

Quality Assurance and Quality Control Plan

Every monitoring program needs to have quality assurance and quality control (QA/QC) plan for evaluation that is both formative and summative. **Formative evaluation** is assessing individual workflows or tasks, such as sample collection, processing or specific analyses. Did the instructions achieve desired results, where they clear, did the volunteer understand what is needed from them, etc. These are lower stakes, more of an iterative process and are embedded in the workflow execution. For example, if an unknown pH result fails, staff and volunteer correct the problem, remove any suspect data, document and carry on. Most elements in the QA/QC plan and all **standard operating procedures** (SOPs) provide formative evaluation for River Watch. **Summative evaluation** assess the overall monitoring program as a system, is River Watch answering our monitoring questions? Is the data being used to achieve desired results, outcomes and impacts? Are volunteers staying with program and new ones onboarding? An annual evaluation of all program elements is conducted by staff to address summative evaluation. Here staff break down all program elements and workflows, explore changes in volunteers, data users, regulations and operations that require program adjustments, include adjusting desired results, outcomes or impacts.

Every monitoring program should have **standard operating procedures** (SOPs) that provide the appropriate formality and rigor to achieve data quality objectives and serve as the instructions to implement all tasks, workflows and processes from A to Z in a monitoring program. Most SOPs are considered internal documents and proprietary. Sections of the River Watch SOP can be provided upon request. To bring forth sections for external use the River Watch SOP Manual has several subdocuments, this **Sample Plan** is one and so is a **Quality Assurance Manual (QAM)**. The QAM guides the overall quality of data produced in the Colorado Parks and Wildlife Laboratory. The QAM has SOPs that the entire laboratory follows and identifies a **Quality Control Officer** that oversees those SOPs are followed. A QAM covers training, how the samples and chemicals are handled and stored, analytical machines operation and maintained guidelines, safety of staff, samples, equipment, data and building security protection from human and natural disasters. River Watch follows the Colorado Department of Public Health and Environment QAM by adapting and removing sections that do not apply. For example, River Watch does not process any human or human health related samples.

The other subdocument (and a best management practice in the field), is a document that standardizes and communicates to staff, volunteers and data users what methods, protocols and procedures are in place to generate the quality of data the project claims, is needed to answer the questions being asked and achieve the purpose, outcomes, results and impacts. Each project in a lab has a specific **Quality Assurance Project Plan (QAPP or (QA/QC) Plan)**. This takes the purpose, data use, targeted users and information needs from the Study Design and lays out workflow standards that will generate sufficient quality. A QAPP is a best management practice because it:

1. Guides all staff on how to complete their role in the field, laboratory and data management in a consistent, accurate, precise, reproducible and comparable manner.
2. Communicates to others the quality of the data, making the data of “known quality”.

3. Allows any data user to determine if the data can be used for the same purpose and questions, or other purposes with integrity. Ensures data is an asset and can be used multiple times.
4. Provides a common lexicon and communication to combine data responsibly from multiple sources. Documenting the quality of data collected and being transparent about the quality and methods to achieve that quality is what makes data an asset.

A Quality Assurance Project Plan is an essential component for a monitoring program to deliver measurable results. River Watch's primary data user is the Colorado Department of Public Health and Environment (**CDHPE**). Specifically within the CDPHE, the Water Quality Control Division and the Water Quality Control Commission use our data to implement the Colorado Clean Water Act. River Watch follows most CDHPE field and laboratory methods (but also some Environmental Protection Agency (EPA) methods).

The entire River Watch Study Design, QAM and Quality Assurance Project Plan (QAPP) are available on the River Watch website, www.coloradoriverwatch.org. These documents go into detail on our QA/QC methods and reporting and are often necessary when applying for grants to do water quality work. This QA/QC plan here is a small subset of the larger RW QAPP in simple terms and does communicate what River Watch does to produce desired quality of data. Share it with entities asking about the quality of your data and if they want more information they can access the formal QAPP on our website.

Essential QAPP Elements

There are many elements of the River Watch QAPP, most of which focus on two themes. **Precision** ensures analyses can be **repeated (repetition)** with similar results, within an acceptable margin of error, this includes **consistency**. **Accuracy** refers to how close a measurement is to the true value. When a method is first developed or an existing method is applied in a new way, the quality assurance program validates the method. If the new method provides acceptable levels of precision and accuracy, it may be applied routinely. Other QA/QC elements include results are **reproducible** by others and **comparable** to other appropriate data sets, even combined. **Errors can occur in the field, laboratory, sample handling and transportation or in data recording or management. The source of those errors can be from human, equipment or chemicals or a combination.**

A quality control program is implemented to maintain the reliability of the measurement process and reduce errors. Reproducibility is concerned with the ability of a data result to be consistently reproduced or be reliable time after time. Comparability focuses on the ability of a result to be compared with other data or criteria. **The River Watch Program approaches quality assurance and quality control holistically, incorporating components in our training, equipment, documentation, activities and evaluation.** Because a primary targeted data user, the Colorado Water Quality Control Commission, requires high quality data, River Watch has many subtle and overt QA/QC measures to ensure that quality is maintained through time and space.

Bad data? Bad data comes from not having checks and evaluation in place to identify data that doesn't meet quality standards or if no quality standards exist. There is no such thing really as a "bad" method, all methods produce a result. If the method is not followed it can

produce data of insufficient quality to answer the questions being asked of it. Two key strategies here are: to make choices that align the best method to produce desired data quality the Study Design purpose requires. Second, that sufficient checks and balances are in place to discover errors, sample contamination and data that doesn't meet desired quality (a QAPPs purpose) and can remove or qualify that data. No one produces data sets without any errors somewhere in the workflow. The local swimming pool monitors chlorine with color strip. That method produces accurate, precise, repeatable, consistent, comparable and reproducible data to answer the question are chlorine levels safe in the pool? That is a Study Design and QAPP, however informal and simple. That same Study Design and QAPP would be sufficient to monitor your fish tank at home, but is not sufficient to answer the Clean Water Act question: Is my river safe enough to play in? That doesn't make data from chlorine strips bad, just insufficient for those questions and Study Design. More accurate and precise data quality is needed and that leads to different methods and data quality sufficient for the task. This is a key role and set of decision to be made in each Study Design.

Quality Assurance

Volunteer Management and Training

River Watch has a robust Volunteer Management Plan as an SOP that addresses best management practices to recruit, onboard, train, support, acknowledge, terminate and retain volunteers. Volunteers are required to attend a training workshop where they are trained to operate and care for the \$3000 of water quality sampling equipment on loan to them while in the program. Training includes sample preparation, collection, analysis, shipping, recording and QA/QC procedures. Participants need to complete the cycle of sample preparation-to-analysis, including all QA/QC procedures, at least twice during the workshop. After the training, volunteer leaders take practice runs prior to the “real” sampling event. Training also includes understanding the River Watch Study Design and education on water quality, quantity, watershed management, the Clean Water Act, stream ecology and data interpretation. Each volunteer group is assigned a unique kit number to track information about the group, performance and data. Each group has a set of performance criteria as part of their Memorandum of Understanding (MOU) that is tracked in the database and includes many of QA/QC program elements.

