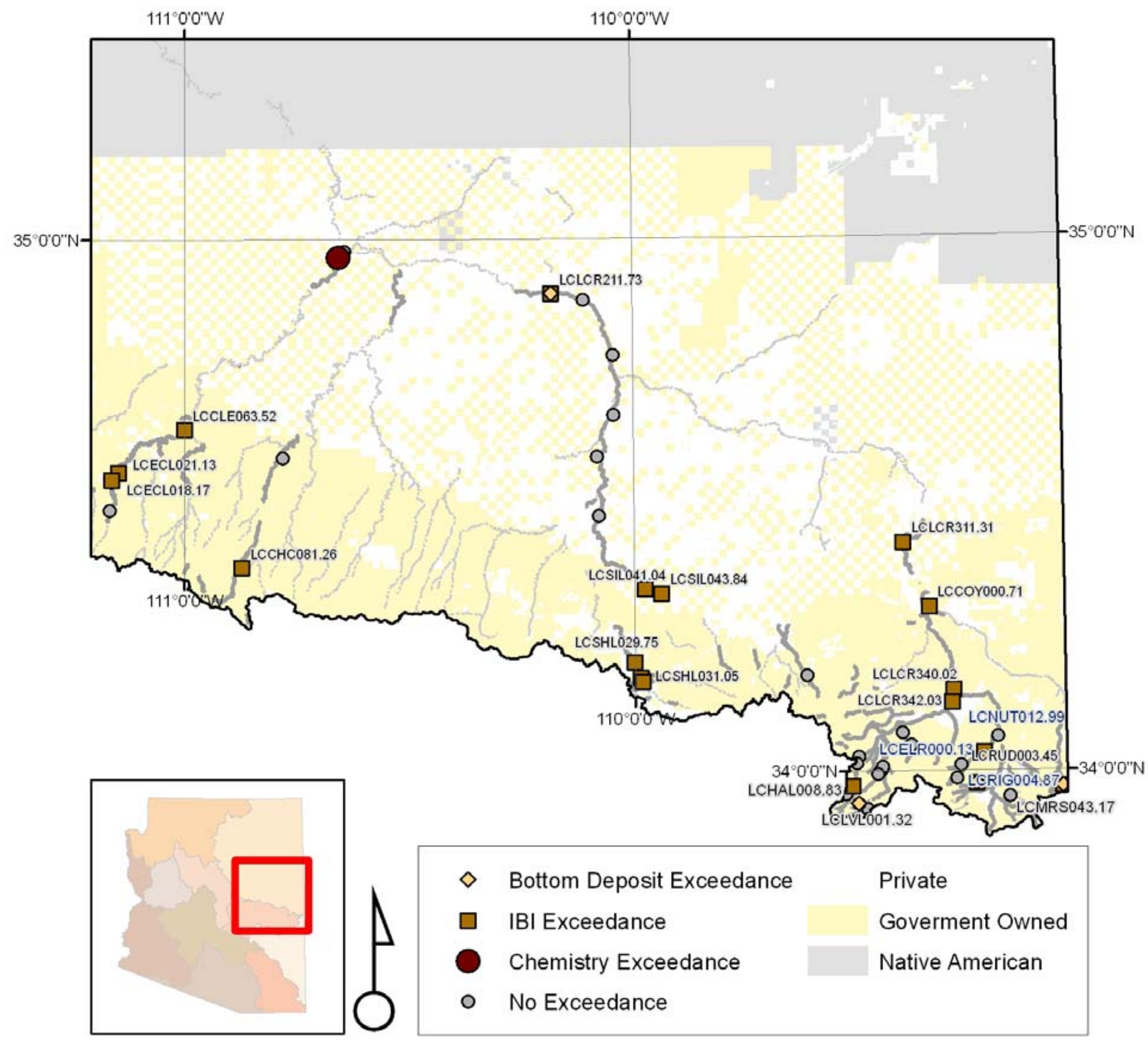


Figure 15. Exceedances in the Little Colorado River Basin

CHAPTER 5 – WHERE TO GO FROM HERE

The pilot study in the LCR watershed will initiate further research statewide based on the probabilistic monitoring design. ADEQ is currently sampling 51 randomly selected sites statewide, which will enable us to statistically assess 100% of all stream miles in Arizona. Statewide probabilistic sampling began in 2007 and will end in 2010.

APPENDIX A - RESULTS

CHEMICAL AND BIOLOGICAL RESULTS FROM FY07 LCR

In addition to the parameters shown below, Antimony (total and dissolved), Beryllium (total and dissolved), Chromium (total), and Selenium (total) were sampled but not included in the table because all values were Non Detect (ND) for these parameters. The mauve colored boxes in the table below represents the exceedances found in the LCR.

