

Protocols for Long Term Monitoring of Water Quality

**Black Canyon of the Gunnison National Monument
Curecanti National Recreation Area**



**National Park Service
United States Department of Interior**

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Black Canyon of the Gunnison National Monument/Curecanti National Recreation Area

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1.0 Introduction

In 1993, Curecanti's water quality monitoring program was reviewed and a consensus reached that a threats based monitoring program be devised. To that end, the monitoring program that had been established since 1988 was revised for the 1993 monitoring season. A copy of the trip report by Barry Long is attached to this protocol and serves as guidance for the 1993 modified sampling program (see Appendix B). A history of water resources correspondence and action is noted in Appendix C.

In 1994, Curecanti underwent a water resources scoping process that resulted in the Curecanti National Recreation Area Water Resource Scoping Report (NPS, 1995a) and a Water Resources Management Plan (NPS, 1996).

The latter document notes:

- The threats-based program continue on a cyclical basis, and that new sites will be adopted when prompted by imminent or potential threats to the water resources. Where appropriate, biological monitoring of macroinvertebrates will occur according to the methodology outlined in this monitoring protocol.
- Each year, when new sites are added to the program, a new list of sites and parameters will be attached to the protocol. The protocol will serve as the document which contains lists of all sites sampled within a sampling period.
- Sites with three or more years of associated data may be dropped if the threat has diminished or if a site which might provide more information could prove fundamentally important to the program.
- The person responsible for the water quality monitoring program become familiar with the Curecanti NRA Scoping Report (NPS, 1995a), Hickman (1987), NPS (1986), Cudlip et. al. (1987), Curecanti Water Resources Management Plan (NPS, 1996), and Review of Curecanti Water Quality Report (NPS, 1995b). Several of these documents contain similar or identical literature reviews. The scoping report identifies specific issues to date and the management plan provides guidance in dealing with the issues.
- Data management should include appending the WRD database with new data. To date the park uses Microsoft ACCESS in the form of the "Resource Stewardship Data Management System". Data will be entered into this system immediately upon analysis and checked by another individual. H2O is Curecanti NRA's original database in Dbase IV format, and ANALY was developed by the Water Resources Division to include STORET codes. Data stored in MS Access can be transferred to the Environmental Protection Agency's STORET database.
- All new sites will be located with the Geographical Positioning System and entered into the Geographical Information System. The 1981-1985, 1987-1992, and 1993-1994 sites are Curecanti NRA's GIS database.
- In 1996, the water quality program was extended to and sites established at Black Canyon of the Gunnison National Monument. These sites will also be included in the "Resource Stewardship Data Management System".

2.0 Sites

Sites may change as a result of choosing to cycle the monitoring program. A description of site locations is offered in Table 6 of Appendix D. This list will be updated any time a site is added.

All present and prior sampling sites and parameters measured are noted in the Curecanti Water Resources Scoping Report (1995) and in Appendix D of this document. When a new set of sampling sites is added and/or sites are dropped, a new table of sites will be added and the sampling period noted for that set of sites.

In 1995, the three historic Gunnison River sites were dropped, because the US Geological Survey, through their NAWQA program sampled at both the East Portal site (GR01) and at the Riverway site (GR07). Park staff maintained the same six Blue Mesa Reservoir sites, and added one site each on Crystal and Morrow Point Reservoirs (CL04 and MPL6). The site names and locations correspond to the same sites used in the 1981-1985 sampling program. The stream sites include WEC1, BC01, PC01, CUR1, CM10, Steuben Creek (STC1), Red Rock Canyon (RRC1), Gunnison River at Red Rock Canyon (GR08), Lake Fork of the Gunnison at Red Bridge (LF01), and Cebolla Creek (CB1A) at Powderhorn. The latter two were added to acquire water quality data on stream systems that provide a fairly large portion of water to Blue Mesa. Also the Upper Gunnison River Water Conservancy District is interested in the water quality of the two rivers.

2.1 Timing of Sampling and Sampling Period

In 1997, a two season sampling protocol was adopted to obtain a year round view of water quality for Curecanti and Black Canyon. A limited number of stream sites are sampled from late November through late April or until icing occurs on the lake. A full compliment of lake and stream sites are sampled from early May through December, until icing occurs on the lake, or snow prohibits access to regular stream sites. Table 10, Appendix D outlines which sites are sampled at which times of year and for what parameters.

Samples are taken every three weeks for each seasonal protocol. Metals, hardness, and alkalinity samples are taken for the Colorado Division of Wildlife Water Watch Network, in conjunction with each sampling. Coliform samples for swimming beaches are taken every two weeks beginning before Memorial Day. Seven to eight rounds of sampling are completed for the summer season and seven to eight rounds for the winter season. Access to stream sites during late fall, winter, and early spring sampling is based on weather and icing conditions. Best judgment for access to these sites should be used during these times.

Most of the tributaries flow into one of the reservoirs, and therefore are affected by rise and draw-down of the individual reservoirs. Actual sampling sites are adjusted such that samples are taken from a segment of the stream which runs freely and is not influenced by slack water of the reservoir. Most stream sites, however, are already set up to alleviate any problems with slack water.

3.0 Parameters

Numerous water quality parameters are measured at each site and can include analysis for chlorophyll a (mg/m^3), pH, air and water temperature ($^{\circ}\text{C}$), dissolved oxygen (mg/L), specific conductance ($\mu\text{S}/\text{cm}$), fecal coliform (CFU/100ml), turbidity (NTU), flow (cfs), and nutrients. Nutrients (mg/L) include total phosphorus, soluble reactive phosphorus (ortho-phosphate), total Kjeldahl nitrogen, ammonia, and nitrate. The two latter nutrients are only measured on waters from Cimarron Creek and Red Rock Canyon.

In 1995, the park partnered with the Colorado Division of Wildlife (CDOW) to document hardness and alkalinity, and metals levels at selected stream sites. To date, Lake Fork of the Gunnison at Red Bridge, Cebolla Creek at Powderhorn, Cimarron River below the campground, Curecanti Creek at the first bridge, and Red Rock Creek at the mouth of the canyon are sampled for these parameters. Metals samples are collected in small bottles and sent to the CDOW labs for analyses while hardness and alkalinity are performed in-house. Directions for collection and analysis are provided below and can be found in detail in the blue binder from the Colorado Division of Wildlife Water Watch Network.

3.1 Methodology

Chlorophyll a, Secchi depth, nutrients, coliform, and basic parameters (pH, specific conductance, dissolved oxygen, and depth) are measured at each of the reservoir sites. Nutrients, basic parameters, coliform, flow, and turbidity are measured at stream sites. Two sites, CL04 and MPL6, are considered reservoir sites although they are more lotic habitats. These sites are measured for only basic parameters and nutrients. Beginning in 1997, stream and reservoir samples for nutrients and turbidity, will be done somewhat differently. In addition, a duplicate sampling procedure will be employed for a selected stream or reservoir site for quality assurance and quality control (QA/QC) during each round of sampling.