Site Determination

During the training workshop and annually thereafter, each volunteer group signs a River Watch MOU that includes where, what kind of, and when sampling will occur for the coming year. Refer to the requirements of a volunteer group for specifics on these obligations. A data gap and needs assessment is conducted by CPW annually to prioritize sample sites. When possible, sample locations will duplicate historic monitoring stations and be close to USGS gauging stations. Each station is given a unique identifier and combined with date and time comprise a unique event identifier for data management. About 20 meta-data fields of information are provided for each station such as county, elevation, latitude and longitude.

Sampling Procedures

Sampling procedures, labeling, containers, and preservation follow Standard Methods (2001) and/or EPA guidelines (from Table II of 40 CFR 136). All sampling and analytical procedures are tracked in the River Watch SOP, QAPP and brought forth to volunteers in the Sample Plan. This includes such items as only using provided sample containers, chemicals and equipment, using current datasheets and protocols, keeping nutrient samples chilled until analysis, compliance with sample holding and shipping times for respective parameters, using certified reagents and standards, and using appropriate detection limits (EPA, CDPHE and/or CPW).

The **detection limit** is the level for which a particular set of equipment and protocols can detect a result that is statistically no different than zero. The **reporting limit**, is the level above the detection limit that a particular set of equipment and protocols can reliably and consistently reproduce. These are accuracy and precision decisions. For each indicator, the reporting limit is determined by the CPW but follows Standard Methods (2001) and/or EPA requirements. All equipment is routinely serviced, calibrated or updated. River Watch supplies all equipment and chemicals to volunteer groups.

Volunteers responsibilities include a volunteer group team leader is designated as the quality control officer (in essence and sample custodian), responsible for sample quality, security and record keeping. The **Chain of Custody** procedure must be followed whenever custody of samples is exchanged. Field results and metal samples are shipped bi-monthly, nutrients within 48 hours on ice and bugs within three weeks to River Watch. The Chain of Custody accompanies all samples and will be checked and signed by a sample custodian prior to shipment and then signed by RW staff once samples are received. See sample matrix in Data FAQ below.

Sample Reporting Limits

See the table **on page 178** below or in the Data FAQ below for parameter methods and limits. All data users are asked to download the River Watch FAQ to understand how to get data, what data exists, the quality of that data so that they can use the data responsibly and be able to communicate accurately the quality of River Watch data. (Versus claims the data is not sufficient quality because of who collected it. That is a diversion tactic, it really doesn't matter who collected it). A better question is what did they do to answer the monitoring question they were asking and was what they did sufficient quality to answer it? River Watch has been producing sufficient water quality data for multiple Colorado Clean Water Act decision processes for over 30 years.

Data Management

River Watch uses standardized datasheets to record data. River Watch has a robust data application that employs the **data schema** (how different data is stored, related to other data and available to validate, analyze or report) from the National Water Quality Portal. This application employs data management practices and adds management of metadata (such as volunteer information, station, QA/QC data). It automates a significant set of data validation providing a specific verification workflow for every data type, capturing errors and changes. Exports and reports are provided for metadata and results and in specific formats for different data hub and data user's needs. The application itself is password protected, has different user levels, lives on a secured and supported server managed by a contractor and

code is secured in an escrow. Two more River Watch SOP subdocuments include a Data Management Developers Manual and a User's Guide for staff where a database dictionary resides, data integrity methods, naming conventions and similar elements. The data is owned by Colorado Parks and Wildlife (CPW) and available via coloradoriverwatch.org, Colorado Data Sharing Network and the National Water Quality Portal (info in the Data FAQ below).

Volunteers enter data through the CPW's Internet and firewall protections. This data is checked against hard copies for validation. Numerous validation steps occur to validate the data against field and laboratory quality assurance and control samples and checks. The validated RW database resides at and is managed by the CPW. All data is validated by CPW staff prior to public release. Data validation protocols are documented in the River Watch SOP in combination with the River Watch Database Application User Guide. Data management is an entire professional field on its own and includes interfaces between hardware, software, the cloud, servers, data security as well as actual programming of applications, and best management practices specific to this type of data (detection limit handling, naming conventions, data dictionary, documentation, relationships between data fields, data security, etc.). River Watch's SOP Chapter 7 contains our Data Management Plan.

Quality Control

Field

Each volunteer group uses the standard set of datasheets. All groups use deionized water from CDHPE laboratory. To test field metal collection from introduced metals or contamination from humans, equipment or chemicals, volunteers collect **field duplicates and blank metal samples** (both filtered and non-filtered). These QA samples are collected every fifth sampling event and are sent along with the regular samples to River Watch for analysis. **Industry standard is 10% of all samples are QA/QC samples. River Watch does employ 20% QA/QC samples.** How these are a test is for blanks, if no metals are introduced to the sample, then the analyses will result in zero or below reporting limit. If contamination exists, results will be greater than reporting limit and the protocol is to remove ALL data for that station and metals between that sample and the previous "clean" blank. Hence the 20% frequency to reduce having to remove data unnecessarily. Field metal duplicates should be within 80-120% recovery. If outside that recovery range, methods are investigated and results are averaged and recorded if it is determine contamination is not systemic. Nutrient duplicates are handled the same, collected at 20% field duplicate frequency. 20% of all macroinvertebrate samples include a QA sample (not a duplicate) where all sample material that would be discarded in a normal sample is preserved in a separate container and analyzed. Unique taxa found in QA sample not found in normal sample are added to total taxa list. If the percentage of organisms are too high in a QA sample, collection and sample process methods are reviewed with that volunteer group.

The **Sample Tracking Sheet** is a QA/QC tool to help volunteers track what samples were collected and analyzed by them. This form looks like the Chain of Custody but is slightly different. It is helpful have one of these forms per station and to highlight every 5th line. Before each sampling event you look at this form, enter the event ID for this trip and if the line is highlighted it is time to collect a blank and duplicate metal. If River Watch staff need to

understand what you collected months after the fact during data validation this form helps. It also helps you remembers what data is available from your stations and when, for example nutrient and bug samples. This makes it easier to create meaningful data exports.

Unknown standards for pH, alkalinity and hardness are prepared for participants to analyze in order to check their procedural accuracy as well as chemical accuracy; twice a year. Staff makes a known (value) solution for each of these that is unknown to the volunteer. Volunteers are taught how to keep the equipment clean as the techniques needed to minimize contamination. Participants are given deionized water from the same source (CDPHE) for all blanks, unknowns and cleaning. **A duplicate test** between each group's equipment and River Watch equipment is performed for alkalinity, hardness and dissolved oxygen tests. An annual QA/QC report is completed with summaries of field, lab and data QA/QC.

Laboratory

The River Watch laboratory is located at the CPW Fort Collins office. The laboratory uses pure standards, solvents and reagents. When applicable, reference standards solutions will be traceable to National Bureau of Standards. Each new lot of reagent grade chemicals will be tested for quality of performance. Nanopure water is used in analytical procedures and the cleaning of glassware. The water is prepared by a deionized water system incorporating reverse osmosis and nanopure filtration. An inductively coupled plasma atomic emission spectrophotometer (ICP) conducts metals analyses, a Lachat flow injection analyzer (FIA) conducts the nutrient analyses and TSS and TDS analyses are performed by laboratory staff. Over 60 River Watch SOPs dictate workflows in the laboratory. Below are an example of some QC sample used in the laboratory to ensure data quality.