SITEID	SAMPDATE	ALK PHEN	NH3	AS-D	AS-T	BA-D	B-T	HARD CACO3	ALK CACO3	CA-T	CO3	CHLORIDE	CU-TRACE	DO-MGL	DO-PERCENT	ECOLI	FINES2MM RIFFLE	DISCHARGE CFS	FLOWFT-S	F-T	HARDNESS	HCO3	TKN
LCBEN002.57	11/15/2006	ND	0.039	ND	ND		ND	85.0	110.0	21.0	ND	ND	ND	9.00	79.9	5.00		0.121	0.50	ND	90	140	ND
LCBEN002.57	4/5/2007	ND	ND	ND	ND		ND	64.0	77.0	15.0	ND	ND		8.29	75.6	1.00		0.220	0.27	ND	63	94	0.130
LCBEN002.57	5/9/2007	ND	ND	ND	ND		ND	58.0	73.0	13.0	ND	ND		9.33	73.2	1.00	5.0	0.680	0.80	ND		89	ND
LCBRB000.27	11/14/2006	ND	ND	ND-1	ND-1		ND	58.0	57.0	11.0	ND	0.5	0.0003	10.03	106.3			0.020	0.01	0.025	50	70	0.110
LCBRB000.27	5/1/2007	ND	ND	ND-1	ND		ND	39.0	37.0	8.3	ND	ND		11.41	107.1	1.00		0.130	0.01	ND	38	45	0.180
LCBRB000.27	5/16/2007	ND	ND	ND-1	ND		ND	50.0	52.0	11.0	ND	ND		7.39	89.4		1.0	0.040	0.15	ND	50	64	0.100
LCBRB006.74	11/28/2006	ND	0.045	ND-1	ND-1		ND	77.0	76.0	16.0	ND	0.5	0.0016	8.90	88.3	2.00		2.040		0.025	75	93	0.150
LCBRB006.74	6/18/2007	ND	ND	ND-1	ND		ND	43.0	46.0	9.0	ND	ND		8.83	93.2	9.30	1.0	0.010	0.02	ND	41	56	0.240
LCCHC060.61	11/15/2006	ND	ND	ND-1	ND-1		ND	120.0	130.0	30.0	ND	0.5	0.0003	9.46	97.3	5.00		0.390	0.01	0.100	130	160	0.140
LCCHC060.61	4/25/2007	ND	ND	ND	ND		ND	81.0	87.0	20.0	ND	12		11.15	117.0			0.440	0.01	ND	80	110	0.210
LCCHC081.26	11/15/2006	ND	ND	ND-1	ND-1		ND	120.0	130.0	29.0	ND	0.5		7.37	71.9	4.00		2.400	0.06	0.025	120	160	ND
LCCHC081.26	4/25/2007	8.9	ND	ND	ND		ND	94.0	93.0	22.0	11.0	ND		10.98	98.6			4.200	0.30	ND	92	92	0.090
LCCHC081.26	6/19/2007	ND	ND	ND	0.0054		ND	140.0	150.0	30.0	ND	ND		8.01	81.1	5.70	0.0	7.900	0.07	ND	133	180	0.210
LCCLE000.69	11/16/2006	2.4	ND	ND-1	ND-1		ND	230.0	190.0	42.0	2.8	610	0.0003	12.62	100.0	12.90		0.090	0.00	0.025	220	220	0.230
LCCLE000.69	5/1/2007	ND	ND	ND-1	ND	ND	ND	83.0	88.0	21.0	ND	54		11.78	124.8	8.00		3.100	0.24	ND	78	110	0.320
LCCLE063.52	5/7/2007	3.3	0.079	ND	ND		ND	120.0	120.0	20.0	4.0	ND		11.10	116.0	1.00	10.0	3.600	0.52	ND		140	0.120
LCCOY000.71	11/28/2006	4.1	ND	ND-1	ND-1		0.18	320.0	280.0	67.0	4.9	60	0.0011	10.85	101.5	82.00		0.100	0.41	0.490	320	330	0.093
LCCOY000.71	3/7/2007	6.9	0.046	ND	ND		0.17	330.0	270.0	66.0	8.3	59		9.79	97.6	1.00		0.060	0.13	0.490	320	310	0.180
LCCOY000.71	4/10/2007	2.7	ND	ND	ND		0.18	260.0	280.0	43.0	3.2	38		7.80	79.9	13.75	22.0	0.100	0.15	0.420	240	340	0.270
LCECL018.17	11/13/2006	2.7	ND	ND-1	ND-1		ND	160.0	180.0	36.0	3.2	0.5		10.45	102.1			0.660	0.03	0.025	170	220	0.071
LCECL018.17	5/2/2007	ND	ND	ND-1	ND		ND	130.0	140.0	27.0	ND	ND		8.81	83.0	1.00	6.0	1.100		ND	130	170	0.150
LCECL018.17	6/20/2007	2.9	ND	ND	ND		ND	190.0	190.0	34.0	3.4	ND		8.72	98.3	8.30		0.320	0.09	ND	171	230	0.190
LCECL021.13	11/14/2006	ND	ND	ND-1	ND-1		ND	90.0	94.0	19.0	ND	0.5	0.0002	9.03	90.6	5.00		0.040	0.00	0.025	90	110	0.074
LCECL021.13	4/30/2007	ND	ND	ND-1	ND		ND	5.0	73.0	15.0	ND	ND		9.70	97.1	1.00		0.930	0.19	ND	68	89	0.150
LCECL021.13	5/3/2007																5.0						
LCECL021.13	5/16/2007	ND	0.100	ND	ND		ND	88.0	94.0	20.0	ND	ND		7.89	103.3	3.00		0.240	0.18	ND	88	110	0.110
LCECL040.69	11/13/2006	ND	ND	ND-1	ND-1		ND	65.0	76.0	14.0	ND	0.5	0.0003	9.22	89.7	4.00				ND	59	79	ND
LCECL040.69	5/1/2007	ND	ND	ND-1	ND		ND	51.0	58.0	10.0	ND	ND		13.10	131.8	2.00		0.010		ND	46	70	0.160
LCECL040.69	5/17/2007	ND	0.054	ND-1	ND		ND	59.0	65.0	13.0	ND	ND		7.51	82.3	4.00				ND	59	79	0.220
LCELR000.13	11/15/2006	ND	ND	ND-1	ND-1		ND	46.0	57.0	10.0	ND	0.5	0.0002	9.93	95.7	4.00		0.950	0.49	0.025	40	70	0.062
LCELR000.13	3/27/2007	ND	ND	ND	ND		ND	22.0	79.0	5.3	ND	ND	0.0008	9.31	71.9	4.00		8.300	1.41	ND	22	96	0.310
LCELR000.13	6/12/2007	ND	ND	ND	ND		ND	43.0	57.0	10.0	ND	ND		7.83	74.3	263.00	6.0	1.500	0.90	ND	41	69	0.250
LCELR007.19	11/14/2006	ND	ND	ND-1	ND		ND	23.0	22.0	3.7	ND	ND	ND	8.74	95.6	1.00		0.500		ND	14	27	0.066
LCELR007.19	4/19/2007	ND	ND	ND	ND		ND	5.0	10.0	2.7	ND	ND		9.85	77.9	11.20		1.700	0.55	ND	7	13	0.170
LCELR007.19	6/13/2007	ND	ND	ND	ND		ND	13.0	21.0	3.6	ND	ND		7.15	76.7	9.00	30.0	0.190	0.23	ND	14	25	0.190
LCHAL004.59	6/4/2007	ND	ND	ND	ND		ND	27.0	24.0	5.7	ND	ND		8.54	91.8	1.00	1.0	0.130	0.08	ND	25	30	1.300