3.1.1 Reservoir sites

A discrete sampler will be used to eliminate possible contamination of nutrient samples from surface films. The sampler is first rinsed in native (reservoir) water to eliminate any residual water from the previous site. The sampler is then lowered to a depth of 1 meter below the surface and triggered to collect the sample. A small amount of sample is decanted into the 500 ml sample bottle, rinsed, and discarded. This is done twice. The remaining sample is decanted into the 500 ml sample bottle. The discrete sampler is then thoroughly rinsed with DI water before the next site is sampled.

3.1.2 Stream sites

Equal-width-increment sampling will be employed to reduce sampling bias from grab samples. A detailed account of equal-width-increment sampling can be found in Edwards and Glysson (1988). For our purposes, however, we have adopted protocols similar to those used by the National Water-Quality Assessment Program (NAWQA) run by the United States Geological Service (Shelton, 1994). Materials used include a DH-81 vertical composite sampler with wading rod, 1/4 and 5/16 Teflon nozzles, and 3 liter and 500 ml sample bottles.

3.2 Temperature (°C), pH, DO (mg/L), Specific Conductance (μS/cm):

Basic parameters are measured using the Scout II Hydrolab. The hydrolab is always calibrated before using it in the field. Follow the instructions in Section 3 of the H2O Operating Manual. The Hydrolab calibration should hold for the four day sampling period, but if unusual readings begin turning up, the unit should be re-calibrated. The following table lists the order of calibration.

Table 1. Order of Hydrolab Calibration

Order	Parameter	Solution
1 st	Dissolved Oxygen	DI Water
2 nd	Conductivity	.005 M KCl
3 rd	pH 7.00	pH 7.00 Solution (Yellow)
4 th	pH 10.00	pH 10.00 Solution (Blue)

A stock .5 M KCl solution is prepared by measuring **EXACTLY** 32.275 g of anhydrous KCl into the 1000 ml volumetric flask. Add DI water to line. .005 M KCl, used for calibration, is prepared by pipetting 10 ml .5 M stock KCl solution into the 1000 ml volumetric flask. Add DI water to line.

The Hydrolab unit is rinsed twice with DI water and twice with the next standard prior to the next calibration step.

Example: After the conductivity calibration, the unit is rinsed twice with DI water. The unit is then rinsed twice with pH 7.00 solution to eliminate any possible dilution from the DI water. The receptacle is refilled with pH 7.00 standard and calibrated.

3.2.1 Reservoir sites

The sonde unit is placed into the water such that the probes extend approximately 1 m below the water surface. The unit is turned on, left to equilibrate for 2 minutes or until the dissolved oxygen reading stabilizes. Measurements are then recorded. **IT IS VERY IMPORTANT THAT THE STIRRING UNIT IS OPERATING AT RESERVOIR LOCATIONS.** To ensure this, power up the unit before deploying the sonde and check the stirring unit.

Beginning in 1994 the hydrolab will be used to profile each of the reservoirs and particularly each of the basins within Blue Mesa Reservoir. Historical profiling sites will be used in Blue Mesa Reservoir. Representative sites will be selected within the other reservoirs. The basic parameters will be measured every meter starting at the surface down to 20 meters and thereafter every 5 meters. These measurements will coincide with water quality sampling efforts which take place every three weeks during open water.

3.2.2 Stream sites

The sonde unit is placed as close to mid-channel as possible and left to rest on the channel bottom. The unit is turned on, left to equilibrate for 2 minutes or until the dissolved oxygen reading stabilizes. Measurements are then recorded.

3.3 Nutrients (mg/L)

3.3.1 Reservoir sites

The discrete sampler is first rinsed in native (reservoir) water to eliminate any residual water from the previous site. The sampler is then lowered to a depth of 1 meter below the surface and triggered to collect the sample. A small amount of sample is decanted into the 500 ml sample bottle, rinsed, and discarded. This is done twice. The remaining sample is decanted into the 500 ml sample bottle. **DO NOT DISCARD THE REMAINING DISCRETE SAMPLE.** The remaining sample may be used to fulfill other parameters and QA/QC samples. If this site has not been chosen as a duplicate sample, then the sample may be discarded. The discrete sampler is then thoroughly rinsed with DI water before the next site is sampled. The nutrient sample bottle must be kept cold during the rest of the day and delivered to Ann Gery at Mountain Meadows Research Center behind Western State College immediately upon completion of the sampling day. A courtesy call is usually made to Ann Gery to let her know when samples will be delivered or if the sampling schedule has changed.

3.3.2 Stream sites

Nutrient sampling at stream sites is dependent upon stream discharge. Flow during early spring and mid-summer may not allow safe access to the streams. If a grab sample is collected, a note must be made on the data sheet and in the corresponding record within the database. If flow is low enough to allow access to the stream, then equal-width-increment sampling is employed to collect nutrients. A tape measure is first stretched across the channel. A flow measurement is made at mid-channel at the .6 feet depth. This measurement is made to determine the vertical transit rate for the DH-81 sampler. The vertical transit rate and operational depth is a function of the stream velocity, sample-container volume, and nozzle size. The following chart lists the recommended vertical transit rates and the maximum depths for isokinetic sampling based on sampler and nozzles.

Table 2. Nozzle Diameter vs. Maximum Vertical Transit Rate

Nozzle diameter (inches)	Ratio
1/4	.4
5/16	.4

The following equation determines the maximum vertical transit rate (MVTR) in feet per second.
Stream velocity x Ratio = MVTR

The indented notches on the DH-81 wading rod denote one foot increments. The DH-81 sampler and appropriate sized nozzle is attached to the wading rod and rinsed in native water several times before attachment of the sample bottle. Best judgment should be used in determining which nozzle size to use. Use the small nozzle for high flows, and the large nozzle for low flows. **DO NOT OVERFILL THE 3 LITER SAMPLE BOTTLE.** Use 5-10 increments for cross sections less than 5 feet wide and a minimum of 10 increments in streams 5 feet wide or greater. A maximum of 20 increments should be used in extremely wide, shallow cross sections. The sample verticals should be spaced at least 6 inches apart. A 3 liter collection bottle is rinsed twice with native water before being attached to the DH-81. Samples taken throughout the water column across the stream channel, facing into the flow. Be sure to keep the sampler and nozzle in front to avoid kicking sediment into the sample.

A small amount of composite sample is decanted into an empty 500 ml sample bottle, rinsed, and

discarded. This rinse is done twice. The 500 ml sample bottle is then filled with composite sample. **DO NOT DISCARD THE REMAINING COMPOSITE SAMPLE.** The remaining sample may be used to fulfill other parameters and QA/QC samples.

3.4 Fecal Coliform Bacteria (CFU/100ml)

Fecal coliform samples are collected at selected stream, beach, and reservoir sites.

3.4.1 Beach sites

Two sterile whirlpak samples are collected from these sites. These are collected directly off of the beaches in the early morning before strong winds disturb the sediment. The inside of the whirlpaks must be kept sterile before and after sample collection. **DO NOT TOUCH OR BREATHE INSIDE OF THE WHIRLPAK BAGS.** The bags are labeled with the appropriate site label. These samples are kept on ice in the cooler and are processed in-house according to the methods outlined in Appendix A.