A **method blank** containing deionized water and reagents is carried through the entire analytical procedure. If results are greater than zero there is contamination in the workflow.

Calibration standards are prepared in the laboratory by adding a known amount of a pure compound in an appropriate matrix. The results obtained from these standards are used to generate a standard curve and thereby quantify the compound in an environmental sample. Like the pH buffers 7 and 10 prepare and calibrate the pH meter.

A **check standard** is prepared in the same manner as the calibration standards. The check standard is used to verify that the existing calibration standard and/or calibration curve is valid during the analysis. The check standards can provide information on the accuracy of the total analytical method and of instrument performance.

A **control sample** of a known value is used to validate the calibration curve, the calibration standards, and the analytical procedure. The control sample is used for validation before and after analysis and the value obtained must fall within $\pm 10\%$ of the true value for validation. Every 10 samples analyses are bracketed by a blank and a control sample or other QA samples. The pH unknown is a control sample volunteers complete to test their pH meter and calibration process.

A **matrix spike** is prepared by adding a known amount of a pure compound to the environmental sample. The compound is the same as that assayed for in the environmental sample. For example, if an environmental sample is being analyzed for iron, then pure iron is added to an environmental sample to make the matrix spike for iron. A random 5% of samples for each metal analyzed are spiked and reanalyzed. Matrix spikes simulate the

background and interference found in actual samples. The calculated percent recovery of the matrix spike is considered to be a measure of accuracy of the total analytical method, sample preparation to analysis. The tolerance limits for acceptable percent recovery are usually those established by the EPA (usually 80-120% recovery).

Duplicate analysis will be performed on at least 5 percent of the samples. The difference between the values of the laboratory duplicate samples is referred to as the relative percent difference (RPD) and is a measure of the precision of the analytical method. The tolerance limit for percent difference between laboratory duplicates is usually that established by the Environmental Protection Agency. This addresses the repeatability and reproducibility of an analyses method.

Quarterly Recalibration's Using CDHPE methods

River Watch Laboratory will recalibrate machine lower method detection limits (MDL) and lower reporting limits (LRL) each quarter (starting July 2020). Changes are input to analyses machines and the River Watch database and specific data exports display the MDL and LRL for each indicator.

Annual Independent Laboratory Splits

River Watch will split one filtered metal sample and one nutrient sample of a relatively high concentration with an independent lab and report those results. When results are comparable this provides credibility for a program and if not, addressing differences retains sufficient quality.

Annual QA/QC River Watch Performance Report

This report provides a summary of how River Watch did implementing its QAPP. No other entity provides such a report to the public. River Watch Program QA/QC performance results annual report is on the [coloradoriverwatch.org website](http://coloradoriverwatch.org).

Volunteer QA/QC Reports

There are four report are available to groups:

- The volunteer annual performance report, which is reviewed at each site visit (*reports/meta/org performance*)
- Access to the stations metal blank and duplicate data (*reports/results/metals QA/QC*)
- Unknown data report for individual organizations (*reports/results/unknown*)
- Annual report of unknown data (combination of all groups' unknown data).

Volunteer Quality Assurance and Quality Control Responsibilities

Quality control and quality assurance (QA/QC) ensures the data each participant collects is valid and usable. The following procedures represent a critical component of the River Watch quality assurance and control plan provided by the volunteer.

Quality control and quality assurance items each volunteer group is directly responsible for include the following:

- Volunteers are the first point of QA/QC with their eyes and ears on the ground, checking results to see if they make sense with what you know, previous results, local

events, for data completeness, recording and communicating what is noticed or happens during sampling and analyses.

- Following all performance criteria on the back of MOU, including using the specified procedures and equipment for collection and analysis of samples.
- Recording data accurately on current data sheets including checking all calculations, results and data entries.
- Analyze field parameters and ship all samples within prescribed holding times.
- Collect samples at frequency and location in River Watch annual MOU.
- Ensuring proper use, care and maintenance of chemicals and equipment.
- Collecting a blank and duplicate metal sample every fifth sample per station (filtered and non-filtered).
- Completing the unknown tests for pH, alkalinity and hardness in a timely fashion.
- Collecting a nutrient duplicate or macroinvertebrate quality assurance sample when requested.
- Keeping an organized file of your River Watch records including a hard copy of your data.
- Participating in QA/QC site visits that test your chemicals, equipment, training and methods as well as provide opportunity to answer questions and update methods and equipment.

Site Visits

The primary purpose of the site visit is to test the equipment, chemicals, and training of volunteers, as well as their skills at performing the tests. This helps River Watch validate data and is a significant part of your quality assurance and control responsibilities. The secondary purpose is to update as necessary sample collection and analyses methods in person. Additionally, a site visit enables us to answer any questions our volunteers may have, trouble shoot performance or equipment issues, replenish supplies, pick-up samples and connect with each volunteer. This a key volunteer retention strategy. This visit certifies a group's data for the agreement year (along with all the other quality assurance and control measures).

Our desire is to spend as much times as needed with each volunteer group and to schedule visit times that are convenient for you. We thank you in advance for your patience and extra work you do to prepare for the visit. We appreciate the time you set aside for us and will strive to be efficient and effective at the visits. We are usually on a tight schedule so your preparedness and communication with us about the visit is appreciated.

All test results are discussed with the volunteer. Results are shared with other groups for educational and comparison purposes. We will try to answer any questions to help our volunteers during these visits. River Watch produces a Site Visit Calendar for all groups that have signed an agreement and/or are attending a training that year. It will be sent to you and posted on the website early in the contract year. Our Site Visit Season is generally from October through February, working around holidays. River Watch will remind you of your site visit about one month prior. If there is a problem with scheduling, please let us know as soon as possible. The earlier we know the more flexibility we will have. If we miss visiting you we will conduct a site visit call.

During a site visit:

- Volunteers complete an “unknown” sample RW for alkalinity, hardness and pH. River Watch will provide the unknown samples, instructions and data sheets for the visit.
- Volunteers prepare (fix) and titrate a dissolved oxygen test. A split of the sample might be analyzed using a dissolved oxygen probe and meter. A test to measure precision of a volunteer’s ability to replicate 2 dissolved oxygen tests within an acceptable margin of error may also be applied.
- Volunteers simulate or describe sample collection procedures, including metal blanks and duplicates.
- The River Watch staff member will titrate a water sample with our staff green box AND your green box while the volunteer performs their tests. This is a “duplicate” that tests different batches of chemicals and your equipment. RW staff could use outside lab standards to test your chemicals.
- We review results and complete a report card. We answer questions and introduce changes in methods or new methods. We can pick up samples; have them ready to go with chain of custody and data sheets. We can refill your equipment; if possible let us know what you need in advance so we can make sure we have it when we arrive.
- A great time to have your next year contract ready! It is due by May 1st!

After a site visit:

- Certificates for all site visit participants are sent, certifying them as samplers and your data for a year
- A letter is sent to the principal or sponsor thanking them for their support of said volunteer
- Equipment requests are filled
- Data or method issues address, notification of changes or remaining issues

River Watch Standard Operating Procedures Table of Contents

Level 1 Table of Contents of the River Watch SOP which has eight subdocuments, seven tutorials for specific applications or processes, four reports and over 290 SOPs covering the entire program and 27 plus tracking tools. Every datasheet and form is its own SOP. An Excel Spreadsheet serves as a master roadmap of all SOP components and maps subdocument content to its primary SOP Source.