SITEID	SAMPDATE	ALK PHEN	NH3	AS-D	AS-T	BA-D	B-T	HARD CACO3	ALK CACO3	CA-T	CO3	CHLORIDE	CU-TRACE	DO-MGL	DO-PERCENT	ECOLI	FINES2MM RIFFLE	DISCHARGE CFS	FLOWFT-S	F-T	HARDNESS	HCO3	TKN
LCHAL005.62	11/16/2006	ND	0.044	ND	ND		ND	22.0	10.0	3.6	ND	ND	ND	8.65	96.2	1.00		0.020	0.03	ND	16	13	ND
LCHAL005.62	4/4/2007	ND	ND	ND	ND		ND	17.0	17.0	4.0	ND	ND		10.30	109.1	1.00		0.300	0.91	ND	18	21	0.760
LCHAL008.83	6/4/2007	ND	ND	ND	ND		ND	20.0	19.0	3.9	ND	ND		9.12	94.8	78.00		0.006	0.01	ND	16	23	0.340
LCHAL008.83	6/5/2007	ND	ND	ND	ND		ND	11.0	17.0	3.3	ND	ND		10.61	88.9	2.00		0.020		ND	13	21	0.170
LCHAL010.20	6/7/2007													7.83	92.4		10.2	0.050					
LCLCR211.73	11/28/2006	4.1	0.052	ND-1	ND-1		ND	470.0	260.0	110.0	4.9	420	0.0149	9.25	98.7	2.00		3.300	0.56	0.190	450	310	0.170
LCLCR211.73	3/6/2007	4.8	0.032	ND	ND		ND	410.0	210.0	100.0	5.7	470		9.57	94.2	6.00		2.500	0.29	0.260	390	240	0.150
LCLCR211.73	4/24/2007	ND	ND	ND	ND	0.16	0.14	660.0	200.0	140.0	ND	ND		5.44	60.0	4.00	100.0	0.380	0.20	0.370	580	240	0.170
LCLCR211.73	5/15/2007	ND	0.093	ND-1	ND	0.19	0.16	620.0	160.0	150.0	ND	ND		6.87	100.7	9.00		0.310	0.21	0.330	630	200	0.220
LCLCR216.67	11/28/2006	3.4	0.043	ND-1	ND-1		ND	480.0	270.0	120.0	4.1	440	0.0008	7.70	84.0	0.00		7.500	0.10	0.200	460	320	0.130
LCLCR216.67	3/6/2007	5.2	0.037	ND	ND		ND	440.0	220.0	110.0	6.3	490		11.05	91.1	1.00		0.150	0.01	0.250	430	260	0.170
LCLCR226.31	11/28/2006	10.0	0.038	ND-1	ND-1		ND	300.0	310.0	67.0	12.0	14	0.0009	8.83	93.0	6.00		1.900	0.28	0.130	310	360	0.150
LCLCR226.31	3/6/2007	7.7	0.043	ND	ND		ND	230.0	210.0	54.0	9.3	20		11.57	86.4	1.00		1.500	0.34	0.180	220	240	0.220
LCLCR226.31	5/17/2007	4.1	0.079	ND-1	ND	0.30	ND	220.0	180.0	50.0	4.9	27		7.06	82.3	152.00		0.250	0.35	ND	200	210	0.200
LCLCR311.31	11/28/2006	ND	ND	ND-1	ND-1		0.41	640.0	440.0	150.0	ND	260	0.0009	10.90	105.0	5.00		0.600	0.35	2.300	610	540	0.150
LCLCR311.31	3/7/2007	6.5	0.075	ND	ND		0.42	700.0	410.0	170.0	7.9	300		11.54	100.0	32.00		0.740	0.42	2.500	680	480	0.240
LCLCR311.31	4/9/2007	ND	ND	ND	ND		0.50	700.0	390.0	160.0	ND	320		7.08	80.4	12.00		0.640	0.43	3.000	660	470	0.220
LCLCR340.02	11/15/2006	4.2	ND	ND	ND		ND	180.0	220.0	42.0	5.0	7.5	0.0005	9.30	102.0	33.00		2.600	0.48	0.220	170	260	0.190
LCLCR340.02	3/28/2007	ND	0.025	ND	ND		ND	72.0	150.0	17.0	ND	ND	0.0008	7.54	77.0	3.00		15.000	1.32	ND	70	180	0.190
LCLCR340.02	4/18/2007	ND	ND	ND	ND		ND	92.0	110.0	21.0	ND	5.8		10.37	89.7	2.00	6.0	2.500	0.45	ND	88	130	0.150
LCLCR342.03	11/28/2006	5.9	ND	ND-1	ND-1		ND	160.0	210.0	41.0	7.1	6.1	0.0003			4.00		2.800	0.49	0.210	160	240	0.098
LCLCR342.03	3/6/2007	3.0	0.040	ND	ND		ND	130.0	150.0	33.0	3.6	5.7		10.16	91.4	1.00		4.000	1.20	0.160	130	180	0.230
LCLCR342.03	4/11/2007	ND	ND	ND	ND		ND	64.0	74.0	15.0	ND	ND		8.61	77.3	8.24	2.9	15.000	2.07	ND	61	91	0.170
LCLCR360.06	11/15/2006		ND	ND-1	ND-1		ND	35.0	41.0	7.3	ND	0.5		11.17	102.0	1.00		4.700	0.63	0.025	30	50	0.068
LCLCR360.06	3/27/2007	ND	ND	ND	ND		ND	22.0	58.0	5.6	ND	ND	0.0007	9.39	77.3	1.00		23.000	1.49	ND	23	71	0.200
LCLCR360.06	6/5/2007	ND	ND	ND	ND		ND	19.0	28.0	5.2	ND	ND		7.49	75.1	18.00	1.0	8.100	0.98	ND	20	34	0.310
LCLVL001.32	11/14/2006	ND	ND	ND-1	ND		ND	12.0	14.0	3.0	ND	ND		9.31	89.6	2.00		0.150		ND	11	18	0.057
LCLVL001.32	4/19/2007	ND	ND	ND	ND		ND	12.0	14.0	3.3	ND	ND		9.89	70.7			0.750		ND	12	16	0.090
LCLVL001.32	6/13/2007	ND	ND	ND	ND		ND	11.0	14.0	3.0	ND	ND		7.81	78.4	1.00	42.0	0.260	0.26	ND	5	17	0.160
LCMIN018.05	6/26/2007	ND	ND	ND	ND		ND	44.0	50.0	8.9	ND	ND		6.24	67.9	29.00	18.0	0.240	0.31	ND	42	61	0.080
LCMLK001.18	11/14/2006	ND	0.037	ND	ND		ND	55.0	72.0	15.0	ND	ND	ND	10.81	102.0	1.00		0.030	0.06	ND	60	88	0.077
LCMLK001.18	4/10/2007	ND	0.033	ND	ND		ND	80.0	87.0	20.0	ND	ND		7.17	72.6			0.030	0.06	ND	78	110	0.160
LCMLK001.18	5/22/2007	ND	ND	ND	ND		ND	62.0	71.0	16.0	ND	ND		8.10	75.0		15.4	0.220	0.86	ND	63	86	0.150
LCMRS043.17	11/14/2006	ND	0.033	ND	ND		ND	140.0	170.0	42.0	ND	ND	0.0002	8.69	93.7	2.00		0.027	0.21	0.100	140	210	ND
LCMRS043.17	3/28/2007	ND	ND	ND	ND		ND	71.0	150.0	21.0	ND	ND	0.0017	8.39	72.6	2.00				ND	75	190	0.250
LCMRS043.17	5/23/2007	2.0	ND	ND	ND		ND	170.0	190.0	48.0	2.4	4.7		5.46	65.9		40.0	0.260	0.08	0.120	160	230	0.140
LCNUT012.99	11/13/2006	3.7	0.050	ND	ND		ND	260.0	340.0	63.0	4.4	12	0.0003	10.24	112.7	1.00		0.030	0.01	0.510	240	400	0.350
LCNUT012.99	3/5/2007	7.1	0.039	0.0090	ND		ND	230.0	290.0	56.0	8.5	12		8.89	90.6			0.000		0.400	210	340	0.430
LCNUT012.99	5/21/2007	20.0	0.042	ND	ND		ND	150.0	220.0	32.0	24.0	11		13.85	164.5	2.00		0.020	0.03	0.390	150	220	0.470
LCRDF015.45	11/28/2006	ND	0.084	ND-1	ND-1		0.23	170.0	210.0	34.0	ND	72		8.59	99.6	5.80		0.050	0.02	0.025	180	250	ND
LCRDF015.45	3/7/2007	ND	0.065	ND	ND		0.22	140.0	160.0	30.0	ND	73		8.64	88.1	4.00		2.000	0.42	ND	140	200	1.600
LCRIG004.87	11/15/2006	ND	0.044	ND	ND		ND	100.0	140.0	25.0	ND	ND	0.0002	9.34	86.3	212.00		0.111	0.80	ND	100	170	ND
LCRIG004.87	3/28/2007	ND	ND	ND	ND		ND	106.0	170.0	23.0	ND	ND		9.17	75.6	6.29		0.200	0.25	ND	98	200	0.120
LCRIG004.87	5/10/2007	ND	0.072	ND	ND		ND	99.0	130.0	23.0	2.2	ND		6.71	74.0	2.00	70.0	0.200	0.25	ND		150	0.080