3.4.2 Stream sites

Two sterile whirlpak samples are collected from these sites. These are collected as close to mid-channel as possible as a grab sample. The inside of the whirlpaks must be kept sterile before and after sample collection. **DO NOT TOUCH OR BREATHE INSIDE OF THE WHIRLPAK BAGS.** The bags are labeled with the appropriate site label. These samples are kept on ice in the cooler and are processed in-house according to the methods outlined in Appendix A.

3.4.3 Reservoir sites

Two sterile whirlpak samples are collected from these sites. These are collected from the surface as a grab sample. The inside of the whirlpaks must be kept sterile before and after sample collection. **DO NOT TOUCH OR BREATHE INSIDE OF THE WHIRLPAK BAGS.** The bags are labeled with the appropriate site label. These samples are kept on ice in the cooler and are processed in-house according to the methods outlined in Appendix A.

The incubator should be turned on at least 2 hours before petri dishes are placed inside. The results from the two plates at each site are averaged and recorded.

In fall of 1995, equipment was purchased to analyze for fecal bacteria on an in-house basis. The methods are found in Appendix A.

3.5 Chlorophyll a (mg/m³)

A 5m long PVC pipe is used to collect a chlorophyll sample at each reservoir site. This procedure is best accomplished with two people (one to work the sampler and one to hold the composite bucket). At the site the tube is plunged perpendicularly into the water up to the 5 meter mark (a black line). The cord is pulled in order to stopper the end of the tube. The captured water is decanted into a 5 gallon bucket to ensure proper mixture of the sample. One liter of this sample is collected and placed immediately into the cooler. Light exposure to the chlorophyll samples is avoided by keeping the cooler lid closed. The chlorophyll is extracted according to the methodology outlined in Appendix A.

3.6 Turbidity (NTU)

Turbidity is monitored only at stream sites. The Hach turbidity meter should be turned on and left at the 1000 ntu setting **AT LEAST 24 HOURS** before sample analysis.

The remaining sample collected during the equal-width-sampling nutrient procedure will be used to measure turbidity. Decant a small amount of composite sample water into an appropriately labeled 125 ml sample bottle and discard. Next fill the 125 ml bottle with composite sample water. Instructions for calibrating the unit are on top of the turbidity meter, however, the park lacks the correct calibrating standards. Therefore, a modified calibration is employed. The calibration standard used depends on the visible clarity of the sample. The following table illustrates which calibration standards are used under differing circumstances.

Table 3. Turbidity Standards

Visible water clarity	Primary Standard	Secondary Standard
Clear	.61	.925
Somewhat Cloudy	.61	.925
Very Cloudy	20	92

Once the unit has been calibrated, the sample is decanted into the clean, dry sample cuvette. The cuvette is placed in the turbidity unit and the extension cap immediately placed over the top. The correct range is selected, and a reading taken immediately. Do not measure the drift of the instrument. Record the first reading immediately after the sample is inserted and the extension cap placed over the top.

3.7 Flow (cfs)

Flow is measured at each stream site when the streams are accessible. Best judgment should be used during winter sampling since icing may not give a representative discharge of the particular stream. Items needed for flow measurements include the increment wading rod, either the Mini current meter (small) or AA (large) current meter, and the digimeter digital display. The Mini current meter is used for periods of low flow and the large, AA meter used for periods of high flow.

A representative cross-section of the stream where the flow is uniform is selected. This site should be used on a continuous basis. A tape measure is suspended across the channel, and the total distance is noted on the datasheet. The correct type of head-unit must be selected in the display unit. The following table illustrates which current meters and digimeter settings are used under what conditions.

Table 4. Current Meter Choice for Maximum Flow

Current Meter	Whisker Type	Maximum Flow
Mini	Whisker-1	5.0 ft/sec
AA	Whisker-1	>5.0 ft/sec
AA	Whisker-5	>5.0 ft/sec

Whisker-1 and Whisker-5 settings on the AA current meter are employed by selecting the appropriate wire contact. Whisker-5 records every 5 revolution and is used when flows are exceedingly high. Wading measurements in flows of this magnitude is probably not a good idea. For the most part, the Mini and AA Whisker-1 meters will be used for flow measurements at BLCA/CURE.

Flow and depth are measured every 1 to 2 feet according to the width of the stream. The display unit takes reading every second for a forty second time period and averages these readings. A

minimum of five to ten points should be sampled across the stream channel. Measurements are taken at .2, .6, and .8 depths at each point depending on stream depth. Overall discharge for the channel can be calculated by replacing the number in the Excel spreadsheet called Flow.xls. Once overall discharge is calculated, it is recorded on the WQ datasheet for the corresponding site. See Appendix E. Flow for CM10, LF01, and GR08 can be obtained from the USGS Water Resources of Colorado water data server: http://webserver.cr.usgs.gov/water_data.html/.

3.8 *Secchi depth (m)*

The Secchi depth is taken at each reservoir station. The Secchi disc is lowered into the water on the sunny side of the boat until the disk can no longer be seen. The disk is then raised until the disk is visible. The line at water level is noted, and the disk brought on board. The distance, in meters, which the disk extended is measured on the line. The technician should not wear sunglasses when she or he is taking the measurement.

4.0 QA/QC Samples

Quality control and quality assurance samples are collected to ascertain that proper standard procedures are being followed for sample collection and analysis. During every sampling period a site is randomly selected for duplicate sample and analysis. Site selection is accomplished through the Resource Stewardship Data Management System. A button on the water quality form randomly selects sites for either winter or summer sampling schemes. See Figure 1. A site may be randomly selected again for the next sampling period. This selection should be made prior to beginning the sampling period so that bottles, whirl-paks, and other sampling items can be appropriately labeled. Duplicate samples are named similarly to the normal sample with the exception of a "D" at the end. An example of a duplicate collected at Lake Fork at Red Bridge would be named "LF01D".

4.1 Nutrient Duplicates

Duplicates collected for nutrients are field split from the equal-width composite sample. Duplicate samples are collected, handled, rinsed, poured, and analyzed exactly like their standard counterparts. Nutrient sample duplicates, however, are considered "blind dups" and receive no labeling other than "Duplicate" on the 500 ml bottle. A note of which sample is the QA/QC site is made on the datasheet. The nutrient sample is delivered to Mountain Meadow Research Center and the site from which it was collected never divulged to the analyst.

4.2 Turbidity Duplicates

Duplicate turbidity samples are lab splits from the 125 ml sample bottle collected in the field. Essentially, another analyte is poured directly from the sample bottle after the standard sample is analyzed.

4.3 Fecal Coliform Duplicates

Duplicate fecal coliform samples are collected in the field and **NOT SPLIT**. Two extra whirlpak bags, labeled accordingly, are collected in mid-channel for stream sites and surface grab samples for reservoir sites, of the sample site in addition to the standard samples. These samples are analyzed according to the standard methods outlined in Appendix A.