1.0 Introduction and Overview

- a. Purpose Use and Responsibilities of this Document and Intended Audience
- b. Master Document Road Map, Tracking and Outlines
- c. Standard Operating Procedures (SOPs)
- d. River Watch
- e. River Watch Study Design Scientific and Operational
- f. Partnerships and Benefits
- g. Program Benefits
- h. Summary What RW Program Manager Needs to Know

2.0 Program Implementation Strategy

- a. Overall Workflow and Calendar Year

- b. Implementation Strategy
- c. Roles and Personnel
- d. Volunteer Management Plan
- e. Safety
- f. Data Quality
- g. Summary What RW Program Manager Needs to Know
- 3.0 Administration Standard Operating Procedures**
 - a. Stations
 - b. Training
 - c. Site Visits
 - d. Equipment
 - e. Summary What RW Program Manager Needs to Know
- 4.0 Sample Collection Standard Operating Procedures**
 - a. Sample Collection Matrix (Why, What and When)
 - b. River Watch Indicators Why Monitor
 - c. Data Interpretation 101
 - d. Stream Ecology
 - e. Summary What RW Program Manager Needs to Know
- 5.0 Sample Processing Standard Operating Procedures**
 - a. Pre Volunteer Sample Handling, Custody and Shipping
 - b. Non RW Samples (CPW, Other)
 - c. Sample Process Work Flow Overview
 - d. Sample Intake Cooler or Package
 - e. Sample Processing
 - f. Results Upload, Validation, Import, Edit, Delete and Archive
 - g. Summary What RW Program Manager Needs to Know
- 6.0 Sample Analyses Standard Operating Procedures**
 - a. Analyses Matrix (Container, Preservative, Methods, Laboratory, Holding Time, Detection, Reporting) SOP
 - b. Validation of Examination Procedures
 - c. Safety (QAM 12.0)(SOP)
 - d. Field Indicators
 - e. Metals
 - f. Nutrients
 - g. Macroinvertebrates
 - h. Physical Habitat
 - i. Summary What RW Program Manager Needs to Know
- 7.0 Database Management Standard Operating Procedures**
 - a. RW Data Inventory Mapping
 - b. RW Data Pathways
 - c. RW Data Management System
 - d. What the RW Program Manager Needs to Know
- 8.0 Data Analyses, Reporting, Information Products and Services Standard Operating Procedures** (make this be where all p and s is and 9 is communication and outreach plan, it has audiences from Chapter 1/p and s form 8, into a plan)
 - a. RW Study Design
 - b. Information Products

- c. Videos
- d. CPW and RW Websites
- e. Data Management of Information Products
- f. Services
- g. Summary of What RW Program Manager Needs to Know
- 9.0** Information Delivery, Communication and Outreach Standard Operating Procedures
 - a. Communication Outreach Program
 - b. Identify Target Audiences
 - c. Outreach and Communication Strategy
 - d. Summary What RW Program Manager Needs to Know
- 10.0** Program & Monitoring Evaluation (not results evaluation)
 - a. Spring Evaluations
 - b. End of Year Tasks
 - c. Summative Evaluation Retreat
 - d. Summary What RW Program Manager Needs to Know

River Watch Database Application FAQ

We ask every user download and read this document before exporting data from the River Watch database application to appropriately understand and utilize the data. This is updated every year, this version is dated **July 2019**.



River Watch Data and Program Information



A. How to generate a River Watch data export to meet your needs.

B. River Watch Program and Data Objectives.

C. Information about River Watch Data.

D. What is the River Watch Program? Information for accurate interpretation of data objectives, program training, certification, support, volunteer and data management, standard operating procedures and quality assurance and control, information on volunteer groups and watershed reports.

A. How to generate an export for your needs.

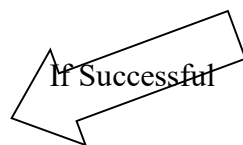
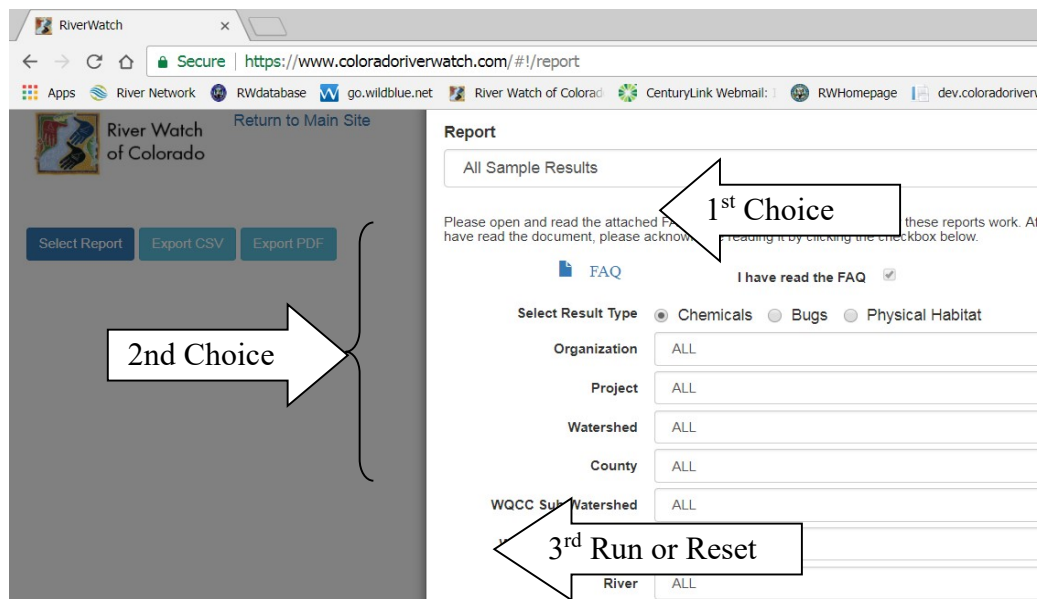
All Samples: Chemical, Bug and Physical Habitat Report / Export

This report allows you to filter a subset of data from the larger RW data set through query selections. The output will be Excel file. **Every time you run a report here, you MUST check "I have read the FAQ", regardless if this is the first report or fifth.** This report is for a subset of the data only, please do not try and download entire database from this report. There are other options for that (see #4 below and **GIS or Map Interface, CVS or Normalized format or Large Inclusive Results Export** sections below).

1. The *first choice* you need to make is CHEMICAL, BUG or PHYSICAL HABITAT DATA. Please see example below.
2. The *second choice* allows you to subset the larger database. You can choose your data by Organization, Project, Geography Watershed, County, WQCC sub watershed, Watershed gathering, River, Water code, WBID, Watershed report or Station and/or Year. Hover over the name of the query to understand that query. The default year is current year, if you want data for all years, you must clear out the year.
 - o Note that based on your first selection, choices under other options will only reflect information that is within the first selection. For example, if you chose, South Platte under Watershed, information under all other options will only display choices that exist in the South Platte basin (no station in Colorado River basin for example, only in South Platte basin).
 - o If you do not know enough about the meta-data available to subset your export, please see the **Metadata Reports** below for other reports that might help you identify or refine your query.