SITEID	SAMPDATE	ALK PHEN	NH3	AS-D	AS-T	BA-D	B-T	HARD CACO3	ALK CACO3	CA-T	CO3	CHLORIDE	CU-TRACE	DO-MGL	DO-PERCENT	ECOLI	FINES2MM RIFFLE	DISCHARGE CFS	FLOWFT-S	F-T	HARDNESS	HCO3	TKN
LCRUD003.45	11/27/2006	ND	ND	ND-1	ND-1		ND	150.0	190.0	44.0	ND	0.5	0.0003	8.25	68.4	27.00		0.070	0.11	0.110	160	240	0.068
LCRUD003.45	3/6/2007	ND	0.036	ND	ND		ND	140.0	160.0	38.0	ND	ND		11.55	100.0			1.000	0.58	0.160	140	190	0.120
LCRUD003.45	5/23/2007	2.0	0.050	ND	ND		ND	230.0	310.0	64.0	2.4	7.5		7.45	72.0	8.00		0.210	0.43	0.360	230	370	0.260
LCRUD007.23	6/27/2007	ND	ND	ND	ND		ND	94.0	120.0	24.0	ND	ND		8.16	82.0	223.00	13.0			ND	96	140	0.140
LCSHL026.50	4/16/2007	ND	ND	ND-1	ND		ND	90.0	93.0	19.0	ND	12		12.44	114.0	2.00	6.0	4.000	0.54	ND	89	110	0.340
LCSHL029.75	6/27/2007	9.5	ND	ND	ND		ND	140.0	150.0	27.0	11.0	11		10.88	136.0	3.00	7.9	1.000	0.36	ND	141	160	0.400
LCSHL031.05	11/14/2006	ND	0.038	ND	ND		ND	130.0	150.0	27.0	ND	8.7	0.0006	10.55	112.6	1.00		1.500	0.37	ND	140	180	0.270
LCSHL031.05	3/5/2007	ND	0.039	ND	ND		ND	99.0	100.0	22.0	ND	8.9		11.12	104.7	1.00		4.900	1.07	ND	100	120	0.390
LCSHL031.05	4/17/2007	ND	ND	ND	ND		ND	130.0	140.0	26.0	ND	10		9.23	76.5	1.00	19.0	0.630	0.35	ND	130	170	0.310
LCSIL006.13	11/15/2006	7.8	0.035	ND	ND		ND	330.0	350.0	63.0	9.3	10	0.0003	10.66	95.8	6.00		1.500	0.60	ND	320	400	0.320
LCSIL006.13	3/6/2007	9.3	ND	ND	ND	0.21	ND	300.0	290.0	63.0	11.0	10		8.17	68.0	1.00		1.100	0.44	0.110	310	330	0.210
LCSIL013.53	11/27/2006	11.0	0.060	ND-1	ND-1		ND	380.0	390.0	84.0	13.0	10	0.0009	8.21	89.3	2.67		0.660	0.03	0.100	380	450	0.310
LCSIL013.53	3/5/2007	14.0	0.021	ND	ND		ND	320.0	320.0	64.0	17.0	10	0.0012	10.07	79.6	4.00		1.300	0.32	0.120	300	350	0.270
LCSIL024.83	11/15/2006	4.0	0.034	ND	ND		ND	360.0	380.0	74.0	4.8	8	0.0005	7.06	71.2	21.00				0.100	350	450	0.120
LCSIL024.83	3/6/2007	14.0	ND	ND	ND		ND	280.0	300.0	64.0	17.0	7.9		8.46	79.7	50.00		1.500	0.04	ND	310	330	0.290
LCSIL024.83	4/23/2007	ND	ND	ND	ND		ND	200.0	140.0	37.0	ND	7.1		10.85	104.5	156.00		8.700	0.84	0.100	180	170	0.120
LCSIL041.04	11/15/2006	ND	0.034	ND	ND		ND	64.0	88.0	12.0	ND	ND	ND	8.51	92.7	2.00		7.500	1.05	ND	60	110	ND
LCSIL041.04	3/6/2007	ND	ND	ND	ND		ND	68.0	83.0	18.0	ND	ND		8.12	89.8	4.00		7.300	1.00	ND	77	100	0.140
LCSIL041.04	4/24/2007	ND	ND	ND	ND		ND	64.0	62.0	11.0	ND	ND		10.66	104.0	4.00	9.8	8.000	0.39	ND	57	75	0.170
LCSIL043.84	6/28/2007	11.0	ND		ND		ND	54.0	76.0	11.0	13.0	ND		11.87	140.0		25.0	5.500	0.50	ND	56	66	0.080
LCSLR001.42	11/16/2006	ND	0.050	ND	ND		ND	82.0	110.0	20.0	ND	ND	ND	9.97	88.8	1.00		0.980	0.31	ND	85	130	0.065
LCSLR001.42	3/7/2007	ND	ND	ND	ND		ND	74.0	90.0	19.0	ND	ND		10.08	89.1	1.00		1.700	0.36	ND	80	110	0.090
LCSLR001.42	5/24/2007	ND	0.041	ND	ND		ND	75.0	95.0	18.0	ND	ND		8.25	80.3	1.00	6.7	1.600	0.59	ND	75	110	0.050
LCSLR003.72	6/21/2007	ND	ND	ND	ND		ND	69.0	92.0	16.0	ND	ND		8.68	88.5	4.00	4.9	0.350	0.14	0.120	66	110	0.100
LCWLR000.92	11/13/2006	ND	ND	ND-1	ND		ND	22.0	37.0	5.2	ND	ND	ND	9.12	98.5	1.00		6.300	0.71	ND	20	45	ND
LCWLR000.92	3/26/2007	ND	ND	ND	ND		ND	20.0	64.0	5.3	ND	ND	0.0005	9.05	76.9	1.00		15.000	1.04	ND	22	79	0.120
LCWLR000.92	6/12/2007	ND	ND	ND	ND		ND	18.0	25.0	4.5	ND	ND		7.48	76.9	22.00	9.0	6.700	0.85	ND	17	30	0.170
MRL		**2.0**	**0.020**	**ND-1**	**ND-1**	**0.10**	**0.10**	**10**	**2**	**1**	**2.0**	**5**	**0.0002**	**0.2**	**--**	**--**	**--**	**--**	**--**	**0.1**	**--**	**2**	**0.05**
Units		***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***%***	***CFU***	***%***	***CFS***	***ft/s***	***mg/L***	***mg/L***	***mg/L***	***mg/L***

ND-1. MRL for As 0.010 mg/L. The MRL for the remaining total and dissolved As values is 0.005 mg/L.