Duplicate data are entered in the Resource Stewardship Data Management System via a button on the standard water quality form. See Figure 1. All duplicate data are entered into the specific site record. Data for basic parameters (pH, conductivity, dissolved oxygen, water and air temperature) are re-entered into the duplicate form. There is no certifiable method for duplicate samples using the H2O Hydrolab so standard data is used.

5.0 Aquatic Macroinvertebrates

Once per year, usually mid to late July depending on run-off, aquatic macroinvertebrates are sampled at each of the stream and tributary sites. In 1993, two samplings occurred, one in July and the other in September. From 1994 through 1995, macroinvertebrates were sampled according to the Level III Rapid Bioassessment Technique (EPA, 1989). In 1996, techniques were changed since the EPA technique is accurate only when numbers of organisms per sample is high. The EPA technique takes into account only the first 100 organisms picked per sample. Most of the macroinvertebrate samples collected at CURE rarely contain 100 organisms.

Prior to 1995, a 1 foot square Surber sampler was used to collect macroinvertebrates at stream sites. In 1995, a 13 inch diameter Hess sampler was purchased. IF macroinvertebrate data are ever analyzed for the number of organisms per square meter, then this change must be corrected in the calculations.

At each site which is located at riffles near the water quality sampling site, three (3) quantitative Hess samples are recovered across the width of the stream channel. Bottles are labeled accordingly.

Example labels for replicate macroinvertebrate samples collected at Pine Creek:

PC01-1
PC01-2
PC01-3

The substrate within the sampler is disturbed for approximately one minute to a depth of at least 10 cm. Large rocks should be delicately rubbed free of all detritus, periphyton, and organisms. Every attempt should be made to keep stream flow from entering the top of the sampler.* The contents in the cod-end are transferred to the 250 ml container. The net is rinsed several times in order to transfer all the contents. The sample is preserved with 70% ethanol with a volume equivalent to 30% of the liquid sample. The sample should be softly agitated to ensure proper mixture of the ethanol. **NEVER SHAKE THE SAMPLES ROUGHLY.** The organisms being collected are VERY fragile and will easily fall apart making identification nearly impossible.

In the laboratory, the invertebrates are picked from the debris and placed in vials containing 70 % alcohol. The organisms are pick into three categories; Trichoptera, Plecoptera, and Others. Small sample labels are included in each sample vial and include information on site, replicate, date, and county of collection. Green Teflon stoppers are used to cap the sample vials. Quality control calls for another individual to re-examine the samples enumerated by another picker. If 90% of the organisms were not collected in the first enumeration, all of that individual's samples must be re-picked and a random sample checked again. After picking the samples, the organisms are identified to genus and to species when possible.

* A small, round, plastic garbage can with the bottom cut out and a slit cut up the side can be used to extend the top of the sampler. In this case, a small garden trowel can be used to disturb the bottom material.

6.0 Data Management

All water quality data are entered into the computer as soon as the results are received. To date the park uses Microsoft ACCESS in the form of the "Resource Stewardship Data Management System". Data will be entered into this system immediately upon analysis and checked by another individual. To date, there is no set protocol for data QA/QC. H2O is Curecanti NRA's original database in Dbase IV format, and ANALY was developed by the Water Resources Division to include STORET codes. Data stored in MS Access can be transferred to the Environmental Protection Agency's STORET database.

Figure 1. Standard Water Quality Form From Database

The screenshot displays a software window titled "CURE Water Quality". It contains a grid of input fields for water quality data. A label "Select/Enter New WQ Sampling Sites" points to the "Site ID" field. The "Comments" field is a large text area on the left. At the bottom, a status bar shows "Record: 1045" and "1045/1048". Four buttons are labeled at the bottom: "View WQ Protocols", "View WQ Graphs", "Select Random Duplicate Sample", and "Enter Duplicate Sample Data".

Field	Value
Site ID	1040
Site Name	Charron below Squaw
Date	4/1/97
Time	09:10
Air Temperature	16
H2O Temp	2.48
pH	8.08
Conductivity	604
Dissolved O2	10.38
Secchi	-9.99
Total Nitrogen	4.48
Nitrate	0.22
Ammonia	0.24
Total Phosphorus	0.339
Soluble Reactive Phosphorus	0.117
Chlorophyll	0.00
Fecal Coliform	3
Flow (cfs)	17
Turbidity	87
Hardness	70
Phenolphthalein Alkalinity	8
Total Alkalinity	118

6.1 Duplicate Data

Duplicate data are entered by pressing the button on the water quality form which access the duplicate data form. Data are entered and compared with the standard sample data. If duplicate and standard data are not consistent more precise protocols should be followed for the next sampling period.

6.2 Macroinvertebrate Data

The macroinvertebrate data are entered into the aquatic invertebrate section of the data management system.

Figure 2. Macroinvertebrate Data Form From Database

The screenshot shows a software window titled "Aquatic Invertebrate:". The form contains the following fields and controls:

- Site ID:** A dropdown menu.
- Site Name:** Text field containing "West Elk Creek".
- Collection Date:** Text field containing "7/17/88".
- Order:** Text field containing "Ephemeroptera".
- Family:** Text field containing "Leptophlebiidae".
- Specimen Number:** Text field containing "1".
- Substrate Type:** Text field containing "Gravel".
- Comments:** A large empty text area.
- Buttons:** "Add", "Edit", "Delete", "Print", and "Exit".
- Record Navigation:** A bar at the bottom showing "Record 1470 of 1470".

Annotations with arrows point to the following elements:

- "Select Invertebrate Sampling Sites" points to the Site ID dropdown.
- "Select Enter New Invertebrate Genera" points to the Family text field.
- "View Invertebrate Richness" points to the Record navigation bar.

6.3 Fecal Coliform Data

Fecal coliform data for beach sites are also entered in this system. All data for beach sites should be added to this database.

Figure 3. Fecal Coliform Data Form From Database

The screenshot shows a software window titled "Fecal Coliform Beach Sites". The form contains the following fields and controls:

- Site ID:** A dropdown menu.
- Name:** Text field containing "Old Hwy 50 Beach".
- Date:** Text field containing "8/11/87".
- Time:** Text field.
- Air Temperature:** Text field containing "-9.99".
- Water Temperature:** Text field containing "-9.99".
- Colony Count:** Text field containing "4".
- Buttons:** "Add", "Edit", "Delete", "Print", and "Exit".
- Record Navigation:** A bar at the bottom showing "Record 1 of 22".

7.0 The Colorado Division of Wildlife Rivers of Colorado Water Watch Network

In 1995, the park partnered with the Colorado Division of Wildlife (CDOW) to document hardness and alkalinity, and metals levels at selected stream sites. Curecanti NRA now has five River Watch sites for which the CDOW pays for metals analyses.