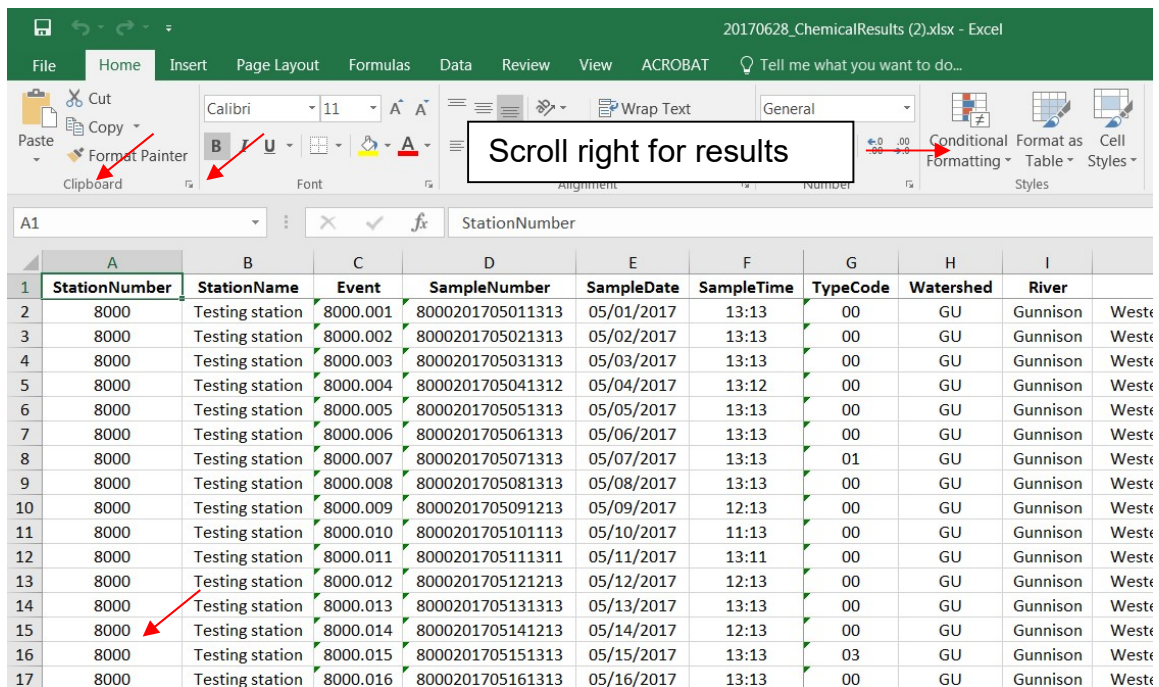
3. Once your query selections are chosen, select “Run Report”. If you are not getting the results you want (like “no results for these selections shows up”), re-evaluate the query selection or order of queries selected, select “Reset” to clear previous query options. For example if you select South Platte under watershed and 2017 as year and no data appear, try another year.
4. We advise you to **NOT** try to export the entire RW database from this report (i.e. leave all queries on ALL), all chemical data from all stations, for example. That report is easier and more efficient to get from the National Portal (which includes EPA STORET), from Colorado Data Sharing Network, from RW directly, see **GIS or Map Interface, CVS or Normalized format or Large Inclusive Results Export**.

This export option is designed to retrieve subsets of data. Not all menu selections need to have a selection. You can select “ALL” in several items per report, like Watershed and WBID for example.



5. Chemical results are reported in an Excel spreadsheet and include two tabs. The first tab, Chemical Results, displays stations in the first column, in order of smallest station number to largest. Corresponding data will be the right starting with meta-data (date, watershed, river, organization, etc.), followed by field data, then metal and nutrient data.
6. The second tab “Chemical Qualifiers” will keep the station number, station name and event ID columns as the first tab, and order of stations using a pivot table. The columns to the right display, the method detection limit, lower reporting limit, qualifier and detection condition for each result.
7. The “Chemical Qualifiers” tab will be blank for all legacy data (all data before July 2017 is considered legacy data). Legacy data limits are in a table later in this document.
8. **Qualifiers and Detection Conditions for River Watch data are the following and help the user determine how River Watch handles results below detection, between detection reporting limit, null and results above reporting limit. This is a best management practice.**

Qualifier	Detection Condition
A	Not Reported (Null)
D	Detected
J	Result is greater than detection limit, but less than reporting limit
U	Not Detected



StationNumber	StationName	Event	PhenAlkMDetLimit	PhenAlkLRepLimit	PhenAlkQual	PhenAlkDetCond	USGSFlowMDetLi
8000	Testing station	8000.001	0.1	0.1	D	Detected	
8000	Testing station	8000.002	0.1	0.1	D	Detected	
8000	Testing station	8000.003	0.1	0.1	A	Not Reported	
8000	Testing station	8000.004	0.1	0.1	A	Not Reported	
8000	Testing station	8000.005	0.1	0.1	A	Not Reported	
8000	Testing station	8000.006	0.1	0.1	A	Not Reported	
8000	Testing station	8000.007	0.1	0.1	A	Not Reported	
8000	Testing station	8000.008	0.1	0.1	D	Detected	
8000	Testing station	8000.009	0.1	0.1	D	Detected	
8000	Testing station	8000.010	0.1	0.1	D	Detected	
8000	Testing station	8000.011	0.1	0.1	A	Not Reported	
8000	Testing station	8000.012	0.1	0.1	A	Not Reported	
8000	Testing station	8000.013	0.1	0.1	D	Detected	
8000	Testing station	8000.014	0.1	0.1	A	Not Reported	
8000	Testing station	8000.015	0.1	0.1	D	Detected	
8000	Testing station	8000.016	0.1	0.1	A	Not Reported	

9. You can delete any field from the Excel sheet you don't want. For example, columns exist for Dissolved Organic Carbon, chlorophyll a and Ortho phosphate results, but none exists. RW is planning for the future.

Metadata Reports (information about the data)

If you do not know the exact data you want from a specific organization, project, station or river the following metadata reports and filter/queries might help narrow your search. Then you can go to the [All Samples Results Report Query](#) to obtain those results. Metadata and all other result reports will export in a cvs (text delimited) or pdf format. For cvs files you can export into Excel and manipulate columns and rows as needed. Available meta-data reports are:

- Report – Metadata – [Organization by Project](#) (if RW has made your specific stations into a project you can get that name and request a data export by that project name)
- Report – Metadata – [Stations](#) (allows you to find list of stations by Project, Organizations, Status, Watercode (*CO Parks and Wildlife water management segments*), river name, eco region, station type, WBID (*CO Dept. of Public Health and Environment water management segments*), major watersheds, watershed reports or county)
- Report- Metadata- [Stations with Gauges](#) (list of stations with USGS or State Engineer flow gauges, can further narrow search by status, major watershed or watercode (*CO Parks and Wildlife water management segments*))

- Report – Metadata- Station Samples by Type will list all RW stations in numeric order and the type of data that exists for that station (field, metals, nutrients, macroinvertebrates and physical habitat) and the date range of that data. You need to know specific station numbers for this to be of value – which you can find from Stations Report.