SITEID	SAMPDATE	PB-D	PB-T	MG-T	MN-T	HG-T	NITRATE & NITRITE	NITRATE	PH-FIELD	P-T	K-T	NA-T	SPCOND-FIELD	SO4-T	SSC	TEMP-AIR	TEMP-WATER	TDS-FIELD	TOTALHABITATSCORE	TURBIDITY	ZN-D	ZN-T	IBI
LCBEN002.57	11/15/2006	ND	ND	8.40	ND	ND	ND		7.75	0.037	0.76	11.0	196.2	4.3	ND	9.4	4.07	125.60		0.57	ND	ND	
LCBEN002.57	4/5/2007		ND	6.10	ND	ND	ND		8.12	0.040	0.75	8.1	159.0	ND	ND	15.1	10.98	104.00		1.03	ND	ND	
LCBEN002.57	5/9/2007		ND	5.60	ND	ND	ND	ND	7.97	0.040	1.10	6.0	134.0	1.1	ND	5.0	6.10	87.00	19.0	2.75	ND	ND	63.71
LCBRB000.27	11/14/2006	0.000150	ND	5.80	ND	ND	ND		8.24	0.022	ND	1.2	83.4	ND	20.0	12.9	8.79	50.00			ND	ND	
LCBRB000.27	5/1/2007		ND	4.10	ND	ND	ND		8.67	ND	ND	1.1	81.0	ND	ND	21.4	12.80	52.00		2.00	ND	ND	
LCBRB000.27	5/16/2007	0.002500	ND	5.40	ND	ND	ND		7.75	0.030	ND	1.1	94.3	ND	ND	25.7	16.36	60.40	17.0	7.37	ND	ND	
LCBRB006.74	11/28/2006	ND	ND	8.40	ND	ND	ND		8.16	ND	ND	1.2	123.0	ND	ND		0.42	79.00		1.31	ND	ND	
LCBRB006.74	6/18/2007		ND	4.50	ND	ND	ND		7.89	0.020	ND	1.2	88.0	ND	ND	33.6	18.21	57.00	16.5	2.00	ND	ND	63.71
LCCHC060.61	11/15/2006	ND	ND	13.00	ND	ND	ND		7.92	ND	0.57	2.2	214.0	11.0	ND	15.7	7.97	137.00		5.51	ND	ND	
LCCHC060.61	4/25/2007		ND	7.40	ND	ND	ND	ND	8.52	ND	0.53	1.6	151.0	5.5	ND	20.0	17.62	98.00		3.43	ND	ND	
LCCHC081.26	11/15/2006	ND	ND	12.00	ND	ND	0.035		7.65	ND	0.66	2.2	201.0	ND	ND	13.1	6.20	128.10		0.85	ND	ND	
LCCHC081.26	4/25/2007		ND	8.90	ND	ND	ND	ND	8.20	ND	0.63	1.8	171.0	ND	ND	20.0	10.54	111.00		6.50	ND	ND	
LCCHC081.26	6/19/2007		ND	14.00	ND	ND	0.026		7.68	0.030	0.77	2.1	268.0	ND	ND	37.5	16.58	174.00	19.3	1.11	ND	ND	37.89
LCCLE000.69	11/16/2006	0.000096	ND	27.00	ND	ND	ND		8.01	ND	2.10	390.0	213.6	42.0	23.0		5.03	136.70		5.46	ND	ND	
LCCLE000.69	5/1/2007		6.3000	ND	ND	ND	ND		8.87	0.020	0.64	32.0	285.0	8.5	9.0	24.6	18.09	177.00		12.20	ND	ND	
LCCLE063.52	5/7/2007		ND	13.00	ND	ND	ND	ND	8.43	ND	ND	1.4	223.0	ND	4.0	14.0	17.60	145.00	17.0	1.89	ND	ND	22.06
LCCOY000.71	11/28/2006	0.000104	ND	38.00	0.061	ND	ND		8.10	0.040	3.60	140.0	1111.0	310.0	7.0	12.2	7.88	710.00		5.95	ND	ND	
LCCOY000.71	3/7/2007		ND	37.00	0.068	ND	ND	ND	8.24	0.025	3.00	150.0	1215.0	310.0	6.0	18.3	7.51	776.90		4.85	ND	ND	
LCCOY000.71	4/10/2007		ND	32.00	0.055	ND	ND		8.86	0.020	3.70	200.0		350.0	25.0	15.6	16.48		12.5		ND	ND	27.11
LCECL018.17	11/13/2006		ND	19.00	ND	ND	0.022		8.57	ND	ND	1.6	271.0	ND	ND	12.3	5.30	170.60		1.35	ND	ND	
LCECL018.17	5/2/2007		ND	14.00	ND	ND	0.033		8.09	ND	ND	1.4	236.0	ND	ND	22.1	12.76	153.00	17.0	1.76	ND	ND	28.35
LCECL018.17	6/20/2007		ND	21.00	0.085	ND	ND		8.05	0.030	0.69	1.8	337.0	ND	ND	27.5	21.25	219.00		2.97	ND	ND	
LCECL021.13	11/14/2006	0.000038	ND	9.30	0.099	ND	0.024		8.23	ND	0.51	1.0	137.0	ND	6.0	14.7	5.90	87.50		3.34	ND	ND	
LCECL021.13	4/30/2007		ND	7.10	0.068	ND	0.024		8.75	ND	ND	1.1	129.0	ND	ND	22.6	15.38	84.00		2.57	ND	ND	
LCECL021.13	5/3/2007																		16.0				36.60
LCECL021.13	5/16/2007		ND	9.20	0.100	ND	0.024		7.79	0.030	0.52	1.1	159.3	ND	ND	22.3	20.86	101.60		2.68	ND	ND	
LCECL040.69	11/13/2006	ND	ND	7.4	ND	ND	0.021		8.61	ND	ND	1.4	111.3	ND	ND	10.8	4.7	71		1.28	ND	ND	
LCECL040.69	5/1/2007		ND	5.00	ND	ND	0.033		8.90	0.020	ND	1.1	104.0	ND	ND	24.0	13.14	68.00		1.51	ND	ND	
LCECL040.69	5/17/2007		ND	6.50	ND	ND	ND		7.41	ND	ND	1.3	103.5	ND	ND	16.6	10.93	66.30		1.20	ND		
LCELR000.13	11/15/2006	ND	ND	4.00	ND	ND	0.025		8.14	ND	1.50	5.8	94.0	ND	ND		1.64	61.00		1.81	ND	ND	
LCELR000.13	3/27/2007	ND	ND	2.20	ND	ND	ND		8.29	0.030	1.10	2.8	60.0	ND	ND	12.6	4.51	39.00		14.70	ND	ND	
LCELR000.13	6/12/2007		ND	4.00	ND	ND	ND		8.18	0.040	1.70	6.1	104.0	ND	ND		12.84	68.00	17.0	11.80	ND	ND	55.10
LCELR007.19	11/14/2006	ND	ND	1.20	ND	ND	ND		8.80	0.024	1.40	3.0	39.0	2.4	ND		4.42	25.00		5.30	ND	ND	
LCELR007.19	4/19/2007	0.000196	ND	ND	0.067	ND	ND		7.75	0.030	0.93	2.4	38.0	ND	ND	14.0	5.41	24.00		6.04	ND	ND	
LCELR007.19	6/13/2007		ND	1.10	ND	ND	ND		7.88	0.050	1.90	3.0	47.0	ND	ND		18.78	30.00	13.5	2.71	ND	ND	67.59
LCHAL004.59	6/4/2007		ND	2.60	0.050	ND	ND		7.51	0.170	1.30	3.5	65.0	1.9	ND	20.1	18.87	42.00	20.0	4.33	ND	ND	51.31
LCHAL005.62	11/16/2006	ND	ND	1.60	ND	ND	ND			0.050	2.20	4.7	40.3	12.0	ND	17.2	6.04	25.90		2.64	ND	ND	
LCHAL005.62	4/4/2007		ND	1.90	ND	ND	ND		7.82	0.100	2.40	2.7	55.0	ND	ND	17.4	18.32	36.00		4.62	ND	ND	
LCHAL008.83	6/4/2007		ND	1.50	0.100	ND	0.040		7.64	0.190	1.90	3.3	49.0	3.7	25.0	21.6	17.28	32.00		31.00	ND	ND	
LCHAL008.83	6/5/2007		ND	1.20	ND	ND	ND		7.69	0.050	1.90	2.9	45.0	3.8	5.0	15.2	7.70	29.00	18.0	20.30	ND	ND	39.36
LCHAL010.20	6/7/2007								7.02				43.6			8.0	8.85		17.0				52.75
LCLCR211.73	11/28/2006	0.000611	ND	42.00	0.160	ND	ND		7.94	ND	5.60	270.0	1990.0	190.0	43.0	11.8	5.75	1273.00		36.70	ND	ND	
LCLCR211.73	3/6/2007		ND	35.00	0.170	ND	ND	ND	8.34	0.025	4.00	280.0	1705.0	150.0	52.0	18.6	15.44	1108.00		43.50	ND	ND	