7.1 Current River Watch Sites

The River Watch sites include the following:

Lake Fork of the Gunnison at the Red Bridge Campground

Cebolla Creek at Powderhorn

Cimarron River below the Camp Ground

Curecanti Creek at the first bridge

Red Rock Canyon at the mouth

These sites will be tested for alkalinity, hardness, and metals in addition to those parameters collected as part of the long-term monitoring program. The protocol which the CDOW wishes us to follow is in the Rivers of Colorado Water Watch Network book (big binder with a blue cover). For the Black Canyon/Curecanti sites, pH, specific conductance, dissolved oxygen, and temperature will be measured using the Hydrolab. Prior to taking measurements, the instrument will be calibrated according to Hydrolab directions.

7.1.1 Alkalinity and Hardness

Alkalinity and hardness will be measured using the green kit supplied by CDOW in the water lab. The analyst must keep track of solutions, bottles, and filters and order more from CDOW when running low.

7.1.2 Metals

Metals will be collected according to methodologies outlined in the River Watch manual. These samples will be preserved and kept in a refrigerator until they are sent to the CDOW on a bimonthly basis.

Samples at each of the sites will be collected every three weeks along with samples associated with the long-term monitoring program.

Individuals who collect water samples for the Curecanti/Black Canyon water sampling program must be trained in accordance with the River Watch protocols. These individuals will become familiar with all the collection protocols and with the data sheets, and the protocols for sending samples to the CDOW.

Table 5. Water Watch Site Labels

School: CURE River: Cebolla Cr Station Name: Powderhorn Station Number: 520.xxx	School: CURE River: LkFk Gunnison Station Name: Red Br Station Number: 521.xxx
School: CURE River: Cimarron Station Name: Camp Grd Station Number: 576.xxx	School: CURE River: Curecanti Station Name: 1 st Bridge Station Number: 574.xxx
School: CURE River: Red Rock Station Name: Mouth Station Number: 575.xxx	

7.2 Labels

Each metals bottle is labeled:

River
Station Name
Date
Sample No.
Filtered or Not Filtered

Every fifth sample taken for CDOW metals requires a duplicate and blank. A detailed description of how to collect these samples can be found in the Water Watch Network binder.

The Curecanti/Black Canyon water quality program relies on the Colorado Division of Wildlife Water Watch Program as a source of deionized water. A small 25 liter carboy is shipped to the CDOW to be refilled. The water is then added to the larger 50 liter carboy located in the water lab. The analyst must never run out of DI water. Once the 25 liter carboy is added to the 50 liter container, it should be immediately shipped for refill. If the Water Watch Program is discontinued for any reason at Curecanti/Black Canyon, there will no longer be an outlet for DI water.

8.0 Sample Bottles and Washing Procedures

Table 11 in Appendix D lists the size and types, and washing procedures of sample containers associated with each collection parameter.

8.1 Phosphorus free detergent wash

THE LAB SINK SHOULD NOT BE USED TO DISPOSE OF FOOD OR DRINKS. Bottles are washed in the clean lab sink with a very small amount of phosphorus detergent. The detergent is very concentrated so not much should be used. Washing procedures for those bottles requiring detergent washing and acid wash can be found in Table 11, Appendix D.

8.2 5% HCl wash

5% hydrochloric acid (HCl) wash is prepared by using 100 ml acid per 2000 ml DI water. **EXTREME CAUTION MUST BE USED WHEN POURING THE ACID. THE ROOM MUST BE PROPERLY VENTILATED.** 100 ml HCl is measured out in a clean graduated cylinder and transferred to the 2 L plastic container. The plastic container is then filled to the neck with DI water.

APPENDIX A. Analysis Methodology

Chlorophyll a Analysis

Chlorophyll a analysis takes place in-house. The following steps outline analytical procedures. **DIRECT EXPOSURE OF THE SAMPLES TO SUNLIGHT SHOULD BE AVOIDED DURING THIS PROCEDURE.**

1) Each 1 liter sample is filtered using glass fiber filters (GF/C or GF/A) in the old, scratched, gold colored Gelman filter unit. **DO NOT USE THE GELMAN FILTER UNITS FOR COLIFORM ANALYSIS.** Filters are promptly removed from the filtering apparatus, folded, placed in labeled petri dishes, and frozen until extraction takes place. Extraction can take place immediately if time allows.

2) To extract the chlorophyll, each individual filter is ground using the tissue homogenizer (glass grinder). A filter is placed in the grinder. Approximately 5 ml of 90% acetone is added to the tube. The filter is ground until no more filter material is present. The liquid is decanted into an appropriately labeled test tube. The grinding tube is rinsed two times (1-2ml) and the rinse material is added to the contents of the test tube. Be careful not to overfill the test tube. The tube should be about 1/2 full when complete. All test tubes are placed in a refrigerator overnight for extraction.

3) The samples are clarified by centrifuging for 20 minutes at 500g (the black line on the centrifuge). Loosen the caps on the test tubes to lessen the chance of breakage. The spectrophotometer is blanked to a 90% acetone solution at 630, 647, and 664 nm. 647 nm is blanked first. The machine is set to 0 absorbance. The 630 and 664 nm readings are blanked, but not set to 0 absorbance. The offset for each of these wavelengths is recorded and subtracted from each subsequent sample analysis. Each test tube sample is measured for volume and this volume recorded on the water quality data sheet. See Appendix E. The solution is transferred from the graduated cylinder to a spectrophotometer tube. Each sample is analyzed at 630, 647, 664nm and the offsets subtracted for 630 and 664. These data can be entered on the back of the water quality data sheet. See Appendix E. The optical density readings are used in the following equation.

$$\begin{aligned} \text{chl a} &= 11.85(\text{OD}_{664}) - 1.54(\text{OD}_{647}) - 0.08(\text{OD}_{630}) \\ \text{mg/m}^3 &= \text{chl a} \times \text{ml of solution in test tube} \end{aligned}$$

The Resource Stewardship Data Management System calculates mg/m³ of chlorophyll when the optical densities are entered for each sample.