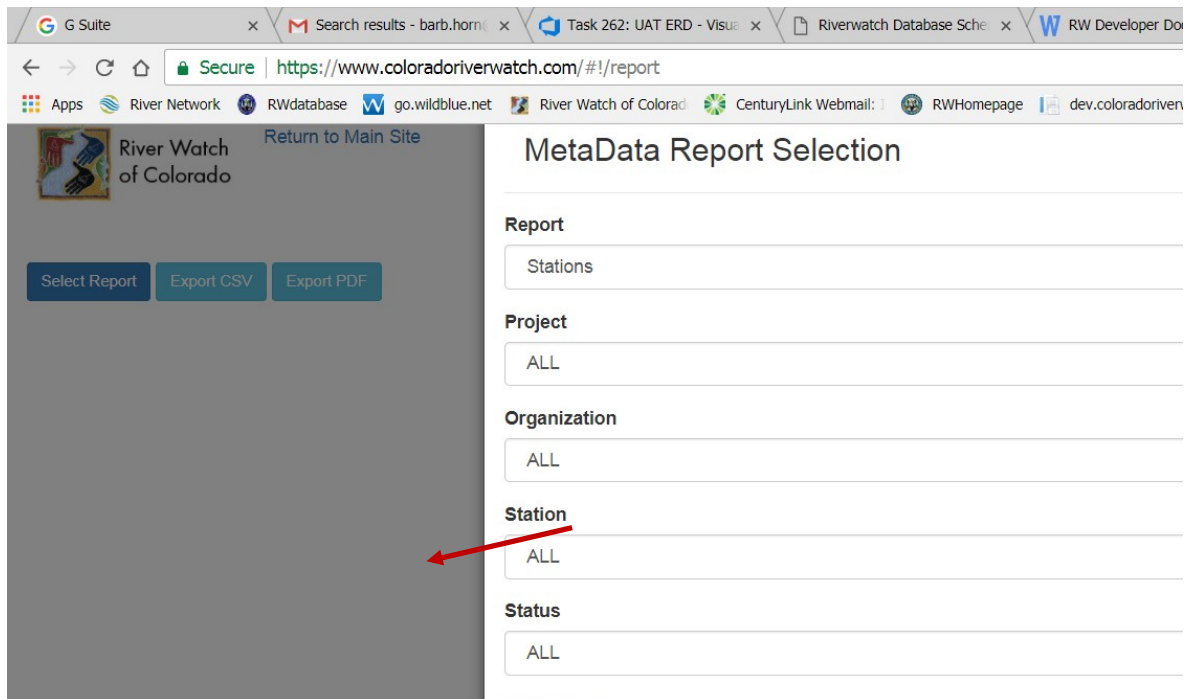
10. **Under the “All Samples Results” Report, “Bug” option:** If you check the “Bugs” option the results will be displayed in Excel with one station/Event ID per spreadsheet. Macroinvertebrate data includes event/sample ID and meta-data, family/species taxa name and laboratory grid counts. Not all events have bug samples see frequency information below and illustration of export is on last page.

You also have access to the River Watch Taxonomic table, which has, for each taxa, TSN numbers, habitat, functional feeding group and family, genus and species information.

11. **Under the “All Samples Results” Report: Physical habitat option:** If you check the “Physical Habitat” report, the results will be displayed in Excel with one station/Event ID per spreadsheet. Data includes event/sample ID and meta-data, cross section, four microhabitat kick samples and a macro riparian and river habitat assessment. Not all events have physical habitat assessments or all three types of assessments see frequency information below. Illustration of export is on last page.

Please note if no report exports for bugs or physical habitat it is because no data exists for the filters you chose.

Example of Stations Metadata report: **First, select what organizational or geographic option** that will help you narrow your station list. Multiple selections must align, for example if I select Chalk Creek and Colorado River Basin, and there is no Chalk Creek in the CO Basin, I will not get a result. **Second, select Run Report at bottom.**



After select run report your screen will display results. **Now you can do these things:**

- a. Sort on any column using the carrot
- b. Type in a value in any box below a field name and see those results on the screen
- c. Hide an entire column (like you do in Excel)
- d. Export to cvs or pdf, **HOWEVER YOU LEAVE YOUR VIEW on the screen will be what you see in export**
- e. Return to the main site

On column header, right click and hide

Project Name	Organization	Station Name	Station Number	Station Status	Water Body Id	Water Code	River
RiverWatch	DOW (0)	Cement Cr	323	NonActive		:RE...	Ceme
RiverWatch	Silverton HS (63)	Cement Cr	323	NonActive		:RE...	Ceme
RiverWatch	DOW (0)	Below S Fk Conf	3456	NonActive		:RE...	Ceme
RiverWatch	DOW (0)	Above N Fk Conf	3457	NonActive	COSJAF07	CEMENT CRE...	Ceme

GIS or Map Interface, CVS, Normalized format or Large Inclusive Results Export

If you desire a large RW data export, for example all chemical data for the entire state or a major basin, or data in a normalized format, text delimited or want to see what is available via a GIS map interface we suggest you visit:

- Colorado Data Sharing Network (www.Coloradowaterquality.org)
- USEPA National Water Quality Central STORET Warehouse (https://ofmpub.epa.gov/storpubl/dw_pages.querycriteria)
- or the National Water Quality Portal (<https://www.waterqualitydata.us/>)

River Watch uploads to all three of these at the same time and frequency. Colorado Data Sharing Network (CDSN) has more Colorado Data than STORET and Portal. All three sites have tutorials on how to download data and soon www.ColoradoRiverWatch.org site will have a RW specific tutorial. Data availability is explained below.

River Watch data application tools and interpretation tools are being developed all the time. Please visit www.coloradoriverwatch.org for latest updates and more resources.

B. River Watch Program and Data Objectives

The main goal of River Watch is to collect long-term high quality data on the health of Colorado Rivers while providing a hands-on experience for volunteers to understand the value and function of river ecosystems. The primary targeted decision makers for the data are the Water Quality Control Division (WQCD), the Colorado Water Quality Control Commission (WQCC), Colorado Parks & Wildlife (CPW) Biologists and volunteer groups. Targeted decision processes involve Commission implementation of the Colorado Clean Water Act (CCWA), assessment of water quality standards across the state, CPW mission and strategic priorities and goals of individual volunteers that align with River Watch data objectives.

The WQCD and CCWA have the highest data quality objectives and thus, all field and laboratory methods match or compliment WQCD methods for CCWA assessment processes, standard development, and protection and restoration efforts. For example, the laboratory recalibrates detection and reporting limits quarterly. The exception is River Watch performs 20% quality assurance and control samples and industry standard is 10%. Also, River Watch volunteers receive more training and are tested more than most state, local and private technicians for what they do. As regulations and standards change, River Watch updates methods and protocols as quickly as possible. River Watch's best management practice is to be transparent about methods, data and data quality as these evolve for everyone in the monitoring community.

Lag times exist between data collected and reported (time is the price for volunteer monitoring) and the programs ability to update a method. For example, River Watch utilizes an ICP analytical machine to analyze metals and for selenium. That machine's lowest method detection limit for selenium is higher than the Colorado Clean Water aquatic life standard (5.0 ug/l versus 4.6 ug/l). This does not make River Watch selenium data "bad" or "wrong", just not appropriate *for all* Clean Water Act processes while remaining relevant and useful *for some* processes. Selenium and arsenic River Watch data should be used as screening data until River Watch secures an ICP-MS analytical machine that can achieve a lower detection limit.