SITEID	SAMPDATE	PB-D	PB-T	MG-T	MN-T	HG-T	NITRATE & NITRITE	NITRATE	PH-FIELD	P-T	K-T	NA-T	SPCOND-FIELD	SO4-T	SSC	TEMP-AIR	TEMP-WATER	TDS-FIELD	TOTALHABITATSCORE	TURBIDITY	ZN-D	ZN-T	IBI
LCLCR211.73	4/24/2007		ND	57.00	0.067	ND	ND	ND	8.34	ND	5.80	590.0	3893.0	410.0	35.0	18.0	18.93	2530.00	6.0	6.67	ND	ND	25.90
LCLCR211.73	5/15/2007		ND	62.00	ND	ND	ND		7.88	ND	6.00	670.0	4308.0	400.0	ND	28.4	28.32	2760.00	8.0	5.92	ND	ND	13.87
LCLCR216.67	11/28/2006	0.000094	ND	40.00	0.270	ND	ND		8.01	0.060	5.00	270.0	2071.0	190.0	26.0	11.8	6.24	13.25		20.40	ND	ND	
LCLCR216.67	3/6/2007		ND	38.00	0.310	ND	ND	ND	8.16	0.025	4.10	280.0	2304.0	200.0	21.0	22.5	6.80	1497.00		21.90	ND	ND	
LCLCR226.31	11/28/2006	0.000112	ND	35.00	0.055	ND	ND		8.47	0.028	5.10	26.0	590.0	48.0	24.0	10.4	4.93	378.00		57.40	ND	ND	
LCLCR226.31	3/6/2007		ND	21.00	0.099	ND	ND	ND	8.39	0.025	3.70	24.0	545.0	44.0	6.0	11.0	3.20	354.00		37.30	ND	ND	
LCLCR226.31	5/17/2007		ND	19.00	0.150	ND	ND		8.21	0.060	4.50	34.0	517.9	80.0	24.0	22.0	16.80	331.40		81.60	ND	ND	
LCLCR311.31	11/28/2006	0.000065	ND	58.00	0.094	ND	ND		7.51	ND	ND	240.0	213.3	430.0	9.0	10.7	2.90	126.70		6.34	ND	ND	
LCLCR311.31	3/7/2007		ND	61.00	0.150	ND	ND	ND	7.45	0.025	15.00	270.0	2441.0	430.0	ND	12.3	2.64	156.20		6.74	ND	ND	
LCLCR311.31	4/9/2007		ND	64.00	0.170	ND	ND		8.72	0.020	17.00	290.0		490.0	19.0	20.8	21.66		7.0	18.10	ND	ND	19.77
LCLCR340.02	11/15/2006	0.000053	ND	16.00	0.055	ND	ND		8.44	0.034	1.70	23.0	371.0	6.7	14.0		8.02	237.00		29.80	ND	ND	
LCLCR340.02	3/28/2007	0.000132	ND	6.70	ND	ND	ND		7.54	0.050	1.40	7.9	80.0	ND	9.0	6.9	16.04	50.00		11.40	ND	ND	
LCLCR340.02	4/18/2007		ND	8.40	0.110	ND	ND		8.25	0.050	1.70	12.0	217.0	ND	6.0	14.6	8.80	141.00	11.0	11.80	ND	ND	25.67
LCLCR342.03	11/28/2006	ND	ND	15.00	ND	ND	ND			0.043	1.60	24.0		4.5	ND	15.4				5.92	ND	ND	
LCLCR342.03	3/6/2007		ND	11.00	0.070	ND	ND	ND	6.90	0.025	1.30	14.0	283.0	2.1	ND	29.3	2.62	181.10		6.18	ND	ND	
LCLCR342.03	4/11/2007		ND	5.70	ND	ND	ND		7.37	0.060	1.70	7.0		ND	6.0	10.0	10.55		15.0	16.10	ND	ND	26.94
LCLCR360.06	11/15/2006	ND	ND	2.60	ND	ND	0.024		8.57	ND	1.60	3.0	68.0	2.5	ND		-0.60	44.00		1.81	ND	ND	
LCLCR360.06	3/27/2007	0.000068	ND	2.20	ND	ND	ND		8.06	0.030	1.30	3.0	63.0	ND	ND	15.3	6.92	41.00		7.20	ND	ND	
LCLCR360.06	6/5/2007		ND	1.80	ND	ND	0.074		8.34	0.050	1.80	3.6	60.0	ND	8.0	19.5	15.47	39.00	19.5	15.10	ND	ND	65.65
LCLVL001.32	11/14/2006		ND	0.93	ND	ND	ND			ND	1.10	2.7	32.0	3.5	6.0		0.14	20.00		5.99	ND	ND	
LCLVL001.32	4/19/2007		ND	1.00	ND	ND	ND		8.38	0.040	1.00	2.5	34.0	ND	ND	7.6	1.37	22.00		13.60	ND	ND	
LCLVL001.32	6/13/2007	ND	ND	ND	ND	ND	ND		7.88	0.060	1.30	2.6	40.0	2.5	6.0		15.57	26.00	15.0	3.34	ND	ND	66.44
LCMIN018.05	6/26/2007		ND	4.70	ND	ND	0.051		7.82	0.100	0.83	4.3	98.0	ND	10.0	33.8	20.88	64.00	16.5	6.88	ND	ND	53.57
LCMLK001.18	11/14/2006	ND	ND	5.00	ND	ND	ND		7.82	ND	0.64	6.7	126.3	4.1	6.0	6.4	0.38	81.00		1.63	ND	ND	
LCMLK001.18	4/10/2007		ND	6.90	ND	ND	ND		8.42	0.030	0.63	8.5		3.5	7.0	19.1	15.94			2.35	ND	ND	
LCMLK001.18	5/22/2007		ND	5.60	ND	ND	ND		8.54	0.050	0.72	6.8	147.0	7.6	24.0	19.0	11.79	95.00	18.5		ND	ND	46.73
LCMRS043.17	11/14/2006	ND	ND	9.50	ND	ND	0.023		8.05	0.045	0.53	20.0	320.8	11.5	9.0	11.1	5.19	205.60		1.25	ND	ND	
LCMRS043.17	3/28/2007	0.000134	ND	5.50	0.051	ND	0.120		7.95	0.070	0.60	7.8	70.0	1.7	19.0	1.2	9.02	5.00		11.00	ND	ND	
LCMRS043.17	5/23/2007		ND	10.00	0.100	ND	ND		8.45	0.190	0.61	18.0	361.0	8.7	43.0	20.5	23.87	235.00	17.5		ND	ND	43.71
LCNUT012.99	11/13/2006	ND	ND	21.00	0.320	ND	ND		7.71	0.076	1.00	47.0	579.4	ND	7.0	19.5	8.70	371.10		7.80	ND	ND	
LCNUT012.99	3/5/2007		ND	18.00	0.300	ND	ND	ND	5.71	0.025	0.70	37.0	564.5	ND	5.0	22.9	7.18	364.00		7.95	ND	ND	
LCNUT012.99	5/21/2007		ND	17.00	0.075	ND	ND		9.30	0.050	ND	40.0	395.0	ND	6.0	26.6	23.35	257.00		5.47	ND	ND	
LCRDF015.45	11/28/2006		ND	22.00	ND	ND	2.900		8.15	ND	13.00	69.0	623.0	28.0	5.0		6.55	399.00		4.60	0.056	0.058	
LCRDF015.45	3/7/2007		ND	17.00	ND	ND	3.200	3.20	7.65	4.000	13.00	57.0	627.0	21.0	ND	12.6	16.20	407.00		0.90	0.074	0.085	
LCRIG004.87	11/15/2006	ND	ND	10.00	ND	ND	ND		7.98	0.035	0.88	15.0	248.0	ND	ND	9.8	0.28	158.40		1.77	ND	ND	
LCRIG004.87	3/28/2007		ND	9.90	ND	ND	ND		8.12	0.060	0.73	15.0	224.0	ND	ND	5.5	7.63	146.00		4.70	ND	ND	
LCRIG004.87	5/10/2007		ND	9.00	ND	ND	ND	ND	8.07	0.080	0.84	14.0	99.0	ND	21.0	28.0	19.80	64.00	13.0	9.20	ND	ND	32.93
LCRUD003.45	11/27/2006	ND	ND	12.00	ND	ND	ND		7.51	0.059	0.49	15.0	314.6	1.7	ND	7.3	1.93	201.40		1.37	ND	ND	
LCRUD003.45	3/6/2007		ND	9.90	ND	ND	ND	ND	7.79	0.070	0.67	12.0	284.8	ND	ND	14.7	0.40	182.70		1.84	ND	ND	
LCRUD003.45	5/23/2007		ND	17.00	0.130	ND	ND		8.43	0.120	0.71	43.0	563.0	13.0	7.0	17.3	11.95	366.00	7.0	8.99	ND	ND	19.42
LCRUD007.23	6/27/2007		ND	8.70	ND	ND	0.069		8.22	0.150	1.40	11.0	221.0	ND	5.0	36.4	15.59	144.00	18.0	5.53	ND	ND	63.28
LCSHL026.50	4/16/2007		ND	10.00	0.087	ND	ND		8.96	0.020	ND	9.6	213.0	ND	ND	11.0	11.37	138.00	16.0	2.81	ND	ND	19.56
LCSHL029.75	6/27/2007		ND	18.00	0.089	ND	ND		8.75	0.040	2.30	12.0	312.0	5.2	18.0	34.1	26.69	203.00	19.0	15.10	ND	ND	37.42
LCSHL031.05	11/14/2006	ND	ND	17.00	ND	ND	0.023			0.021	2.10	11.0	273.4	5.7	ND		6.92	175.00		3.88	ND	ND	