Fecal Coliform Analysis

- 1) Two samples are collected in whirlpaks and brought back to the lab
- 2) The samples are processed according to Standard Methods, 15th Edition (909 C. Fecal Coliform Membrane Filter Procedure) (1980).
 - a) Filtration units consist of 2 side-arm flasks, 4 Gelman filter units, and a vacuum pump. An alcohol burner and forceps are used to aseptically move the filters from the units to the petri dishes. The filter units must be sterilized in the UV lamp chamber for a minimum of 3 minutes. The 4 filter units can be rotated (one set sterilizing while the other set is being used) to save analysis time.
 - b) 0.45µm filters are placed on the Gelman filter unit using sterilized forceps.
 - c) After gently shaking the sample, 100 ml from each is filtered through a sterilized 0.45µm filter. Use the graduations on the side of the Gelman filtration setup to measure the 100 mls. **DO NOT USE A GRADUATED CYLINDER OR ANY OTHER MEASURING INSTRUMENT.** This will contaminate the sample.
 - d) The petri dishes are pre-sterilized and have pads. The media must be kept in the refrigerator when not in use. One ampule of media, using aseptic technique, is emptied into each petri dish just prior to putting the filter onto it. The forceps are kept in a small amount of ethanol between use and flamed to remove any excess alcohol. The filters, using the sterilized forceps, are removed from the Gelman filters and each placed in a separate, appropriately labeled petri dish. Make sure that the filters are placed on the petri dish pads so that the entire filter touches the pad. **NO BUBBLES.**
 - e) In addition to field samples, a laboratory blank is prepared as the last sample each day. A full bottle of DI water is sterilized with the last preparation of Gelman filters. This "sample" is prepared just like the field samples and is labeled "c1", "c2", etc. depending on which day in the sampling scheme you are in. This blank should **NEVER** have colony growth. If colonies are present after incubation, more stringent aseptic techniques should be followed during the next sample preparation.
 - f) All petri dishes are labeled properly, and placed, upside-down to inhibit condensation dripping on colony formation, in the incubator at a temperature of $44.5 \pm 0.2^\circ\text{C}$ for 24 ± 2 hours.
 - g) Blue colonies are counted at the end of the 24 hour period.
 - h) Counts from the two samples per site are averaged and recorded as # of colonies/100ml.
 - i) If counts are too numerous to count over the entire filter, count a half or quarter and multiply that number appropriately.
 - j) If colonies are convergent and too numerous to count, the number 3500 should be recorded in the data base. Measures should be taken on the next sampling event for this site to collect smaller amounts of water, or a range of amounts so that an actual count can be established.

APPENDIX B. Barry Long Trip Report

Purpose: To participate in a Water Resources Issue Scoping Workshop conducted by the Staff of Curecanti National Recreation Area.

Itinerary: Traveled to the Park via government vehicle on April 12, 1994, accompanied by Janet Wise and Daryl Jennings from the Rocky Mountain Regional Office. Returned after the meeting adjourned on April 13, 1994. Mark Wondzell, of the Water Resources Division Water Rights Branch has been working with the Park in order to address water rights concerns in the scoping report, but did not travel to the Park for the workshop.

Contacts: See attached list of participants.

Discussion: We attended these meeting in response to a request for technical assistance from the Park and Region. The purpose of the workshop was to identify issues and management objective to be addressed in a Water Resources Scoping Report. Upon completion, this report will likely lead to a project proposal for preparing a Water Resources Management Plan for the Park.

The Park has a large amount of scientific study, data, and other records predominantly focused on water quality and fisheries management in Blue Mesa Reservoir. The information base for the other two reservoirs and in other topic areas is much less extensive.

Of the many issues identified, most of the high priority issues were the result of activities of the watershed that affected the quality and quantity for timing of flow downstream.

A major point of emphasis will be cooperative management efforts involving the Park and surrounding land owners and management agencies, and state and local governments. There is a long history of grazing and mining on the watershed, stream channelization and developments on the floodplains upstream of the Park. Development pressures are currently high in and near the resort town of Crested Butte and spilling into the town of Gunnison.

The Park is targeting mid-summer for completion of the scoping report.

Action Items:

- 1) Continued assistance in exploring the issues identified. Responsible Parties: Sharrow, Long Target Date: July 30, 1994.
- 2) Assist Park in developing the water rights sections of the scoping report. Responsible Party: Mark Wondzell. Target Date: July 30, 1994.

APPENDIX C. Time of Events Related to Water Resources

Resource Management Plan project statement (1984):

Discusses reasons for needing water resource management plan--high quality designation of CURE waters by Colorado Water quality Control Commission, potential threats--mining, abandoned mines, acid rain, irrigation, livestock/agriculture, sewage treatment plant, septic systems, development adjacent to CURE, uranium tailings.

Potential threats (sometime in 1986 fall):

Uranium tailings--projected to be moved in 1986, removal began fall 1992.
Swimming beaches--fecal contamination
new sewage treatment facility with experimental sterilization (UV)
Commercial development near Blue Mesa Reservoir
Sewage contamination indicated by studies of benthic organisms in 1984-5
Inadequate analysis of water quality parameters (some) in 1982-4 (detection limits too high)
Very little data available on lower reservoirs and their tributaries

Proposed water quality projects for 1987 (memo to Sam Kunkle from WHV, 6 Nov 1986):

Aquatic/water resources management plan
Monitoring water contact areas
Monitoring uranium tailings pollution
Monitoring commercial development

Memo to Terry Boyle about water projects (3 Dec 1986):

Monitoring of uranium tailings pollution (same as memo to Kunkle)
Monitoring of commercial development (same as memo to Kunkle)
Limnological survey--evaluate existing data, identify research needs
Re-introduction of the giant stonefly to Gunnison River (I think this has happened with help from Trout Unlimited)
Trout maturation study--why do trout only live about four years in Blue Mesa

Memo to Supt from WHV--summary of water resource work accomplished at CURE 1966-86, and concerns for 1987 (5 Jan 1987):

This includes a list of all? pertinent literature on Gunnison River/Blue Mesa from 1966-86
Has list of proposed projects for 1987--see memos to Kunkle and Boyle

Phone conversation between Alston? and Dave Mueller (USGS) (26 Feb 1987):

Selenium samples taken in 1982 and 1983 on Blue Mesa

Description of existing and proposed recreational and residential development sites within and/or adjacent to CURE (9 Mar 1987), sent to Mark Flora from WHV:

These are similar to previous descriptions of issues, but note specifics of each development site. Water quality monitoring continues at 8 of 10 sites described (2 were at Iola, we do 1 site there). We don't monitor Sapinero.

April 1994 Water Resources Scoping Meeting

1995 Curecanti National Recreation Area Water Resource Scoping Report published

1995-1997 Development of Water Resources Management Plan

APPENDIX D. Sampling Sites, Locations, and Parameters by Sampling Period

There are three defined periods of past sampling: **1982-1985, 1987-1992, and 1993-1994.** Analysis and a summary of water quality data can be found in the Curecanti NRA Scoping Report (NPS, 1995a), Hickman (1986), NPS (1986), Cudlip et. al. (1987), Review of Curecanti Water Quality Report (NPS, 1995), and this Curecanti Water Resources Management Plan (NPS, 1996).