It us up to the user to understand their data quality objectives and employ best management practices when using River Watch data and or combining data from multiple sources. For example, when combining data from different sources, regardless of who generated the data, the best management practice is to compare and evaluate all data sets field and laboratory methods, detection and reporting limits. In many cases, different detection limits for an analyte can be used for some decision processes as long as all methods are precise enough. However, that same data may not work in a robust statistical model due to the same detection limit differences. It is a case-by-case evaluation.

Data quality is not a function of "collector" but a function of adequate data quality objectives to answer monitoring questions the data is designed to answer as well as the ability of the data generator to demonstrate and document that data quality objectives are met. All data

generators are human and subject to making errors in the field, laboratory and data management. The key questions to ask all data generators in a combined data set are:

- What questions are the data being asked to answer?
- Is the data quality in field, laboratory, data management, etc. of sufficient quality to answer that question? How does that question relate to the questions I am asking the data (if it is different from original data objectives)? How do the methods compare and are the similar enough to combine for this data objective?
- Are the right processes in place to capture errors along the data to information pathway?

Asking and answering those questions demonstrates best management practices, professionalism and integrity. Data is then not “good” or “bad” but instead “appropriate” or “not appropriate” to achieve stated monitoring data quality objectives. Good data is data that meets quality control and assurance objectives and bad data does not, regardless of who collected the data and data objectives.

RW data has been involved in many duplicate and replicate studies and combined data efforts. Here is a list of those results:

- RW data compared to other data, USGS, EPA, third party, consultant, etc. and was same
- RW data compared to other data, USGS, EPA, third party was different than some others sources and the same as some sources, and the differences were explained, the result was all sets of data remained appropriate for decision and were retained
- RW data was compared with other data sets and was different, difference was explained and data retained, there was no scientific or valid reason to discard
- RW data was different but at a location that was more accurate for answering the data objective than other data sets, data retained
- RW was compared and data difference could not be explained or difference was explained and data not used, deleted, etc.
- RW data was compared and the RW data was more accurate and precise than USGS, EPA, and third party data and was retained

To find River Watch’s methods and SOP, see last section for links. Each group must commit to the following baseline sampling; some may deviate in frequency or indicator for a variety of reasons. The parameters include field, metal (both total and dissolved metals) and nutrient collection, macroinvertebrate sampling, identification and physical habitat assessment.

Sample Parameter Criteria Matrix

Indicator	Frequency	Method	Lower Report Limit	Method Detection Limit
pH	monthly	Meter, probe for fresh water	0.1 S.U.	0.1 S.U.
Temperature	monthly	Celsius thermometer	1.0 unit	1.0 unit
Dissolved Oxygen	monthly	SM 421.B	0.5 mg/l	0.5 mg/l
Phenol/Total Alkalinity	monthly	EPA 310.1	0.1 mg/l	0.1 mg/l
Total Hardness	monthly	SM 314 B	0.1 mg/l	0.1 mg/l
Aluminum	monthly	EPA 200.15 (ICP)	10 ug/l	2.1 ug/l
Arsenic	monthly	EPA 200.15 (ICP)	10 ug/l	5.8 ug/l
Calcium	monthly	EPA 200.15 (ICP)	100 ug/l	18.6 ug/l
Cadmium	monthly	EPA 200.15 (ICP)	0.5 ug/l	0.18 ug/l
Copper	monthly	EPA 200.15 (ICP)	1.0 ug/l	0.5 ug/l
Iron	monthly	EPA 200.15 (ICP)	10 ug/l	5.2 ug/l
Magnesium	monthly	EPA 200.15 (ICP)	200 ug/l	91 ug/l
Manganese	monthly	EPA 200.15 (ICP)	5 ug/l	2.4 ug/l
Lead	monthly	EPA 200.15 (ICP)	3 ug/l	2.4 ug/l
Potassium	monthly	EPA 200.15 (ICP)	200 ug/l	100 ug/l
Selenium	monthly	EPA 200.15 (ICP)	5 ug/l	2.4 ug/l
Sodium	monthly	EPA 200.15 (ICP)	200 ug/l	100 ug/l
Zinc	monthly	EPA 200.15 (ICP)	5 ug/l	2.6 ug/l
Ammonia	High/Low Flow	EPA 350.1	0.01 mg/l	0.004 mg/l
Nitrate-Nitrite	High/Low Flow	EPA 353.2	0.02 mg/l	0.01 mg/l
Total Phosphorus	High/Low Flow	EPA 365.1 and .3	0.005 mg/l	0.0009 mg/l
Chloride	High/Low Flow	EPA 325.1	1.0 mg/l	0.17 mg/l
Sulfate	High/Low Flow	EPA 375.4	0.5 mg/l	0.2 mg/l
Total Suspended Solids	High/Low Flow	Standard Methods	4 mg/l	1.0 mg/l
Macroinvertebrates	Annually/Fall	See RW Sample Plan – sandy/rocky methods	NA	

Indicator	Frequency	Method	Lower Report Limit	Method Detection Limit
Physical habitat	Annually/Fall	Micro for bug kick, macro both banks assessed	NA	
Field quality assurance samples	20% plus 2 unknowns/yr	80-120% recovery Except pH 96-104%	NA	
Laboratory	20% according to machine protocol	Function(test)	NA	

Method Detection Limit – is the lowest result a method can deliver that is significantly different than zero. However, with some methods there can be a lot of noise around this limit, which produces perhaps false positives or negatives. That does not mean a pollutant doesn't exist, just that it is not detectable at this minimum level.

Lower Reporting Limit – this is often the level reported and is a quantifiable amount away from the method detection limit, such as two standard deviations. This is a result that the method reliably, consistently and accurately produces a result with confidence and is statistically different than zero.

River Watch volunteers collect all sample types; analyze field parameters and conduct physical habitat assessment. Analyses of metals and nutrients occur at CPW's Fort Collins laboratory and a certified taxonomist identifies our macroinvertebrates. Volunteer monitoring is cost effective but not free, and the biggest trade off is time. River Watch sets a goal for analysis and posting turnaround time for each sample type and barring events outside of their control, generally meets those times.

C. Information about River Watch Data

Reporting Legacy data (Pre July 2017) in the River Watch database, CDSN and National Portal will report all results > Method Detection Limit and < Lower Reporting Limit as zero, a "U" is placed in the qualifier field and "not detected" in detection condition field. Nulls are reported as "A" in qualifier field and "not reported" in detection condition field. Detection and reporting limits varied from 1989 to June 2017 but followed CDPHE SOP's during the respective period. For sample frequency see below.

July 2017 forward, all results > Method Detection Limit and < Lower Reporting Limit will report an actual result, with a "J" is placed in the qualifier field. All values < Method Detection Limit will be reported as zero, a "U" is placed in the qualifier field and "not detected" in detection condition field. Nulls are reported as "A" in qualifier field and "not reported" in detection condition field. Detected results will have a "D" in qualifier and "Detected" in detection condition for RW Exports and " " in qualifier and "Present Above Quantification Limit" in detection condition for AWQMS, CDSN and National Portal (STORET) data.