SITEID	SAMPDATE	PB-D	PB-T	MG-T	MN-T	HG-T	NITRATE & NITRITE	NITRATE	PH-FIELD	P-T	K-T	NA-T	SPCOND-FIELD	SO4-T	SSC	TEMP-AIR	TEMP-WATER	TDS-FIELD	TOTALHABITATSCORE	TURBIDITY	ZN-D	ZN-T	IBI
LCSHL031.05	3/5/2007		ND	12.00	ND	ND	ND		8.37	0.025	1.70	8.4	204.8	4.5	ND	15.6	3.14	131.20		9.42	ND	ND	
LCSHL031.05	4/17/2007		ND	15.00	0.063	ND	ND		8.42	ND	2.00	11.0	280.0	4.8	ND	11.8	6.86	182.00	14.0	11.90	ND	ND	14.04
LCSIL006.13	11/15/2006	ND	ND	39.00	ND	ND	ND			0.029	5.40	24.0	627.0	40.0	21.0	4.8	3.82	401.20		63.80	ND	ND	
LCSIL006.13	3/6/2007		ND	36.00	0.064	ND	ND		8.26	0.025	4.90	19.0	552.4	34.0	10.0	0.9	0.68	353.60		47.50	ND	ND	
LCSIL013.53	11/27/2006	0.000315	ND	41.00	0.084	ND	ND		7.97	0.077	5.50	23.0	671.0	44.0	58.0	11.2	5.65	429.00		140.00	ND	ND	
LCSIL013.53	3/5/2007	0.000132	ND	35.00	0.099	ND	ND	ND	8.44	0.025	4.50	18.0	648.0	31.0	70.0	14.0	4.99	420.00		89.80	ND	ND	
LCSIL024.83	11/15/2006	ND	ND	39.00	0.200	ND	ND			0.075	4.60	21.0	646.2	35.0	31.0	11.4	7.32	413.70		49.60	ND	ND	
LCSIL024.83	3/6/2007		ND	36.00	0.100	ND	ND		8.21	0.025	4.60	17.0	549.2	30.0	35.0	16.1	4.59	351.40		39.20	ND	ND	
LCSIL024.83	4/23/2007		ND	22.00	0.094	ND	ND	ND	8.28	0.110	4.00	14.0	396.0	52.0	56.0		13.61	257.00		64.10	ND	ND	
LCSIL041.04	11/15/2006	ND	ND	7.40	ND	ND	0.030			0.035	3.00	9.0	138.5	ND	ND	14.3	9.79	88.60		13.10	ND	ND	
LCSIL041.04	3/6/2007		ND	7.70	ND	ND	0.057		8.49	0.025	1.40	8.7	143.2	ND	11.0	21.2	10.52	91.60		10.70	ND	ND	
LCSIL041.04	4/24/2007		ND	7.10	ND	ND	ND	ND	8.45	0.070	2.90	8.3	143.0	ND	ND	17.0	12.40	93.00	19.0	11.70	ND	ND	20.44
LCSIL043.84	6/28/2007		ND	6.90	ND	ND	0.063		9.17	0.070	3.00	8.6	147.0	1.0	11.0	32.6	23.20	95.00	19.0	13.00		ND	21.18
LCSLR001.42	11/16/2006	ND	ND	8.40	ND	ND	ND			0.022	1.40	9.6	170.2	2.1	ND	8.0	-0.27	108.90		1.77	ND	ND	
LCSLR001.42	3/7/2007		ND	7.60	ND	ND	ND		8.11	0.025	1.30	8.4	152.7	ND	6.0	9.4	-0.22	97.90		1.53	ND	ND	
LCSLR001.42	5/24/2007		ND	7.30	ND	ND	ND		8.79	0.040	1.50	9.0	177.0	ND	ND	19.6	14.08	115.00	20.0	1.69	ND	ND	53.84
LCSLR003.72	6/21/2007		ND	6.40	ND	ND	ND		8.33	0.050	1.60	8.7	171.0	ND	ND	29.7	16.36	111.00	20.0	2.23	ND	ND	67.31
LCWLR000.92	11/13/2006	ND	ND	1.80	ND	ND	0.063		8.38	0.020	1.70	3.5	53.0	2.6	7.0		5.40	34.00		4.78	ND	ND	
LCWLR000.92	3/26/2007	0.000065	ND	2.10	ND	ND	0.021		8.37	0.040	1.50	3.0	61.0	ND	5.0	16.7	8.26	40.00		6.15	ND	ND	
LCWLR000.92	6/12/2007		ND	1.50	ND	ND	0.065		8.24	0.050	1.80	3.2	55.0	ND	11.0	20.8	16.74	36.00	20.0	7.37	ND	ND	77.52
MRL	**--**	**0.00005**	**0.005**	**1**	**0.05**	**0.0002**	**0.02**	**0.02**	**--**	**0.02**	**0.5**	**1**	**1**	**1**	**4**	**--**	**--**	**--**	**--**	**0.01**	**0.05**	**0.05**	**--**
Units	***--***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***SU***	***mg/L***	***mg/L***	***mg/L***	***uS/cm***	***mg/L***	***mg/L***	***C***	***C***	***mg/L***	***None***	***NTU***	***mg/L***	***mg/L***	***None***

Appendix B – Raw Statistics

The summary statistics below include all variables where sufficient data was available for analysis. These statistics were compiled from the data presented in Appendix A. Half the mean reporting limit (MRL) was used for all non-detect values (ND). All values were calculated with a 95% confidence interval and an alpha=.05.

ALKPHEN	Q2	Q3	Q4
Mean	2.55	4.26	2.13
Standard Error	0.46	0.93	0.48
Median	1.00	1.00	1.00
Standard Deviation	2.67	4.28	3.37
Sample Variance	7.12	18.33	11.34
Range	10.00	13.00	19.00
Count	33.00	21.00	50.00
Coefficient of Variance	1.04	1.00	1.58

NH3	Q2	Q3	Q4
Mean	0.03	0.03	0.02
Standard Error	0.003	0.004	0.003
Median	0.022	0.025	0.010
Standard Deviation	0.020	0.020	0.024
Sample Variance	0.000	0.000	0.001
Range	0.07	0.07	0.09
Count	34.00	21.00	50.00
Coefficient of Variance	0.72	0.70	1.16

HARDCACO3	Q2	Q3	Q4
Mean	174.59	200.19	117.16
Standard Error	26.34	37.62	21.48
Median	125.00	140.00	72.00
Standard Deviation	153.57	172.40	151.88
Sample Variance	23585.28	29721.46	23068.38
Range	628.00	680.00	695.00
Count	34.00	21.00	50.00
Coefficient of Variance	0.88	0.86	1.30

ALKCACO3	Q2	Q3	Q4
Mean	170.71	187.33	102.18
Standard Error	20.39	21.13	11.27
Median	145.00	160.00	87.00
Standard Deviation	118.87	96.83	79.72
Sample Variance	14129.30	9376.03	6354.60
Range	430.00	352.00	380.00
Count	34.00	21.00	50.00
Coefficient of Variance	0.70	0.52	0.78

CA-T	Q2	Q3	Q4
Mean	39.73	46.87	26.35
Standard Error	6.09	8.92	4.85
Median	29.50	33.00	17.00
Standard Deviation	35.50	40.86	34.27
Sample Variance	1260.53	1669.57	1174.62
Range	147.00	164.70	157.30
Count	34.00	21.00	50.00
Coefficient of Variance	0.89	0.87	1.30

CO3	Q2	Q3	Q4
Mean	2.87	5.03	2.41
Standard Error	0.55	1.15	0.58
Median	1.00	1.00	1.00
Standard Deviation	3.22	5.26	4.08
Sample Variance	10.38	27.71	16.61
Range	12.00	16.00	23.00
Count	34.00	21.00	50.00
Coefficient of Variance	1.12	1.05	1.69

CHLORIDE	Q2	Q3	Q4
Mean	57.89	70.90	12.25
Standard Error	25.07	32.92	6.42
Median	2.50	7.90	2.50
Standard Deviation	146.20	150.87	45.40
Sample Variance	21375.00	22760.36	2061.37
Range	609.50	487.50	317.50
Count	34.00	21.00	50.00
Coefficient of Variance	2.53	2.13	3.71

CU-TRACE	Q2	Q3	Q4
Mean	0.00092	0.00095	*No data
Standard Error	0.00050	0.00018	
Median	0.00030	0.00080	
Standard Deviation	0.00271	0.00043	
Sample Variance	0.00001	0.00000	
Range	0.01480	0.00120	
Count	29.00	6.00	
Coefficient of Variance	2.96	0.46	

DO-MGL	Q2	Q3	Q4
Mean	9.42	9.60	8.96
Standard Error	0.21	0.27	0.27
Median	9.25	9.39	8.61
Standard Deviation	1.18	1.22	1.92
Sample Variance	1.40	1.50	3.69
Range	5.56	4.03	8.41
Count	33.00	21.00	51.00
Coefficient of Variance	0.13	0.13	0.21

DO-PERCENT	Q2	Q3	Q4
Mean	93.97	85.79	91.51
Standard Error	1.84	2.28	2.97
Median	95.70	88.10	83.00
Standard Deviation	10.56	10.44	21.24
Sample Variance	111.61	108.91	451.28
Range	44.30	36.70	104.50
Count	33.00	21.00	51.00
Coefficient of Variance	0.11	0.12	0.23

ECOLI	Q2	Q3	Q4
Mean	14.45	6.54	25.92
Standard Error	6.94	2.90	9.24
Median	4.00	2.00	4.00
Standard Deviation	39.23	12.63	59.87
Sample Variance	1539.27	159.58	3584.94
Range	212.00	49.00	262.00
Count	32.00	19.00	42.00
Coefficient of Variance	2.72	1.93	2.31