Table 6. General Site Description

Site	Site Name	Description	UTMs/Elevation (m)		
BM01	Lake Fork Arm	Site is located directly underneath the second set of powerlines (those farther south) on the Lake Fork Arm of the Gunnison.	4257769.76	299398.15	2292.99
BM03	Haystack Gulch	Site located in the arm immediately east of Elk Creek Marina on the north side of the reservoir below the employee housing area and sewage lagoons. Sight on the large block of concrete on the west side.	4259434.24	311481.64	2291.24
BM04	Sunnyside	Site located on north side of BM reservoir at Old Stevens Creek. Lineup with the culvert draining underneath highway 50.	4261313.30	316844.96	2293.77
BM05	Iola	Site located at drainage east of Iola picnic shelters. Line up with small inlet below picnic area.	4260337.02	317274.64	2293.55
BM18	BM Highlands	Site located on south side of reservoir in Sapinero Basin. Line up east ridge of Soap Creek drainage with drainage north of the hwy. Note the small Ponderosa pine at the side of the drainage.	4260400.55	300305.72	2292.53
BM19	Elk Creek Marina	Site located at Elk Creek Marina. Line up with water supply pipe that climbs the hill. Stay in no wake zone, but away from boat docks.	4258766.55	311323.42	2293.76
WEC1	West Elk Creek	Site is located on West Elk Creek above slack water just north of the pit toilet.	4264337.54	301822.88	2300.60
PC01	Pine Creek	Site is located on Pine Creek, third set of steps down trail in large pool	4258197.32	295416.28	2246.90
BC01	Blue Creek	Site is located on Blue Creek downhill from the first west-bound turnout after entering Blue Creek Canyon.	4254636.49	289934.09	2465.94
CUR2	Curecanti Creek	Site is located above first bridge that crosses creek on Curecanti Creek Trail.	To date, not GPS'd		
CM10	Cimarron Creek	Site is located downhill from the campground on the pull-off.	4258249.77	277018.11	2101.12
STC1	Steuben Creek	Steuben Creek at north boundary of park. Site is ~1/8 of a mile north on county road 20 near the large boulder.	4262345.03	320363.08	2299.64
MPL6	Morrow Point Reservoir	Pine Cr Trail at first set of picnic benches. There is a small trail leading down to the site.	4258384.60	295325.88	2189.58
CL04	Crystal Res.	Across the second bridge on Mesa Creek trail, below Mesa Creek	4259175.38	277926.64	2064.66
LF01	Lake Fork of the Gunnison	Red Bridge BLM Campground	4243934.01	305336.71	2375.21
CB1A	Cebolla Creek	At Powderhorn to the north south of bridge crossing.	4238270.94	316630.38	2470.73
RRC1	Red Rock Creek	At the mouth of Red Rock Canyon near the campground on the Gunnison river. Site drops down off of steep embankment at the end of the trail.	To date, not GPS'd		
GR08	Gunnison River at Red Rock Canyon	Site is at the Campground <u>above</u> the mouth of Red Rock Creek	To date, not GPS'd		
14	Old Hwy 50	Beach site located on old hwy 50 west of Elk Visitor Center.	To date, not GPS'd		
15	Bay of Chicks West	Beach site located on west side of Bay of Chicks entrance road.	To date, not GPS'd		
16	Bay of Chicks East	Beach site located on east side of Bay of Chicks entrance road.	To date, not GPS'd		
17	Iola Beach	Beach site located off hwy 149 across from blue weather info sign	To date, not GPS'd		

Table 7. 1982-1985 Sampling Period

There were 48 sites on Blue Mesa (BML1-BML48), also 6 on the Gunnison River (GR1-GR7, no GR6 found on map), three of these were above Blue Mesa, and one below each dam. Crystal Reservoir had 4 sites (CL1-CL4), and Morrow Point had 6 sites (MPL1-MPL6). A number of tributaries were also sampled, as listed below:

Blue Mesa tributaries:

- SOAP Soap Creek
- LF1 Lake Fork
- RC1 Red Creek
- DG1 Dry Gulch
- EEC1 East Elk Creek
- Ceb1 Cebolla Creek (in Blue Mesa)
- CB1a Cebolla Creek (stream)
- NWC1 North Willow Creek
- SWC1 South Willow Creek
- SC1 Steuben Creek
- NBC1 North Beaver Creek
- SBC1 South Beaver Creek
- WEC1 West Elk Creek

Morrow Point tributaries:

- COR1 Corral Creek
- BC1 Blue Creek
- CUR1 Curecanti Creek
- PC1 Pine Creek

Crystal tributaries:

- CYC1 Crystal Creek
- MC1 Mesa Creek
- CIM1 Cimarron Creek (mouth)
- CIM2 Cimarron Creek (near E. Cimarron picnic area)

The above sites had the following parameters measured at them, at least one time:

Air Temperature, Water Temperature, Discharge, Depth, Elevation, Conductivity, pH, Dissolved oxygen, Secchi depth, Total Dissolved Solids, Total Suspended Solids, Fecal coliform, Fecal streptococcus, Total acidity, Total alkalinity, Ca, Cl, Mg, Organic-N, TKN-N, NH_3/NH_4 , $\text{NO}_3\text{-N}$, Na, SO_4 , K, P-ortho, P-total, Hardness.

Table 8. 1987-1992 Sampling Period

Site	Site Name
BM01	Lake Fork Arm (on Blue Mesa Reservoir)
BM02	Lake Fork Marina
BM03	Haystack Gulch
BM04	Sunnyside
BM05	Iola
NW06	North Willow downstream from Blue Mesa Rec. Ranch
GR07	Riverway on Gunnison River
CM08	Cimarron Creek above confluence with Squaw Creek
SC09	Squaw Creek above confluence with Cimarron Creek
CM10	Cimarron Creek below confluence with Squaw Creek
NW11	North Willow upstream from Blue Mesa Rec. Ranch
CM12	Cimarron Creek at E. Cimarron picnic area
BM13	McIntyre Gulch
BM18	Blue Mesa Highland RV park

The above sites had the following parameters measured at them, at least one time:

Air Temperature, Water Temperature, Conductivity, pH, Dissolved oxygen, Secchi depth, Total Dissolved Solids (until July 1992), TKN-N, P-total, SRP, and Fecal coliform.

In addition, all lake sites (BM##) had chlorophyll a measured in a 5m X .025m cylinder of water. The 3 Cimarron sites, and the Squaw Creek site had NH₃, and NO₃/NO₂ nitrogen measured as well.

There are also 4 swimming beach areas that are monitored for fecal coliform only: BM14-BM17.

Table 9. 1993-1994 Sampling Period

SITE#	SITE NAME	PARAMETERS *
BM01	Lake Fork Arm	Nutrients, Chl a,
BM03	Haystack Gulch	Nutrients, Chl a, Fecal Coliform
BM04	Sunnyside	Nutrients, Chl a, Fecal Coliform
BM05	Iola	Nutrients, Chl a, Fecal Coliform
GR07	Riverway	Nutrients, Fecal Coliform
14	Old Hwy 50 Beach	Fecal Coliform
15	Bay of Chickens W.	Fecal Coliform
16	Bay of Chickens E.	Fecal Coliform
17	Iola Beach Site	Fecal Coliform
BM18	BMH Site	Nutrients, Chl. a, Fecal Coliform
BM19	Elk Creek Marina	Nutrients, Chl. a.
GR4A	Cooper Ranch	Nutrients
WEC1	West Elk Creek	Nutrients, Fecal Coliform
PC01	Pine Creek	Nutrients, Fecal Coliform
BC01	Blue Creek	Nutrients
CUR2	Curecanti Creek	Nutrients, Fecal Coliform
CM10	Cimarron below Squaw	Nutrients, Fecal Coliform
CYC1	Crystal Creek	Nutrients, Fecal Coliform
GR01	Black Canyon	Nutrients, Fecal Coliform

* Water and air temperature, dissolved oxygen, pH, and specific conductance are measured at each site with the exception of the four beach sites.