Frequency River Watch has collected field and metal data since 1989. Not all stations have filtered or dissolved metals in the early years. Therefore, the majority of posted results contain field and most have metal data. River Watch followed the changes in analytical technology as well as changes in CWA regulations. In 1999 technology switched from the atomic absorption method to the inductively Coupled Plasma Mass Spectrometry (ICP and ICP-MS), this allowed River Watch to lower some detection and reporting limits, as well as add more metals. Analyses of cadmium, copper, iron, lead, Manganese and zinc occurred. In late 1990's the ICP allowed the addition of Aluminum, Arsenic, and Calcium, Magnesium, Potassium, Selenium and sodium. Aluminum, Arsenic and Selenium remain screening triggers until CPW moves to the ICP-MS analytical machine scheduled for FY 2018. Nutrient regulations initiated the addition of nutrients in River Watch and Nitrate-Nitrite, Ammonia, Total Phosphorus, Chloride, Sulfate and Total Suspended Solids. We added Total Nitrogen in FY 2017.

You will see the variation in results based on River Watch's capacity as characterized above, as well as by the duration of the volunteer and variations on our baseline study objective. Some stations have 10 years of data without one month missed while others have only one sample. Initial years in River Watch volunteers sample 24 times per year (once a month September through February, twice in March and August, three times in April and July and four times in May and June). Macroinvertebrate sampling and physical habitat assessment was introduced in early 2000 and chemical sampling was reduced to once a month per year.

Flow River Watch volunteers are taught the difference between velocity and flow, as well as concentrations versus loadings. Volunteers are encouraged to select stations by USGS or State Engineer flow gauges but do not collect flow themselves. Professional cross section flow results can be calculated and recorded in River Watch. All flow data in the gauge field is from a gauge. Flow estimates are recorded in a comments field.

Availability River Watch data is available to anyone as it is public data. To access the data visit the River Watch public website www.coloradoriverwatch.org; there is a database tab link to the data application. River Watch data is uploaded annually to the Colorado Data Sharing Network (www.Coloradowaterquality.org) as well as the USEPA National Water Quality Portal (<https://www.waterqualitydata.us/>). Soon these uploads will be biannual and quarterly. Data request can be submitted to the CPW River Watch Program Manager, megan.mcconville@state.co.us.

Analyzed data is also available on the River Watch website www.coloradoriverwatch.org. Watershed reports evaluating River Watch volunteer data against Colorado Clean Water Act Standards on specific river segments call Water Body ID's (WBIDS). If you have the reports for all the WBIDS on a river, then you have a report for the entire watershed versus a segment. Once the entire state has been completed, these reports will be updated basin by basin following the WQCC's Basin Rule Making Hearing rotation cycle.

Use River Watch data is submitted to the Colorado Department of Public Health and Environment, Water Quality Control Division and Commission in their data calls for Rule Making Hearings on an annual basis. Data is also provided to them to develop standards or ground truth metrics, such as with macroinvertebrate data. CPW biologist, researchers, watershed groups, other state and federal agencies, municipalities, academia, special districts and non-profits all use River Watch data at their convenience.

Sample Operating Procedures (SOP) River Watch has every aspect of the program documented, from training, recruitment, quality assurance and control, safety, how to select a station, study design, data management and program management. This large document contains subdocuments like the quality assurance plan and data management plan. This large Standard Operating Procedures document is a re-write process and the new version will be available in chapters on www.coloradoriverwatch.org by December 2021. Volunteers receive a “Sample Plan” that is their guide for their role and has all relevant instructions, background, safety, quality assurance and volunteer management information. The River Watch sample plan is also on our website by chapter, updated annually.

D. What is Colorado River Watch?

A citizen science volunteer monitoring network that started in 1989 with five schools on the Yampa River. Within a few years, we grew to serve 140 groups annually, who monitoring about 500 stations on 200 rivers each year. Currently, our database holds information on more than 1200 stations and 700 rivers. In any given River Watch year, approximately 80% of our volunteer organizations are school groups and the remaining 20% are a diverse mix of individuals and adult groups. Visit www.coloradoriverwatch.org to learn more about volunteer groups to post a picture and story about your volunteer group.

To become a volunteer with River Watch, a group representative must attend a four-day intensive training, pass tests for certification and commit to one year of monthly sampling for most indicators. Annually, each group certifies their data through our quality assurance and control program. Volunteers, partners and professional staff must comply with our methods and protocols for collection and sign an annual memorandum. RW conducts 20% quality assurance and control measures relative to the 10% industry standard. Initially each group receives \$3000 of equipment, restocked by the program annually. All needed supplies are provided except travel to sites and shipping of samples. Any unused equipment is reclaimed and reallocated. Visit www.coloradoriverwatch.org to sign up and find out more about the program.

Administration

CPW implements River Watch with an external partner to provide professional support, diversity in fundraising and expansion into areas outside of CPW mission. CPW’s role in this partnership includes the two ends of the spectrum in the “data to action” continuum and oversight of steps in the middle. CPW provides the study design, data objectives, quality objectives, equipment, all methods, procedures, protocols, documentation, and data validation. CPW is also the entity who takes the data to the decision making process for action. Partner implements the program and provides volunteer and data management support.

To learn more or sign up to volunteer please visit www.coloradoriverwatch.org.

Any questions or comments about the program or data please contact Megan McConville at megan.mcconville@state.co.us.

Example Bug Report Display

River Watch Water Quality Sampling Manual
Quality Assurance and Quality Control Plan

RiverWatch Benthics Event: (433.264)		Benthics Event Detail	
Norwood Hill #433		Norwood Hill #433	
Sample Date	10/20/2014	ActivityCategory	Composite w/o Parents
Sample Time	09:45	CollectionMethod	Macroinvertebrate Sampling
Sample Number	433201410200945	GearConfig	18" x 8" Modified D-net
Watershed	Dolores	ActivityType	Field Measurement or Observation
River name	San Miguel	Medium	Biological
Organization	Norwood HS	Intent	Taxon Abundance
Kit#	160	Community	Benthic Macroinvertebrates
Water Code	46866	BioResultGroup	Multi-Taxon Population Census
WaterShed Report	SMDO	Kicks	4
WaterShed Gathering	DO	Comments	3 in 100% count
County	San Miguel		
Benthics Taxonomy		Number of grids reported: 6	

Example Physical Habitat Report Display

Colorado River Watch (433.264)		Stream Reach Physical Habitat					
Site Information		Cross Section		Habitat Features		Riparian Vegetation	
Watershed	Dolores	Distance	Depth	Cobble (%)	100	Right Bank	
River	San Miguel	1	0.04	Snags (%)		Trees	
Organization	Norwood HS	2	0.04	Vegetated Banks (%)		Shrubs	Yes
Sample Date	10/20/2014	3	0.33	Sand (%)		Grasses	
Sample Time	09:45	4	0.17	Watershed Features			
Event	433.264	5	0.67	Right Bank		Other	
Field Data	Yes	6	0.75	Forest	Yes	Dominant Species	willow,alder
Metals Data	Yes	7	0.83	Field/Pasture		Width (ft)	
Nutrient Data	Yes	8	0.83	Irrigated		Left Bank	
PhysHab Data	Yes	9	0.92	RR/hwy		Trees	
Bugs Data	Yes	10	1.08	Dense Housing		Shrubs	Yes
		11	1.25	Sparse Housing		Grasses	
		12	1.33	Commercial		Herbaceous	
		13	1.17	Industrial		Other	
		14	1.08			Dominant Species	willow