F-T	Q2	Q3	Q4
Mean	0.16	0.25	0.15
Standard Error	0.07	0.12	0.06
Median	0.05	0.05	0.05
Standard Deviation	0.39	0.53	0.42
Sample Variance	0.16	0.28	0.18
Range	2.28	2.45	2.95
Count	34.00	21.00	50.00
Coefficient of Variance	2.40	2.15	2.92

HARDNESS	Q2	Q3	Q4
Mean	171.47	197.48	114.83
Standard Error	25.47	36.44	21.40
Median	135.00	140.00	68.00
Standard Deviation	148.52	166.98	146.72
Sample Variance	22058.50	27881.06	21526.62
Range	599.00	658.00	655.00
Count	34.00	21.00	47.00
Coefficient of Variance	0.87	0.85	1.28

HCO3	Q2	Q3	Q4
Mean	203.32	218.86	120.92
Standard Error	23.99	23.57	13.40
Median	175.00	200.00	102.00
Standard Deviation	139.87	108.01	94.72
Sample Variance	19563.80	11666.53	8971.50
Range	527.00	409.00	457.00
Count	34.00	21.00	50.00
Coefficient of Variance	0.69	0.49	0.78

TKN	Q2	Q3	Q4
Mean	0.11	0.28	0.22
Standard Error	0.02	0.07	0.03
Median	0.08	0.21	0.17
Standard Deviation	0.09	0.31	0.20
Sample Variance	0.01	0.10	0.04
Range	0.33	1.51	1.28
Count	34.00	21.00	50.00
Coefficient of Variance	0.82	1.12	0.90

PB-D	Q2	Q3	Q4
Mean	0.00007	0.00009	0.00091
Standard Error	0.00002	0.00002	0.00080
Median	0.00003	0.00010	0.00020
Standard Deviation	0.00012	0.00005	0.00138
Sample Variance	0.0000	0.0000	0.0000
Range	0.00059	0.00011	0.00248
Count	31.00	6.00	3.00
Coefficient of Variance	1.67	0.50	1.52

MG-T	Q2	Q3	Q4
Mean	17.58	19.56	11.39
Standard Error	2.59	3.54	2.02
Median	12.00	12.00	7.00
Standard Deviation	15.12	16.22	14.26
Sample Variance	228.52	263.06	203.28
Range	57.07	58.90	63.50
Count	34.00	21.00	50.00
Coefficient of Variance	0.86	0.83	1.25

MN-T	Q2	Q3	Q4
Mean	0.06	0.08	0.05
Standard Error	0.01	0.02	0.01
Median	0.03	0.05	0.03
Standard Deviation	0.07	0.09	0.04
Sample Variance	0.005	0.007	0.001
Range	0.30	0.29	0.15
Count	34.00	21.00	50.00
Coefficient of Variance	1.24	1.04	0.77

NITRATEITE	Q2	Q3	Q4
Mean	0.10	0.17	0.02
Standard Error	0.08	0.15	0.00
Median	0.01	0.01	0.01
Standard Deviation	0.49	0.69	0.02
Sample Variance	0.2448	0.4827	0.0003
Range	2.89	3.19	0.06
Count	34.00	21.00	49.00
Coefficient of Variance	4.92	4.09	0.95

PH-FIELD	Q2	Q3	Q4
Mean	8.10	7.94	8.22
Standard Error	0.07	0.14	0.07
Median	8.08	8.16	8.24
Standard Deviation	0.34	0.65	0.48
Sample Variance	0.12	0.42	0.23
Range	1.29	2.78	2.28
Count	26.00	21.00	51.00
Coefficient of Variance	0.04	0.08	0.06

P-T	Q2	Q3	Q4
Mean	0.03	0.22	0.05
Standard Error	0.00	0.19	0.01
Median	0.02	0.03	0.04
Standard Deviation	0.02	0.87	0.05
Sample Variance	0.0005	0.7493	0.0021
Range	0.07	3.98	0.18
Count	34.00	21.00	50.00
Coefficient of Variance	0.75	3.89	0.89

K-T	Q2	Q3	Q4
Mean	2.249706	3.357143	1.79
Standard Error	0.44117	0.838668	0.365245
Median	1.45	1.5	1.05
Standard Deviation	2.57244	3.843262	2.582675
Sample Variance	6.617445	14.77066	6.670208
Range	12.75	14.4	16.75
Count	34	21	50
Coefficient of Variance	1.143456	1.144801	1.442835

NA-T Q	Q2	Q3	Q4
Mean	49.94	59.19	42.60
Standard Error	16.41	21.03	18.50
Median	11.00	15.00	6.05
Standard Deviation	95.67	96.37	130.78
Sample Variance	9152.67	9286.26	17103.81
Range	389.00	277.20	668.90
Count	34.00	21.00	50.00
Coefficient of Variance	1.92	1.63	3.07

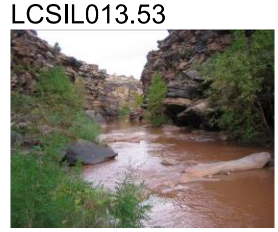
SPCOND-FIELD	Q2	Q3	Q4
Mean	392.77	608.46	340.80
Standard Error	84.99	156.07	118.45
Median	213.60	284.80	147.00
Standard Deviation	488.24	715.22	812.08
Sample Variance	238382.19	511537.1	659479.2
Range	2039.00	2381.00	4274.00
Count	33.00	21.00	47.00
Coefficient of Variance	1.24	1.18	2.38

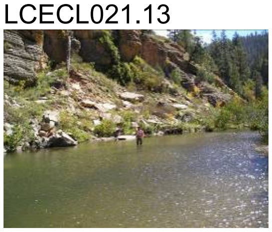
SO4-T	Q2	Q3	Q4
Mean	42.25	60.13	37.36
Standard Error	16.42	25.49	16.04
Median	4.20	2.10	0.50
Standard Deviation	95.77	116.83	113.44
Sample Variance	9172.22	13649.37	12868.27
Range	429.50	429.50	489.50
Count	34.00	21.00	50.00
Coefficient of Variance	2.27	1.94	3.04

TDS-FIELD	Q2	Q3	Q4
Mean	211.10	323.50	224.41
Standard Error	43.26	82.77	77.93
Median	128.10	181.10	96.50
Standard Deviation	248.49	379.29	528.58
Sample Variance	61747.6	143863.3	279397.0
Range	1259.75	1492.00	2738.00
Count	33.00	21.00	46.00
Coefficient of Variance	1.18	1.17	2.36

TURBIDITY	Q2	Q3	Q4
Mean	15.00	18.31	10.09
Standard Error	4.89	4.77	2.17
Median	4.78	9.42	5.92
Standard Deviation	28.07	21.84	14.85
Sample Variance	788.08	477.02	220.41
Range	139.43	88.90	80.57
Count	33.00	21.00	47.00
Coefficient of Variance	1.87	1.19	1.47

APPENDIX C - SITE PHOTOS

List of Photo's by Site Identification Number			
LCBEN002.57 	LCELR000.13 	LCLCR342.03 	LCSHL026.50 
LCBRB000.27 	LCELR007.19 	LCLCR360.06 	LCSHL031.05 
LCBRB006.74 	LCHAL004.59 	LCLVL001.32 	LCSIL006.13 
LCCHC060.61 	LCHAL005.62 	LCMIN018.05 	LCSIL013.53 
LCCHC081.26 	LCHAL008.83 	LCMLK001.18 	LCSIL024.83 
LCCLE000.69  File Missing	LCHAL010.20 	LCMRS043.17 	LCSIL041.04 

List of Photo's by Site Identification Number			
LCCLE063.52 	LCLCR211.73 	LCNUT012.99 	LCSIL043.84 
LCCOY000.71 	LCLCR216.67 	LCRDF015.45 	LCSLR001.42 
LCECL018.17 	LCLCR226.31 	LCRIG004.87 	LCSLR003.72 
LCECL021.13 	LCLCR311.31 	LCRUD003.45 	LCWLR000.92 
LCECL040.69 	LCLCR340.02 	LCRUD007.23 	

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