Table 10. 1995 - Present

SITE#	SITE NAME	Season	PARAMETERS *	Schedule
BM01	Lake Fork Arm	Summer	Nutrients, Chl a, Fecal Coliform	Day 1
BM03	Haystack Gulch	Summer	Nutrients, Chl a, Fecal Coliform	Day 1
BM04	Sunnyside	Summer	Nutrients, Chl a, Fecal Coliform	Day 1
BM05	Iola	Summer	Nutrients, Chl a, Fecal Coliform	Day 1
BM18	BMH Site	Summer	Nutrients, Chl. a, Fecal Coliform	Day 1
BM19	Elk Creek Marina	Summer	Nutrients, Chl. a., Fecal Coliform	Day 1
WEC1	West Elk Creek	Summer	Nutrients, Fecal Coliform, Flow, Turbidity	Day 1
PC01	Pine Creek	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity	Day 2
BC01	Blue Creek	Summer	Nutrients, Fecal Coliform, Flow, Turbidity	Day 2
CM10	Cimarron below Squaw	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW	Day 2
MPL6	Morrow Pt Res Below Pine Creek	Summer	Nutrients	Day 2
CL04	Crystal Res. Below Mesa Creek	Summer	Nutrients	Day 2
CUR2	Curecanti Creek	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW	Day 3
CB1A	Cebolla Creek	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW	Day 3
STC1	Steuben Creek	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity	Day 3
LF01	Lake Fork	Summer/Winter	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW	Day 3
GR08	Gunnison R - Red Rock Canyon	Summer	Nutrients, Fecal Coliform, Turbidity	Day 4
RRC1	Red Rock Canyon	Summer	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW	Day 4
14	Old Hwy 50 Beach	Summer	Fecal Coliform, Air Temp, H ₂ O Temp	Every 2 Weeks
15	Bay of Chickens West	Summer	Fecal Coliform, Air Temp, H ₂ O Temp	Every 2 Weeks
16	Bay of Chickens East	Summer	Fecal Coliform, Air Temp, H ₂ O Temp	Every 2 Weeks
17	Iola Beach Site	Summer	Fecal Coliform, Air Temp, H ₂ O Temp	Every 2 Weeks

* Water and air temperature, dissolved oxygen, pH, specific conductance are measured at each site with the exception of the four beach sites. Water and air temperature is measured at beach sites. Nutrients include Total Kjeldahl Nitrogen, Total phosphorus, orthophosphate. Ammonia and nitrate are only measured at CM10 and RRC1. CDOW denotes metals and hardness and alkalinity taken at only selected sites. Flow for CM10, LF01, and GR08 can be obtained from the USGS Water Resources of Colorado water data server: http://webserver.cr.usgs.gov/water_data.html/.

Table 11. Containers and Analysis for Specific Parameters

Parameter	Container	Analysis	Washing Procedures
Nutrients	500 ml wide mouth Nalgene. (Stream sites are collected and composited in 3 L wide mouth Nalgene)	Mountain Meadows	1 soak and wash in phosphorus free detergent 1 vigorous rinse with warm tap water 1 vigorous rinse with 5% HCl solution 2 rinses with DI water
Turbidity	250 ml Nalgene (Stream sites are collected and composited in 3 L wide mouth Nalgene)	In house	2 vigorous rinses with DI water
Fecal Coliform	2 Sterile whirlpak bags	In house	Disposable
Hardness/Alkalinity	250 ml Nalgene	In house	3 vigorous rinses with DI water
Metals	60 ml Nalgene with 12 drops HNO ₃	CDOW	N/A
Metals Collection	60 ml Syringe/Filter Assembly	N/A	Per Water Watch protocols
Chlorophyll a	100 ml Nalgene	In house	2 vigorous rinses with DI water

Appendix E Forms Associated With Water Quality

Figure 4. Sample DI-1 for Nutrient Analysis

• [The 100 Best Restaurants in America](#)

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Figure 6. Water Quality Field Data Sheet

Water Quality Data

Site	Date	Time	Air Temp °C	H ₂ O Temp °C	pH	Cond µS/cm	DO mg/L	Secchi m	Flow cfs	Turbidity ntu	Fecal Coliform	Comments/Weather
BM01												
BM03												
BM04												
BM05												
BM18												
BM19												
WEC1												
STC1												
MPL6												
CL04												
CM10												
PC01												
BC01												
CUR2												
LF01												
CB1A												
RRC1												
GR8												
14												Old Hwy 50
15												Bay Chickens W
16												Bay Chickens E
17												Iola Beach

Chlorophyll a Data

Site	Volume (ml)	OD664	OD647	OD630	Chl a= 11.85(OD664)- 1.54(OD647)- .08(OD630)	mg/m ³ =Chl a x Volume	Comments
BM01							
BM03							
BM04							
BM05							
BM18							
BM19							

Water Quality Monitoring Site Codes

Site Code	Site Name	Parameters
BM1	Lake Fork Arm	Nutrients, Chl a, Fecal Coliform
BM3	Haystack Gulch	Nutrients, Chl a, Fecal Coliform
BM4	Sunnyside	Nutrients, Chl a, Fecal Coliform
BM5	Iola	Nutrients, Chl a, Fecal Coliform
BM18	BMH Site	Nutrients, Chl a, Fecal Coliform
BM19	Elk Creek Marina	Nutrients, Chl a, Fecal Coliform
WEC1	West Elk Creek	Nutrients, Fecal Coliform, Flow, Turbidity
<u>STC1</u>	Steuben Creek	Nutrients, Fecal Coliform, Flow, Turbidity
MPL1	Morrow Point Lake	Nutrients
CL4	Crystal Lake	Nutrients
<u>CM10</u>	Cimarron Creek	Nutrients, Fecal Coliform, Flow (USGS) , Turbidity, CDOW
<u>PC1</u>	Pine Creek	Nutrients, Fecal Coliform, Flow, Turbidity
BC1	Blue Creek	Nutrients, Flow, Fecal Coliform, Turbidity,
<u>CUR2</u>	Curecanti Creek	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW
<u>LF1</u>	Lake Fork of the Gunnison River	Nutrients, Fecal Coliform, Flow (USGS), Turbidity, CDOW
<u>CB1A</u>	Cebolla Creek	Nutrients, Fecal Coliform, Flow, Turbidity, CDOW
RRC1	Red Rock Canyon	Nutrients, Fecal Coliform, Flow, Turbidity
GR8	Gunnison River Below RRC1	Nutrients, Fecal Coliform, Flow (USGS), Turbidity, CDOW
14	Old Hwy 50	Fecal Coliform
15	Bay of Chickens West	Fecal Coliform
16	Bay of Chickens East	Fecal Coliform
17	Iola Beach	Fecal Coliform

Figure 7 Macroinvertebrate Datasheet

Macroinvertebrate Identification

Sample _____
Date Collected _____
Date Identified _____
Identified By _____

Substrate Type _____

Family	Genus	Species (optional)	Number/ Sample	Comments

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